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

Willow Master Development Plan

Supplemental Environmental Impact Statement

FINAL

Volume 13: Appendix E.9 to E.13

January 2023

Prepared by:

U.S. Department of the Interior

Bureau of Land Management

Anchorage, Alaska

In Cooperation with:

U.S. Army Corps of Engineers

U.S. Environmental Protection Agency

U.S. Fish and Wildlife Service

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 SEIS: $3,350,000

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: North Slope Alaska oil rig during winter drilling.
Photo by: Judy Patrick, courtesy of ConocoPhillips.

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Willow Master Development Plan

Appendix E.9
Vegetation and Wetlands Technical Appendix

January 2023

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List of Acronyms

Project area	Willow Master Development Plan Project 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.

Marine – Produced or originating from or within the sea.

Palustrine – Produced or originating from or within a marsh.

Riverine – Relating or situated on a river or riverbank.

Unconsolidated – Sediment that is loosely arranged or unstratified, or whose particles are not cemented together.

Upland – Land area that under normal circumstances does not satisfy the three required wetland factors (i.e., hydrology hydrophytic vegetation, hydric soils), and does not lie below the ordinary high water mark or high tide line of a jurisdictional water.

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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 Project area (Project area; field-verified area) and the analysis area. Wetland types in the Willow area are not unique and occur throughout the analysis area and the Arctic Coastal Plain. Table E.9.1 also shows the Cowardin code for each wetland type; the Cowardin system (1979) is a national classification system based on wetland characteristics. Figure 3.9.3 in Appendix A, *Figures*, in the Final Environmental Impact Statement 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 in Analysis Area[b]	Acres in Field-Verified Portion of Analysis Area[c]
Estuarine Subtidal **Unconsolidated** Bottom	E1UBL	64,512.9	0.0
Estuarine Intertidal **Emergent** Persistent/Unconsolidated Shore Irregularly Flooded	E2EM1/USP	14,258.4	0.0
Estuarine Intertidal Emergent Persistent Regularly Flooded	E2EM1N	9.3	0.0
Estuarine Intertidal Emergent Persistent Irregularly Flooded	E2EM1P	16,110.0	0.0
Estuarine Intertidal Emergent Nonpersistent/Unconsolidated Shore Irregularly Flooded	E2EM2/USP	5,161.8	0.0
Estuarine Intertidal Unconsolidated Shore/Emergent Persistent Irregularly Flooded	E2US/EM1P	11,405.4	0.0
Estuarine Intertidal Unconsolidated Shore/Emergent Nonpersistent Irregularly Flooded	E2US/EM2P	60.9	0.0
Estuarine Intertidal Unconsolidated Shore Regularly Flooded	E2USN	136.3	0.0
Estuarine Intertidal Unconsolidated Shore Irregularly Flooded	E2USP	30,799.8	0.0
Lacustrine Limnetic Unconsolidated Bottom Permanently Flooded	L1UBH	580,199.4	365.7
Lacustrine Limnetic Unconsolidated Bottom Permanently Flooded Diked/Impounded	L1UBHh	2,681.7	0.0
Lacustrine Limnetic Unconsolidated Bottom Permanently Flooded Excavated	L1UBHx	0.0	<0.1
Lacustrine Littoral Aquatic Bed Aquatic Moss Permanently Flooded	L2AB2H	3.9	0.0
Lacustrine Littoral Emergent Nonpersistent/Unconsolidated Bottom Semi-Permanently Flooded	L2EM2/UBF	153.3	0.0
Lacustrine Littoral Emergent Nonpersistent/Unconsolidated Bottom Permanently Flooded	L2EM2/UBH	3,501.2	0.0
Lacustrine Littoral Emergent Nonpersistent Semi-Permanently Flooded	L2EM2F	1,512.4	0.0
Lacustrine Littoral Emergent Nonpersistent Permanently Flooded	L2EM2H	5,832.8	4.1
Lacustrine Littoral Unconsolidated Bottom/Emergent Nonpersistent Permanently Flooded	L2UB/EM2H	1,229.2	0.0
Lacustrine Littoral Unconsolidated Bottom Semi-Permanently Flooded	L2UBF	34.9	0.0
Lacustrine Littoral Unconsolidated Bottom Permanently Flooded	L2UBH	1,362.2	0.0
Lacustrine Littoral Unconsolidated Shore Temporarily Flooded	L2USA	4,169.0	0.0
Lacustrine Littoral Unconsolidated Shore Seasonally Flooded	L2USC	5,158.9	0.0
Marine Subtidal Unconsolidated Bottom[c]	M1UBL	35,795.1	76.7
Marine Intertidal Unconsolidated Shore Sand Regularly Flooded	M2US2N	1.6	1.6
Marine Intertidal Unconsolidated Shore Regularly Flooded	M2USN	4.6	0.0
Marine Intertidal Unconsolidated Shore Irregularly Flooded	M2USP	275.0	0.0
Palustrine Emergent Persistent/Nonpersistent Semi-Permanently Flooded	PEM1/2F	4,477.2	0.0
Palustrine Emergent Persistent/Moss-Lichen Moss Seasonally Saturated	PEM1/ML1B	300.8	0.0
Palustrine Emergent Persistent/Scrub-Shrub Broad-Leaved Deciduous Temporarily Flooded	PEM1/SS1A	68.1	0.0
Palustrine Emergent Persistent/Scrub-Shrub Broad-Leaved Deciduous Seasonally Saturated	PEM1/SS1B	907,301.3	4,027.6
Palustrine Emergent Persistent/Scrub-Shrub Broad-Leaved Deciduous Continuously Saturated[d]	PEM1/SS1D	2,677.6	2,677.6
Palustrine Emergent Persistent/Scrub-Shrub Broad-Leaved Deciduous Continuously Seasonally Flooded/Saturated	PEM1/SS1E	420,546.6	312.1
Palustrine Emergent Persistent/Scrub-Shrub Broad-Leaved Deciduous Semi-Permanently Flooded	PEM1/SS1F	38,157.7	431.6
Palustrine Emergent Persistent/Scrub-Shrub Broad-Leaved Evergreen Saturated	PEM1/SS3B	7.1	7.1
Palustrine Emergent Persistent/Unconsolidated Bottom Semi-Permanently Flooded	PEM1/UBF	41,116.2	0.0
Palustrine Emergent Persistent/Unconsolidated Bottom Semi-Permanently Flooded Diked/Impounded	PEM1/UBFh	5.3	0.0
Palustrine Emergent Persistent/Unconsolidated Shore Temporarily Flooded	PEM1/USA	1,273.0	0.0
Palustrine Emergent Persistent/Unconsolidated Shore Seasonally Flooded	PEM1/USC	677.8	0.0

Wetland Type	Cowardin Code[a]	Acres in Analysis Area[b]	Acres in Field-Verified Portion of Analysis Area[c]
Palustrine Emergent Persistent/Unconsolidated Shore Seasonally Flooded/Saturated	PEM1/USE	2,913.7	0.0
Palustrine Emergent Persistent Seasonally Saturated	PEM1B	23,883.0	1.6
Palustrine Emergent Persistent Seasonally Flooded	PEM1C	567.2	0.0
Palustrine Emergent Persistent Continuously Saturated	PEM1D	17.6	17.6
Palustrine Emergent Persistent Seasonally Flooded/Saturated	PEM1E	287,035.6	9.5
Palustrine Emergent Persistent Semi-Permanently Flooded	PEM1F	167,131.5	2,608.0
Palustrine Emergent Persistent Semi-Permanently Flooded Diked/Impounded	PEM1Fh	12.8	0.0
Palustrine Emergent Persistent Permanently Flooded[d]	PEM1H	372.3	372.3
Palustrine Emergent Nonpersistent/Persistent Semi-Permanently Flooded	PEM2/1F	5,044.4	0.0
Palustrine Emergent Nonpersistent/Unconsolidated Bottom Semi-Permanently Flooded	PEM2/UBF	64.3	0.0
Palustrine Emergent Nonpersistent/Unconsolidated Bottom Permanently Flooded	PEM2/UBH	781.0	0.0
Palustrine Emergent Nonpersistent Semi-Permanently Flooded	PEM2F	178.8	0.0
Palustrine Emergent Nonpersistent Permanently Flooded	PEM2H	2,408.1	21.2
Palustrine Scrub-Shrub/Emergent Persistent Temporarily Flooded	PSS/EM1A	489.0	0.0
Palustrine Scrub-Shrub/Emergent Persistent Seasonally Saturated	PSS/EM1B	15,969.0	0.0
Palustrine Scrub-Shrub/Emergent Persistent Seasonally Flooded/Saturated	PSS/EM1E	27,599.1	0.0
Palustrine Scrub-Shrub/Emergent Persistent Semi-Permanently Flooded	PSS/EM1F	50.9	0.0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Emergent Persistent Temporarily Flooded	PSS1/EM1A	1,348.5	0.0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Emergent Persistent Seasonally Saturated	PSS1/EM1B	9,850.8	94.0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Emergent Persistent Seasonally Flooded	PSS1/EM1C	167.5	0.0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Emergent Persistent Continuously Saturated	PSS1/EM1D	23.5	23.5
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Emergent Persistent Seasonally Flooded/Saturated	PSS1/EM1E	11,783.9	0.0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Emergent Persistent Semi-Permanently Flooded	PSS1/EM1F	751.6	0.0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Unconsolidated Shore Temporarily Flooded	PSS1/USA	747.5	0.0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Unconsolidated Shore Seasonally Saturated[d]	PSS1/USB	18.0	18.0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Unconsolidated Shore Seasonally Flooded	PSS1/USC	13.9	0.0
Palustrine Scrub-Shrub Broad-Leaved Deciduous Temporarily Flooded	PSS1A	4,449.0	0.0
Palustrine Scrub-Shrub Broad-Leaved Deciduous Seasonally Saturated	PSS1B	2,697.6	374.8
Palustrine Scrub-Shrub Broad-Leaved Deciduous Seasonally Flooded	PSS1C	132.0	105.2
Palustrine Shrub-Scrub Broad-Leaved Deciduous Continuously Saturated[d]	PSS1D	123.1	123.1
Palustrine Shrub-Scrub Broad-Leaved Deciduous Seasonally Flooded/Saturated	PSS1E	117.6	0.0
Palustrine Scrub-Shrub Broad-Leaved Evergreen/Emergent Persistent Seasonally Saturated	PSS3/EM1B	6.4	6.4
Palustrine Scrub-Shrub Broad-Leaved Evergreen/Emergent Persistent Continuously Saturated	PSS3/EM1D	22.0	22.0
Palustrine Scrub-Shrub Broad-Leaved Evergreen Seasonally Saturated[d]	PSS3B	133.1	133.1
Palustrine Unconsolidated Bottom/Emergent Persistent Semi-Permanently Flooded	PUB/EM1F	9,139.7	0.0
Palustrine Unconsolidated Bottom/Emergent Nonpersistent Semi-Permanently Flooded	PUB/EM2F	45.0	0.0
Palustrine Unconsolidated Bottom/Emergent Nonpersistent Permanently Flooded	PUB/EM2H	734.1	0.0
Palustrine Unconsolidated Bottom Semi-Permanently Flooded	PUBF	155.8	0.0
Palustrine Unconsolidated Bottom Semi-Permanently Flooded Diked/Impounded	PUBFh	5.9	0.0
Palustrine Unconsolidated Bottom Permanently Flooded	PUBH	61,283.2	285.0
Palustrine Unconsolidated Bottom Permanently Flooded Diked/Impounded	PUBHh	42.9	0.0
Palustrine Unconsolidated Bottom Permanently Flooded Excavated	PUBHx	26.7	1.0
Palustrine Unconsolidated Shore/Emergent Persistent Temporarily Flooded	PUS/EM1A	483.2	0.0
Palustrine Unconsolidated Shore/Emergent Persistent Seasonally Flooded	PUS/EM1C	69.3	0.0
Palustrine Unconsolidated Shore/Emergent Persistent Seasonally Flooded/Saturated	PUS/EM1E	309.1	0.0
Palustrine Unconsolidated Shore/Scrub-Shrub Broad-Leaved Deciduous Temporarily Flooded	PUS/SS1A	53.5	0.0
Palustrine Unconsolidated Shore Temporarily Flooded	PUSA	265.6	0.0
Palustrine Unconsolidated Shore Seasonally Flooded	PUSC	165.7	0.3

Wetland Type	Cowardin Code[a]	Acres in Analysis Area[b]	Acres in Field-Verified Portion of Analysis Area[c]
Riverine Tidal Unconsolidated Bottom Permanently Flooded[d]	R1UBV	43.0	16.8
Riverine Tidal Unconsolidated Shore Regularly Flooded	R1USQ	7.3	6.2
Riverine Low Perennial Emergent Nonpersistent/Unconsolidated Bottom Permanently Flooded	R2EM2/UBH	578.3	0.0
Riverine Low Perennial Emergent Nonpersistent Semi-Permanently Flooded	R2EM2F	4.5	0.0
Riverine Low Perennial Unconsolidated Bottom/Emergent Nonpersistent Permanently Flooded	R2UB/EM2H	435.4	0.0
Riverine Low Perennial Unconsolidated Bottom Semi-Permanently Flooded	R2UBF	5,790.8	0.0
Riverine Low Perennial Unconsolidated Bottom Permanently Flooded	R2UBH	19,648.2	37.9
Riverine Low Perennial Unconsolidated Shore Temporarily Flooded	R2USA	1,717.4	0.0
Riverine Low Perennial Unconsolidated Shore Seasonally Flooded	R2USC	14,640.3	20.4
Riverine Upper Perennial Unconsolidated Bottom Permanently Flooded	R3UBH	6,342.7	0.0
Riverine Upper Perennial Unconsolidated Shore Temporarily Flooded	R3USA	186.8	0.0
Riverine Upper Perennial Unconsolidated Shore Seasonally Flooded	R3USC	512.3	0.0
Riverine Intermittent Streambed Temporarily Flooded	R4SBA	22.1	0.0
Riverine Intermittent Streambed Seasonally Flooded	R4SBC	10.7	0.0
Riverine Unknown Perennial Unconsolidated Bed Permanently Flooded	R5UBH	70.1	0.0
Upland	U[e]	129.7	129.7
Upland	Upland[e]	12,324.2	0.0
Upland (fill)	Us[e]	582.7	582.7
Total	**N/A**	**2,903,709.2**	**12,914.5**

Note: N/A (not applicable); USFWS (U.S. Fish and Wildlife Service). 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 that in the USFWS inventory (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 to the USFWS inventory (2016) covering a broad area that did not receive the same level of field verification as the Project area.
[e] Cowardin code of "U" was field verified; Cowardin code of "Upland" included all areas in National Wetlands Inventory mapping that were not identified as wetlands; Cowardin code for 'Us' was field verified to distinguish between vegetated uplands and developed uplands.

1.2 Comparison of Alternatives: Wetlands and Vegetation

Tables E.9.2 and E.9.3 detail the acres of direct and temporary fill in wetlands by wetland type and action alternative or module delivery option. Table E.9.4. summarizes direct wetland loss by watershed and action alternative. Table E.9.5 summarizes acres of vegetation damage from ice infrastructure by action alternative or module delivery option. Table E.9.6 summarizes acres of indirect dust shadow on wetlands and vegetation by wetland type and action alternative or module delivery option. Table E.9.7 summarizes indirect effects (dust shadow and vegetation damage) in wetlands and waterbodies by watershed and action alternative.

Table E.9.2. Acres of Wetland Loss Due to Direct Fill or Excavation by Wetland Type and Action Alternative or Module Delivery Option*

Cowardin Code	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
L1UBH	1.5	1.5	1.5	0.0	0.0	0.0	0.0
PEM1/SS1B	290.1	379.1	342.5	252.5	0.0	0.0	2.5
PEM1/SS1D	154.4	168.4	150.9	148.5	0.0	0.0	0.9
PEM1/SS1E	1.8	1.8	1.7	0.3	0.0	0.0	0.0
PEM1/SS1F	8.7	11.3	8.0	2.9	0.0	0.0	0.0
PEM1E	1.0	0.0	1.0	1.7	0.0	0.0	0.0
PEM1F	105.4	131.4	101.7	88.1	0.0	0.0	0.8
PEM1H	8.3	13.3	14.7	6.2	0.0	0.0	0.1
PEM2H	0.6	0.8	0.0	0.6	0.0	0.0	0.0
PSS1/EM1B	8.9	8.5	9.6	8.3	0.0	0.0	0.1
PSS1/EM1D	0.6	0.8	0.6	0.3	0.0	0.0	0.0
PSS1/USB	1.3	1.0	1.0	1.4	0.0	0.0	0.0
PSS1B	10.3	11.2	31.2	8.1	0.0	0.0	0.0
PSS1C	1.6	1.4	1.5	1.3	0.0	0.0	0.0
PSS1D	1.8	1.0	2.2	4.8	0.0	0.0	0.0
PSS3/EM1B	1.1	1.1	0.0	1.1	0.0	0.0	0.0

Cowardin Code	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
PSS3/EM1D	1.6	1.6	0.0	1.6	0.0	0.0	0.0
PSS3B	7.5	6.3	7.6	4.4	0.0	0.0	0.0
PUBH	4.4	7.5	7.7	3.9	0.0	0.0	<0.0
R2UBH	0.6	0.4	0.6	0.6	0.0	0.0	<0.0
R2USC	0.5	0.1	0.3	0.5	0.0	0.0	0.0
U	7.8	3.2	4.6	6.2	0.0	0.0	0.0
Us	0.3	0.3	0.3	0.3	0.0	0.0	0.4
L1UBH	1.5	1.5	1.5	0.0	0.0	0.0	0.0
Total	**620.1**	**752.0**	**689.2**	**543.6**	**0.0**	**0.0**	**5.0**
Total in Wetlands	**605.0**	**739.0**	**674.2**	**532.1**	**0.0**	**0.0**	**4.6**
Total in Freshwater WOUS	**7.0**	**9.5**	**10.1**	**5.0**	**0.0**	**0.0**	**0.0**
Total in Uplands	**8.1**	**3.5**	**4.9**	**6.5**	**0.0**	**0.0**	**0.4**

Note: < (less than); WOUS (Waters of the United States). Cowardin codes are defined in Table E.9.1. Numbers may differ slightly with other reported values in the Environmental Impact Statement due to rounding.
[a] Fill that is not in wetlands would be in uplands or freshwater WOUS (lakes, ponds, or rivers).

Table E.9.3. Acres of Temporary Fill from Multi-Season Ice Pads by Wetland and Waterbody Type and Action Alternative or Module Delivery Option*

Cowardin Code	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
PEM1/SS1B	1.7	4.4	12.1	1.7	18.2	17.9	0.0
PEM1/SS1D	9.7	11.1	4.7	9.7	8.8	9.4	0.0
PEM1/SS1E	0.0	0.0	2.4	0.0	0.0	0.0	0.0
PEM1/SS3B	0.0	0.0	0.0	0.0	1.6	0.0	0.0
PEM1F	16.5	10.0	6.9	16.5	15.2	12.6	0.0
PEM1H	2.0	0.7	0.7	2.0	5.0	8.8	0.0
PSS1B	0.0	3.5	3.2	0.0	0.0	0.0	0.0
PUBH	0.2	0.4	0.0	0.2	1.3	1.3	0.0
Total	**30.1**	**30.1**	**30.0**	**30.1**	**50.1**	**50.0**	**0.0**

Note: Cowardin codes are defined in Table E.9.1. Multi-season ice pads (lasting more than 1 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 Willow Master Development Plan Project's Clean Water Act 404 permit as temporary fill.

Table E.9.4. Direct Wetland Loss by Watershed and Action Alternative*

Watershed (acres)	Alternative B: Proponent's Project (acres)	Alternative B: Proponent's Project (% of watershed)	Alternative C: Disconnected Infield Roads (acres)	Alternative C: Disconnected Infield Roads (% of watershed)	Alternative D: Disconnected Access (acres)	Alternative D: Disconnected Access (% of watershed)	Alternative E: Three-Pad Alternative Access (acres)	Alternative E: Three-Pad Alternative (% of watershed)
Colville River Delta-Frontal Harrison Bay (303,614.3)	2.2	< 0.1	2.2	< 0.1	3.5	< 0.1	1.6	<0.1
Kalikpik River (233,090.1)	28.0	< 0.1	29.1	< 0.1	28.0	< 0.1	0.0	0.0
Outlet Fish Creek (137,576.9)	60.8	< 0.1	111.8	0.1	65.9	< 0.1	54.9	<0.1
Outlet Judy Creek (246,274.6)	358.0	0.1	361.8	0.1	346.1	0.1	324.8	0.1
Ublutuoch River (150,954.4)	155.0	0.1	233.6	0.2	230.0	0.2	150.1	0.1

(acres)	Alternative B: Proponent's Project (acres)	Alternative B: Proponent's Project (% of watershed)	Alternative C: Disconnected Infield Roads (acres)	Alternative C: Disconnected Infield Roads (% of watershed)	Alternative D: Disconnected Access (acres)	Alternative D: Disconnected Access (% of watershed)	Alternative E: Three-Pad Alternative Access (acres)	Alternative E: Three-Pad Alternative (% of watershed)
Ugnuravik River (77,253.8)	0.7	< 0.1	0.7	< 0.1	0.7	< 0.1	0.7	<0.1
Total Fill and Excavation in Wetlands	**604.8**	**N/A**	**739.1**	**N/A**	**674.3**	**N/A**	**532.2**	**N/A**
Fill and Excavation in Waters of the U.S.	**7.0**	**N/A**	**9.5**	**N/A**	**10.0**	**N/A**	**5.0**	**N/A**
Fill and Excavation in Uplands	**8.1**	**N/A**	**3.5**	**N/A**	**4.9**	**N/A**	**6.4**	**N/A**
Total	**619.9**	**N/A**	**752.1**	**N/A**	**689.1**	**N/A**	**543.6**	**N/A**

Note: < (less than); N/A (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. Direct wetland loss would come from either the placement of gravel fill or excavation (e.g., gravel mine site, constructed freshwater reservoir). Total acres of direct fill and excavation may vary slightly from other resource sections in the Environmental Impact Statement because those sections include fill in uplands and this section does not. Wetland loss for Option 3 would be less than 5 acres and thus is not included in the table.

Table E.9.5. Acres of Vegetation Damage from Ice Infrastructure by Action Alternative or Module Delivery Option*

Ice Infrastructure	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
Single-season ice pads	936.6	1,166.4	1,241.4	830.6	118.9	195.2	83.4
Multi-season ice pads	30.1	30.1	30.0	30.1	50.1	50.0	0.0
Freshwater ice roads	3,590.7	4,411.6	5,893.4	3,166.2	710.7	1,530.9	583.2
Total	**4,557.4**	**5,608.1**	**7,164.8**	**4,026.9**	**879.7**	**1,776.1**	**666.6**

Note: The total acres indirectly impacted by ice infrastructure were assumed to be equal to wetland acres, since uplands compose less than 1% of the analysis area.

Table E.9.6. Acres of Indirect Dust Shadow on Wetlands and Vegetation by Wetland Type and Action Alternative or Module Delivery Option*

Cowardin Code	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
L1UBH	17.8	17.6	18.0	26.0	0.0	0.0	<0.1
L2EM2H	0.1	0.1	0.1	1.4	0.0	0.0	0.0
PEM1/SS1B	1225.1	1272.3	931.6	1008.6	0.0	0.0	8.5
PEM1/SS1D	723.4	781.5	584.7	663.1	0.0	0.0	2.5
PEM1/SS1E	31.2	34.9	31.5	10.2	0.0	0.0	4.6
PEM1/SS1F	83.1	95.7	69.2	44.9	0.0	0.0	0.0
PEM1B	1.6	1.6	1.6	1.4	0.0	0.0	0.0
PEM1D	0.0	0.0	0.0	0.0	0.0	0.0	0.3
PEM1E	6.3	0.0	6.3	7.8	0.0	0.0	0.0
PEM1F	780.0	731.6	539.9	627.0	0.0	0.0	2.2
PEM1H	117.2	119.1	98.9	80.2	0.0	0.0	0.0
PEM2H	6.3	5.9	2.4	4.9	0.0	0.0	0.0
PSS1/EM1B	54.5	54.7	45.9	51.8	0.0	0.0	0.1
PSS1/EM1D	12.7	13.0	15.2	3.8	0.0	0.0	0.0
PSS1/USB	12.3	9.1	9.1	12.1	0.0	0.0	0.0
PSS1B	107.2	113.8	110.1	70.9	0.0	0.0	<0.1
PSS1C	26.1	24.7	26.8	22.7	0.0	0.0	0.0

Cowardin Code	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
PSS1D	22.1	14.4	26.2	31.0	0.0	0.0	0.0
PSS3/EM1B	5.3	5.3	0.0	5.3	0.0	0.0	0.0
PSS3/EM1D	20.3	20.0	0.0	20.3	0.0	0.0	0.0
PSS3B	42.4	28.7	45.1	46.3	0.0	0.0	0.0
PUBH	66.9	70.7	58.3	52.7	0.0	0.0	0.1
R1UBV	0.2	0.2	0.2	0.3	0.0	0.0	0.0
R2UBH	14.5	10.0	11.3	14.4	0.0	0.0	0.0
R2USC	7.1	1.9	4.0	7.1	0.0	0.0	0.0
U	64.6	39.8	54.1	39.1	0.0	0.0	0.0
Us	0.2	0.2	0.2	0.1	0.0	0.0	10.1
Total	**3,448.5**	**3,466.8**	**2,690.7**	**2,853.4**	**0.0**	**0.0**	**28.4**
Total in Wetlands[a]	**3,277.1**	**3,326.3**	**2,544.5**	**2,712.3**	**0.0**	**0.0**	**18.2**
Total in Freshwater WOUS	**106.6**	**100.5**	**91.9**	**101.9**	**0.0**	**0.0**	**0.1**
Total in Uplands	**64.8**	**40.0**	**54.3**	**39.2**	**0.0**	**0.0**	**10.1**

Note: < (less than); WOUS (Waters of the United States). Cowardin codes are defined in Table E.9.1. Dust shadow is calculated from all gravel infrastructure. Numbers may differ slightly from other reported values in the Environmental Impact Statement due to rounding.
[a] Fill that is not in wetlands would be in uplands or freshwater WOUS (lakes, ponds, or rivers).

Table E.9.7. Indirect Dust Shadow in Wetlands and Waterbodies by Watershed and Action Alternative*

Watershed (acres)	Alternative B: Proponent's Project (acres)	Alternative B: Proponent's Project (% of watershed)	Alternative C: Disconnected Infield Roads (acres)	Alternative C: Disconnected Infield Roads (% of watershed)	Alternative D: Disconnected Access (acres)	Alternative D: Disconnected Access (% of watershed)	Alternative E: Three-Pad Alternative (acres)	Alternative E: Three-Pad Alternative (% of watershed)
Colville River Delta-Frontal Harrison Bay (224,452.3)	27.7	<0.1	27.7	<0.1	31.0	<0.1	26.5	<0.1
Kalikpik River (233,088.3)	193.1	0.1	193.7	0.1	193.1	0.1	0.0	0.0
Outlet Fish Creek (137,576.9)	563.8	0.4	751.8	0.5	566.7	0.4	403.7	0.3
Outlet Judy Creek (246,274.6)	2,417.5	1.0	2,245.3	0.9	1,680.3	0.7	2206.9	0.9
Ublutuoch (Tiŋmiaqsiuġvik) River (150,954.4)	180.8	0.1	207.6	0.1	164.5	0.1	176.5	0.1
Ugnuravik River (77,253.8)	0.9	<0.1	0.9	<0.1	0.9	<0.1	0.9	<0.1
Total	**3,383.6**	**N/A**	**3,426.9**	**N/A**	**2,636.5**	**N/A**	**2,814.6**	**N/A**

Note: < (less than); N/A (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 sections in the Environmental Impact Statement because those sections include fill to uplands and this section does not. Dust shadow is calculated from all gravel infrastructure. Dust shadow for Option 3 would be less than 28 acres and thus is not included in the table.

2.0 REFERENCES

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Wells, A.F., S.L. Ives, T. Christopherson, D. Dissing, G.V. Frost, M.J. Macander, and R.W. McNown. 2018. *An Ecological Land Survey and Integrated Terrain Unit Mapping for the Willow Master Development Plan Area, National Petroleum Reserve-Alaska, 2017–2018*. Anchorage, AK: Prepared by ABR, Inc. for ConocoPhillips Alaska, Inc.

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Appendix E.10
Fish Technical Appendix

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List of Species

Alaska blackfish (*Dallia pectoralis*)
Arctic grayling (*Thymallus arcticus*)
Broad whitefish (*Coregonus nasus*)
Humpback whitefish (*Coregonus pidschian*)
Least cisco (*Coregonus sardinella*)
Ninespine stickleback (*Pungitius pungitius*)
Round whitefish (*Prosopium cylindraceum*)
Slimy sculpin (*Cottus cognatus*)

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1.0 FISH IN THE ANALYSIS AREA

Tables E.10.1 through E.10.4 summarize Willow project area lakes and the fish species that are present in the analysis area by action alternative.

Table E.10.1. Willow Project Area Lakes and Fish Species that Occur in the Alternative B Analysis Area*

Lake	Species	Winter Water Status	Latitude	Longitude
MM1818	No fish captured	Unfrozen	70.29404	-152.225
Small lake	Not sampled; Nearby larger and similar sized lakes do not contain fish	Unfrozen	70.29929	-152.204
Small lake	Not sampled; NSSB possible	Unfrozen	70.03551	-152.195
M1523	NSSB	Unfrozen	70.15469	-152.113
M8104	No fish captured	Unfrozen	70.28623	-149.866
M9525	BDWF, BKFH, HBWF, LSCS, NSSB, RDWF, SLSC	Unfrozen	70.32266	-150.98
L9824	BKFH, GRAY, NSSB	Unfrozen	70.28425	-151.271
M0015	NSSB, GRAY	Unfrozen	70.10824	-152.058
L9911	NSSB	Unfrozen	70.17073	-151.79
M8103	NSSB	Unfrozen	70.29131	-149.916
M8103	NSSB	Unfrozen	70.28761	-149.894
Wetland ponds	None	Frozen	70.27549	-152.195
Small lake	No fish captured	Frozen	70.31457	-152.193
Small lake	Not sampled; Nearby larger and similar sized lakes do not contain fish	Frozen	70.30939	-152.196
Small lake	Not sampled; Nearby larger and similar sized lakes do not contain fish	Frozen	70.32664	-152.221
Wetland ponds	None	Frozen	70.28688	-152.222
Small lake	Not sampled; Nearby larger and similar sized lakes do not contain fish	Frozen	70.32082	-152.211
Wetland ponds	None	Frozen	70.20368	-152.105
Wetland ponds	None	Frozen	70.27688	-152.199
Wetland ponds	None	Frozen	70.21493	-152.105
M1522	NSSB	Frozen	70.15288	-152.086
Small pond	NSSB inferred, connected to Lake M1523	Frozen	70.15742	-152.088
M2108	BDWF, NSSB	Frozen	70.2494	-152.179
Wetland ponds	None	Frozen	70.17279	-152.121
Wetland ponds	None	Frozen	70.17713	-152.11
Wetland ponds	None	Frozen	70.25424	-152.186
M0017	NSSB	Frozen	70.10085	-152.133
Wetland ponds	None	Frozen	70.17217	-152.113
Small lake	Not Sampled; NSSB possible	Frozen	70.13882	-152.014
Wetland ponds	None	Frozen	70.15845	-151.774
Wetland ponds	None	Frozen	70.15558	-151.81
Wetland ponds	None	Frozen	70.14726	-151.867
Wetland ponds	None	Frozen	70.16142	-151.762
Wetland ponds	NSSB	Frozen	70.12428	-152.078
Wetland ponds	None	Frozen	70.12781	-152.08
Small lake	Not sampled; NSSB possible	Frozen	70.1131	-152.102
Wetland ponds	None	Frozen	70.14187	-151.888
Mine Site	Not sampled; Isolated (fish unlikely)	Frozen	70.28641	-149.887
Wetland ponds	None	Frozen	70.28466	-149.898
Wetland ponds	None	Frozen	70.2754	-150.062
Wetland pond/impoundment	None	Frozen	70.33655	-149.728
Mine Site	Not sampled; Isolated (fish unlikely)	Frozen	70.28669	-149.883
Wetland ponds	None	Frozen	70.27822	-149.911

Note: BDWF (broad whitefish); BKFH (Alaska blackfish); GRAY (Arctic grayling); HBWF (humpback whitefish); LSCS (least cisco); NSSB (ninespine stickleback); RDWF (round whitefish); SLSC (slimy sculpin).

Table E.10.2. Willow Project Area Lakes and Fish Species that Occur in the Alternative C Analysis Area*

Lake	Species	Winter Water Status	Latitude	Longitude
M8103	NSSB	Unfrozen	70.29131	-149.916
M8103	NSSB	Unfrozen	70.28761	-149.894
M0235	No fish captured	Unfrozen	70.23704	-152.188
MM1818	No fish captured	Unfrozen	70.29404	-152.225
Small lake	Not sampled; Nearby larger and similar sized lakes do not contain fish	Unfrozen	70.29929	-152.204
Small lake	Not sampled; NSSB possible	Unfrozen	70.03551	-152.195
M1523	NSSB	Unfrozen	70.15469	-152.113
M8104	No fish captured	Unfrozen	70.28623	-149.866
M9525	BDWF, BKFH, HBWF, LSCS, NSSB, RDWF, SLSC	Unfrozen	70.32266	-150.98
L9824	BKFH, GRAY, NSSB	Unfrozen	70.28425	-151.271
M0015	NSSB, GRAY	Unfrozen	70.10824	-152.058
L9911	NSSB	Unfrozen	70.17073	-151.79
Mine Site	Not sampled; Isolated (fish unlikely)	Frozen	70.28641	-149.887
Wetland ponds	None	Frozen	70.28466	-149.898
Wetland ponds	None	Frozen	70.2754	-150.062
Wetland pond/impoundment	None	Frozen	70.33655	-149.728
Mine Site	Not sampled; Isolated (fish unlikely)	Frozen	70.28669	-149.883
Wetland ponds	None	Frozen	70.27822	-149.911
Wetland ponds	None	Frozen	70.22333	-152.203
Wetland ponds	None	Frozen	70.22217	-152.196
Small pond	Not Sampled; NSSB likely	Frozen	70.13415	-152.01
Wetland ponds	None	Frozen	70.15032	-151.957
Wetland ponds	None	Frozen	70.24239	-152.172
Wetland ponds	None	Frozen	70.27549	-152.195
Small lake	No fish captured	Frozen	70.31457	-152.193
Small lake	Not sampled; Nearby larger and similar sized lakes do not contain fish	Frozen	70.30939	-152.196
Small lake	Not sampled; Nearby larger and similar sized lakes do not contain fish	Frozen	70.32664	-152.221
Wetland ponds	None	Frozen	70.28688	-152.222
Small lake	Not sampled; Nearby larger and similar sized lakes do not contain fish	Frozen	70.32082	-152.211
Wetland ponds	None	Frozen	70.20368	-152.105
Wetland ponds	None	Frozen	70.27688	-152.199
Wetland ponds	None	Frozen	70.21493	-152.105
M1522	NSSB	Frozen	70.15288	-152.086
M2108	BDWF, NSSB	Frozen	70.2494	-152.179
Wetland ponds	None	Frozen	70.17279	-152.121
Wetland ponds	None	Frozen	70.17713	-152.11
Wetland ponds	None	Frozen	70.25424	-152.186
M0017	NSSB	Frozen	70.10085	-152.133
Wetland ponds	None	Frozen	70.17217	-152.113
Wetland ponds	None	Frozen	70.15845	-151.774
Wetland ponds	None	Frozen	70.15558	-151.81
Wetland ponds	None	Frozen	70.14726	-151.867
Wetland ponds	None	Frozen	70.16142	-151.762
Wetland ponds	NSSB	Frozen	70.12428	-152.078
Wetland ponds	None	Frozen	70.12781	-152.08
Small lake	Not sampled; NSSB possible	Frozen	70.1131	-152.102
Wetland ponds	None	Frozen	70.14187	-151.888

Note: BDWF (broad whitefish); BKFH (Alaska blackfish); GRAY (Arctic grayling); HBWF (humpback whitefish); LSCS (least cisco); NSSB (ninespine stickleback); RDWF (round whitefish); SLSC (slimy sculpin).

Table E.10.3. Willow Project Area Lakes and Fish Species that Occur in the Alternative D Analysis Area*

Lake	Species	Winter Water Status	Latitude	Longitude
M8103	NSSB	Unfrozen	70.29131	-149.916
M8103	NSSB	Unfrozen	70.28761	-149.894
M0235	No fish captured	Unfrozen	70.23704	-152.188
MM1818	No fish captured	Unfrozen	70.29404	-152.225
Small lake	Not sampled; Nearby larger and similar sized lakes do not contain fish	Unfrozen	70.29929	-152.204
Small lake	Not sampled; NSSB possible	Unfrozen	70.03551	-152.195
M1523	NSSB	Unfrozen	70.15469	-152.113
M8104	No fish captured	Unfrozen	70.28623	-149.866
M9525	BDWF, BKFH, HBWF, LSCS, NSSB, RDWF, SLSC	Unfrozen	70.32266	-150.98
L9824	BKFH, GRAY, NSSB	Unfrozen	70.28425	-151.271
M0015	NSSB, GRAY	Unfrozen	70.10824	-152.058
Mine Site	Not sampled; Isolated (fish unlikely)	Frozen	70.28641	-149.887
Wetland ponds	None	Frozen	70.28466	-149.898
Wetland ponds	None	Frozen	70.2754	-150.062
Wetland pond/impoundment	None	Frozen	70.33655	-149.728
Mine Site	Not sampled; Isolated (fish unlikely)	Frozen	70.28669	-149.883
Wetland ponds	None	Frozen	70.27822	-149.911
Wetland ponds	None	Frozen	70.10958	-152.135
N77084	None	Frozen	70.10867	-152.154
Wetland ponds	None	Frozen	70.10967	-152.15
Wetland ponds	None	Frozen	70.11185	-152.15
Wetland ponds	None	Frozen	70.111	-152.139
Wetland ponds	None	Frozen	70.24239	-152.172
Wetland ponds	None	Frozen	70.27549	-152.195
Small lake	No fish captured	Frozen	70.31457	-152.193
Small lake	Not sampled; Nearby larger and similar sized lakes do not contain fish	Frozen	70.30939	-152.196
Small lake	Not sampled; Nearby larger and similar sized lakes do not contain fish	Frozen	70.32664	-152.221
Wetland ponds	None	Frozen	70.28688	-152.222
Small lake	Not sampled; Nearby larger and similar sized lakes do not contain fish	Frozen	70.32082	-152.211
Wetland ponds	None	Frozen	70.20368	-152.105
Wetland ponds	None	Frozen	70.27688	-152.199
Wetland ponds	None	Frozen	70.21493	-152.105
M1522	NSSB	Frozen	70.15288	-152.086
Small pond	NSSB inferred, connected to Lake M1523	Frozen	70.15742	-152.088
M2108	BDWF, NSSB	Frozen	70.2494	-152.179
Wetland ponds	None	Frozen	70.17279	-152.121
Wetland ponds	None	Frozen	70.17713	-152.11
Wetland ponds	None	Frozen	70.25424	-152.186
M0017	NSSB	Frozen	70.10085	-152.133
Wetland ponds	None	Frozen	70.17217	-152.113
Wetland ponds	NSSB	Frozen	70.12428	-152.078
Wetland ponds	None	Frozen	70.12781	-152.08
Small lake	Not sampled; NSSB possible	Frozen	70.1131	-152.102

Note: BDWF (broad whitefish); BKFH (Alaska blackfish); GRAY (Arctic grayling); HBWF (humpback whitefish); LSCS (least cisco); NSSB (ninespine stickleback); RDWF (round whitefish); SLSC (slimy sculpin).

Table E.10.4. Willow Project Area Lakes and Fish Species that Occur in the Alternative E Analysis Area*

Lake	Species	Winter Water Status	Latitude	Longitude
M8103	NSSB	Unfrozen	70.29131	-149.916
M8103	NSSB	Unfrozen	70.28761	-149.894
M0014	No fish captured	Unfrozen	70.11906	-152.063
M0110	No fish captured	Unfrozen	70.20167	-152.118
M0112	NSSB	Unfrozen	70.24747	-152.151
L9911	NSSB	Unfrozen	70.17073	-151.79
M0235	No fish captured	Unfrozen	70.23704	-152.188
M1523	NSSB	Unfrozen	70.15469	-152.113
M8104	No fish captured	Unfrozen	70.28623	-149.866
M9525	BDWF, BKFH, HBWF, LSCS, NSSB, RDWF, SLSC	Unfrozen	70.32266	-150.98
L9824	BKFH, GRAY, NSSB	Unfrozen	70.28425	-151.271
M0015	NSSB, GRAY	Unfrozen	70.10824	-152.058
Mine Site	Not sampled; Isolated (fish unlikely)	Frozen	70.28641	-149.887
Wetland ponds	None	Frozen	70.28466	-149.898
Wetland ponds	None	Frozen	70.2754	-150.062
Wetland pond/impoundment	None	Frozen	70.33655	-149.728
Mine Site	Not sampled; Isolated (fish unlikely)	Frozen	70.28669	-149.883
Wetland ponds	None	Frozen	70.27822	-149.911
Wetland ponds	NSSB, GRAY	Frozen	70.11387	-152.079
Small lake	Not Sampled; NSSB possible	Frozen	70.13882	-152.014
Wetland ponds	None	Frozen	70.15845	-151.774
Wetland ponds	None	Frozen	70.15558	-151.81
Wetland ponds	None	Frozen	70.14726	-151.867
Wetland ponds	None	Frozen	70.16142	-151.762
Wetland ponds	None	Frozen	70.14187	-151.888
Wetland ponds	None	Frozen	70.24239	-152.172
M1522	NSSB	Frozen	70.15288	-152.086
Small pond	NSSB inferred, connected to Lake M1523	Frozen	70.15742	-152.088
M2108	BDWF, NSSB	Frozen	70.2494	-152.179
Wetland ponds	None	Frozen	70.17279	-152.121
Wetland ponds	None	Frozen	70.17713	-152.11
Wetland ponds	None	Frozen	70.25424	-152.186
M0017	NSSB	Frozen	70.10085	-152.133
Wetland ponds	None	Frozen	70.17217	-152.113
Wetland ponds	NSSB	Frozen	70.12428	-152.078
Wetland ponds	None	Frozen	70.12781	-152.08
Small lake	Not sampled; NSSB possible	Frozen	70.1131	-152.102

Note: BDWF (broad whitefish); BKFH (Alaska blackfish); GRAY (Arctic grayling); HBWF (humpback whitefish); LSCS (least cisco); NSSB (ninespine stickleback); RDWF (round whitefish); SLSC (slimy sculpin).

Willow Master Development Plan

Appendix E.11
Birds Technical Appendix

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List of Acronyms

ACP	Arctic Coastal Plain
BLM	Bureau of Land Management
DEW	Distant Early Warning
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	English 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	Burgess, Johnson et al. 2003; Burgess, Johnson et al. 2013; Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Burgess et al. 2004, 2005; Johnson, Parrett et al. 2014; Rozell and Johnson 2016
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]	Burgess, Johnson et al. 2013; Johnson, Burgess et al. 2004; Johnson, Parrett et al. 2015; Johnson, Parrett et al. 2014; Johnson, Wildman et al. 2012, 2013; Mowbray, Cooke et al. 2000
Waterfowl	Brant	*Branta bernicla*	Common	Breeder	ONW, BRWA, SAMA, TFB, TLLC, TLHC, DOWIP, SOW, SOWIP, RS, DPC, YBWC, OBWC, NPWM, PWM, BAR	Burgess, Johnson et al. 2013; 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. 2014; Johnson, Wildman et al. 2012, 2013
Waterfowl	Canada goose	*Branta canadensis*	Common	Breeder	DOW, DOWIP, SOW, SOWIP, SEMA, YBWC, OBWC, NPWM, PWM	Burgess, Johnson et al. 2013; Johnson, Burgess et al. 2004, 2005; Johnson, Parrett et al. 2015; Johnson, Parrett et al. 2014; Rozell and Johnson 2016
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, Burgess et al. 2005; Johnson, Parrett et al. 2015; Johnson, Parrett et al. 2016; Jorgenson 2004; Rothe, Markon et al. 1983
Waterfowl	Gadwall	*Mareca strepera*	Casual	Visitor	NA[d]	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	Burgess, Johnson et al. 2003; Johnson, Burgess et al. 2005
Waterfowl	Northern shoveler	*Spatula clypeata*	Uncommon	Breeder	SEMA, GRMA, NPWM, PWM, MSSM	Burgess, Johnson et al. 2003; Johnson, Burgess, Lawhead, Neville et al. 2003; Rothe, Markon et al. 1983
Waterfowl	Northern pintail	*Anas acuta*	Common	Breeder	SEMA, DPC, NPWM, PWM, MSSM, MTT, TLDS, BAR	Burgess, Johnson et al. 2003; Johnson, Burgess et al. 2004, 2005; Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Johnson, Parrett et al. 2015; Rothe, Markon et al. 1983; Rozell and Johnson 2016
Waterfowl	Green-winged teal	*Anas crecca*	Uncommon	Breeder	SEMA, DPC, PWM, MSSM, MTT, TLDS	Burgess, Johnson et al. 2003; Johnson, Burgess et al. 2004, 2005; Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Rothe, Markon et al. 1983; Rozell and Johnson 2016
Waterfowl	Canvasback	*Aythya valisineria*	Casual	Visitor	NA[d]	Johnson and Herter 1989

Group	English Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
Waterfowl	Greater scaup	*Aythya marila*	Uncommon	Breeder	ONW, SEMA, DPC, GRMA, YBWC, NPWM, PWM, MSSM	Burgess, Johnson et al. 2003; Johnson, Burgess et al. 2004, 2005; Johnson, Burgess, Lawhead, Neville et al. 2003; Lysne, Mallek et al. 2004
Waterfowl	Lesser scaup	*Aythya affinis*	Rare	Breeder	ONW, NPWM	Johnson, Burgess et al. 2004; Lysne, Mallek 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	Burgess, Johnson et al. 2013; Fischer and Larned 2004; Johnson, Burgess et al. 2004, 2005; 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
Waterfowl	Common eider[e]	*Somateria mollissima*	Uncommon	Breeder	ONW, BAR[e]	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 deglandi*	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 unpublished 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]**	**Burgess, Johnson et al. 2013; Burgess, Johnson et al. 2003; Day, Prichard et al. 2005; Fischer and Larned 2004; Johnson, Burgess et al. 2004; Johnson, Burgess, Lawhead, Neville et al. 2003; Rothe, Markon et al. 1983**
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]	Burgess, Johnson et al. 2013; Burgess, Johnson et al. 2003; Day, Prichard et al. 2005; Fischer and Larned 2004; Johnson, Burgess, Lawhead, Neville et al. 2003; Kertell 1996; Rothe, Markon et al. 1983; Rozell and Johnson 2016
Loons and grebes	Common loon	*Gavia immer*	Casual/Accidental	Visitor	NA[d]	–
Loons and grebes	**Yellow-billed loon**	***Gavia adamsii***	**Common**	**Breeder**	**ONW, TLHC, DOW, DOWIP, SOWIP, SEMA, DPC, GRMA, NPWM, PWM, MSSM[f]**	**Day, Prichard et al. 2005; Fischer and Larned 2004; Johnson, Burgess et al. 2004; Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2015; Johnson, Parrett et al. 2016; Rothe, Markon et al. 1983**

Group	English Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
Seabirds	Pomarine jaeger	*Stercorarius pomarinus*	Uncommon	Visitor	NA[d]	Johnson and Herter 1989
Seabirds	Parasitic jaeger	*Stercorarius parasiticus*	Uncommon	Breeder	SEMA, YBWC, OBWC, DPC, NPWM, PWM, MSSM, RICO	Burgess, Johnson et al. 2003; Burgess, Johnson et al. 2013; Day, Prichard et al. 2005; Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014; Jorgenson 2004; Rozell and Johnson 2016
Seabirds	Long-tailed jaeger	*Stercorarius longicaudus*	Uncommon	Breeder	OBWC, NPWM, PWM, MSSM, MTT	Anderson, Lawhead et al. 2001; Burgess, Johnson et al. 2003; Day, Prichard et al. 2005; Johnson, Burgess et al. 2004; Johnson, Burgess, Lawhead, Neville 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 et al. 2004; Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2015; Rozell and Johnson 2016
Seabirds	Herring gull	*Larus argentatus*	Casual/ Accidental	Visitor	NA[d]	Johnson and Herter 1989
Seabirds	Thayer's gull	*Larus thayeri*	Casual/ Accidental	Visitor	NA[d]	Johnson and Herter 1989
Seabirds	Glaucous-winged gull	*Larus glaucescens*	Casual/ Accidental	Visitor	NA[d]	Johnson and Herter 1989
Seabirds	Glaucous gull	*Larus hyperboreus*	Common	Breeder	ONW, BRWA, TFB, TLLC, TLHC, DOWIP, SOW, SOWIP, SEMA, YBWC, OBWC, BAR, DPC	Burgess, Johnson et al. 2003; Burgess, Johnson et al. 2013; Day, Prichard et al. 2005; Fischer and Larned 2004; Johnson, Burgess et al. 2004; Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Parrett et al. 2014
Seabirds	**Arctic tern**	***Sterna paradisaea***	**Common**	**Breeder**	**ONW, SKT, SAMA, TLHC, DOW, DOWIP, SOWIP, SOW, SEMA, DPC, YBWC, OBWC, NPWM, PWM, MSSM**	**Day, Prichard et al. 2005; Fischer and Larned 2004; Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Burgess et al. 2002; Johnson, Burgess et al. 2004; Johnson, Parrett et al. 2015; Johnson, Parrett et al. 2014**
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
Shorebirds	Upland sandpiper	*Bartramia longicauda*	Casual/ Accidental	Visitor	NA[d]	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[d]**	**Johnson and Herter 1989**

Group	English Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
Shorebirds	Stilt sandpiper	*Calidris himantopus*	Common	Breeder	YBWC, OBWC, PWM, NPWM	Andres 1989, 1994; LGL Alaska Research Associates Inc. 1988
Shorebirds	Sanderling	*Calidris alba*	Rare	Visitor	TFB[d]	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[d]	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**	**DUCO, NPWM, MSSM, MTT, TLDS, BAR**	**McCarty, Wolfenbarger et al. 2017**
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[d]	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
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[d]	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[d]	Johnson and Herter 1989
Raptors	Snowy owl	*Bubo scandiacus*	Uncommon	Breeder	OBWC, PWM, NPWM, MSSM, MTT, TLDS	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[d]	Johnson and Herter 1989

Group	English Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
Raptors	Gyrfalcon	*Falco rusticolus*	Rare	Visitor	NA[d]	Johnson, Parrett et al. 2014
Raptors	**Arctic peregrine falcon**	***Falco peregrinus tundrius***	**Uncommon**	**Rare Breeder**	**TLDS, HUMO**	**Frost, Ritchie et al. 2007; Ritchie 2014; White, Clum et al. 2002**
Ptarmigan	Willow ptarmigan	*Lagopus 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; Johnson, Burgess 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	TLDS, 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
Passerines	Redpoll	*Acanthis flammea* and *A. hornemanni*	Uncommon	Breeder	MSSM, TLDS	Johnson and Herter 1989; Knox and Lowther 2000a, 2000b
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: Shading denotes species that may use the analysis area year-round. Bolding denotes Special Status Species.
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 Master Development Plan Environmental Impact Statement, Section 3.9, *Wetlands and Vegetation*, and Table E.11.2.

[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 Project vicinity are listed in the table.

[c] Snow goose colonies tend to be on the coast; they initially colonized river deltas on the Arctic Coastal Plain. They have been expanding inland across a variety of habitats. 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] No records of nesting or no nesting habitat are described for the central Beaufort Sea coast.

[e] Common eiders nest on coastal barrier islands, sandspits, and partially vegetated beaches along the Beaufort Sea coast.

[f] Pacific, red-throated, and yellow-billed loons and red-necked grebes nest on the shorelines of waterbodies; terrestrial habitats in the table refer to the shoreline habitat bordering a waterbody.

1.1.1 Special Status Species

Nine bird species listed as sensitive species by the Bureau of Land Management (BLM) may occur in the analysis area: spectacled eider, Steller's eider, yellow-billed loon, red-throated loon, dunlin (*arcticola* subspecies), bar-tailed godwit, whimbrel, buff-breasted sandpiper, and red knot (BLM 2019). The U.S. Fish and Wildlife Service (USFWS) list of species of conservation concern includes seven species on the BLM list above (spectacled and Steller's eiders are not included as they are listed as threatened under the Endangered Species Act), plus Arctic peregrine falcon and Arctic tern. Of the Special Status Species, Steller's eider is a casual visitor whose former breeding range extended across the Artic Coastal Plain (ACP), until its range contracted with a population-wide decline (Quakenbush, Day et al. 2002). Red knot is a rare to casual visitor. Buff-breasted sandpiper, whimbrel, and peregrine falcon are rare breeders. The remaining species are common to uncommon breeders in the analysis area. Red-throated loons are common breeders in some areas that use polygonal ponds, shallow lakes, brackish water, and wetland complexes for nesting and raising broods (Johnson, Burgess et al. 2004, 2005) and marine waters for feeding (Barr, Eberl et al. 2000). Dunlin is among the top six most common nesting shorebirds in the National Petroleum Reserve in Alaska (NPR-A) (Bart, Brown et al. 2012), and one of the top three migrating along the coast (Taylor, Lanctot et al. 2010). It nests primarily in wet and moist sites in wetlands with ponds and drained lake basins (Bart, Brown et al. 2012; Warnock and Gill 1996) and uses silt barrens during post-breeding (Andres 1994). Bar-tailed godwits are widely distributed but uncommon breeders that nest in lowlands and uplands, in wet to moist sedge or tussock meadows, often in association with dwarf or low shrubs; they use a wide range of habitats (Bart, Brown et al. 2012; McCaffery and Gill 2001). Whimbrels nest in low wetlands and dwarf shrubs from flat to low center or high center polygons (Skeel and Mallory 1996). Whimbrel is a rare breeder, found in low numbers (on 21 of 637 plots) in moist and wet habitats on the ACP (Bart, Brown et al. 2012), and only one was recorded during post-breeding on the Colville River Delta (Andres 1994). Another rare breeder in NPR-A, buff-breasted sandpiper (21 birds recorded on 357 plots; Bart, Brown et al. 2012) is considered an "upland" shorebird and is unique among the shorebirds in this area for its use of dry ridges, stream banks, and dwarf shrub and partially vegetated areas for breeding displays; it nests in drier sloping tundra with tussocks and in moist and wet sedge meadows with nonpatterned or polygonal surface forms (McCarty, Wolfenbarger et al. 2017). Red knots are not known to breed east of Point Barrow on the ACP but can occur along the Beaufort Sea coast during migration (Baker, Gonzalez et al. 2013). Peregrine falcon is a rare breeder on the ACP but will nest on bluffs along streams and lakes in the NPR-A (Ritchie 2014) and uses bridges (J. Parrett, Research Biologist, ABR, to C. Johnson. 2018) and elevated structures (White, Clum et al. 2002), such as the Distant Early Warning (DEW) Line site at Oliktok Point (Frost, Ritchie et al. 2007), for nest sites. Arctic terns are common nesters, are not evenly distributed, and are often found in complex fresh and salt marshes and wetlands or emergent vegetation and islands in deep and shallow lakes (Johnson, Burgess, Lawhead, Neville et al. 2003; Johnson, Burgess et al. 2004, 2005); they use marine waters for feeding and migration (Fischer and Larned 2004). Table E.11.2 shows habitat types used by Special Status Species on the ACP from spring arrival to fall staging. All but three habitat types in the analysis area are used by one or more Special Status Species.

Spectacled eiders occur in the analysis area during pre-breeding in a non-uniform distribution (Figure 3.11.2) and nest in some parts of the analysis area in low densities (Johnson, Shook et al. 2019; Morgan and Attanas 2018). Spectacled eiders are more abundant in coastal areas, where the module delivery facilities are located, than they are in the Willow area. Surveys conducted at 50% coverage for the Willow Master Development Plan Project (Project) detected two groups of spectacled eiders in 2017, five groups in 2018, and five groups in 2019 (Figure 3.11.2), resulting in indicated total densities of 0.015, 0.035, and 0.035 birds per square mile, respectively (0.006, 0.014, and 0.014 birds per square kilometer) (Shook, Parrett et al. 2020), which are within the range of densities recorded on USFWS aerial surveys (Figure 3.11.2). The density of spectacled eiders from those Project surveys is approximately 10% to 30% of densities found on the Colville River Delta and the entire ACP (Figure 4 in Johnson, Parrett et al. 2018a). Densities of pre-breeding spectacled eiders from USFWS surveys of the ACP (USFWS unpublished data) vary from 0 to 0.26 birds per square mile in the area of permanent roads and pads, whereas the module delivery options contain higher densities, ranging from 0 to 0.87 birds per square mile (Figure 3.11.2). Spectacled eiders nest in the Kuparuk Oilfield along the Oliktok Road, near Option 3 (Morgan and Attanas 2018), near Point Lonely (Frost, Ritchie et al. 2007), and probably nest in appropriate habitat at Atigaru Point. Three spectacled eider nests were found in a wetland about 7 miles east of the Bear Tooth drill site 4 (BT4) in 2001 and no spectacled eider nests have been found in the Willow area over the past two years of nest searches focused on king eiders and shorebirds (Rozell, Shook et al. 2021). Whereas the 656-foot (200 meters [m]) disturbance zone is intended to protect spectacled eiders from various types of human disturbance, there is some research that suggests this zone may be larger than necessary to protect nesting eiders. Data collected on spectacled eiders on the Colville River during nesting found that nesting spectacled eiders rarely (7% or 6 of 84 hens on nests) flush at distances greater than 82 feet (> 25 m) from people on foot; the greatest distance at which flushing occurred was 131 feet (40 m) (ABR unpublished data). There are several examples of spectacled eider nests that have hatched and some that have failed < 656 feet (200 m) from active roads and airstrips (Attanas and Shook 2020; Johnson, Parrett et al. 2008; Morgan and Attanas 2018; Seiser and Johnson 2018). An analysis of variance of distance to active infrastructure at Alpine CD3 on the Colville Delta found no significant effects of year, construction phase, or nest fate ($P \geq 0.36$), even though on average, successful nests were closer than failed nests to a road, drill pad, or airstrip (Johnson, Parrett et al. 2008). There was no evidence of displacement or decreased nesting success from before construction to the operation phase of the development.

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), but it lapsed 10 years after adoption. 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 territorial breeders, excluding conspecifics from nesting lakes or portions of very large lakes that are shared by two to four pairs (Johnson, Wildman et al. 2019). They are common breeders in the analysis area; surveys conducted since 2001 have detected 67 breeding territories encompassing 71 lakes in the portion of the analysis area within the NPR-A (Johnson, Parrett et al. 2018b, 2019; Parrett and Shook 2021). 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); they nest most often on islands, peninsulas, and shorelines protected from wave action (Haynes, Schmutz et al. 2014; North and Ryan 1989). Citing a lack of population growth, a patchy breeding distribution, specific habitat requirements for breeding lakes, high fidelity to and retention rates of breeding territories, and low rates of colonization of unoccupied lakes in their range, several studies have suggested that yellow-billed loons are habitat limited (Haynes, Schmutz et al. 2014; Johnson, Wildman et al. 2019; Schmutz, Wright et al. 2014).

1.1.2 Bird Habitats

Bird habitat types and use in the analysis area is detailed in Table E.11.1. Table E.11.2 ranks habitat types in order of number of species reported to use them (i.e., species richness) from literature and reports. Table E.11.3 summarizes preferred pre-breeding and all nesting habitat types documented for spectacled eiders in the NPR-A and the adjacent Colville River Delta. The ranking is an index of the importance of the various habitat types to the avian community as a whole, although not all the species on the list may occur in the analysis area, or some may occur sporadically. While species richness can be related to abundance (i.e., the habitat types with more species also tend to support higher numbers, particularly for nesting), species richness is not equivalent to abundance or density. Some habitat types with low species richness may be crucial to some species for important facets of life history. For example, tidal flat barrens on the ACP are important feeding areas for post-breeding and pre-migratory shorebirds that support thousands to tens of thousands of shorebirds during late summer (Andres 1994; Taylor, Lanctot et al. 2010). Another habitat type used by two species, Dune Complex, is one of several habitat types that can include stream banks, barren or partially vegetated ridges and dunes, and uplands, which are used by male buff-breasted sandpipers for leks (i.e., breeding display areas). All but two habitat types in the analysis area are used by one or more Special Status Species.

Table E.11.2. Descriptions and Use of Bird Habitats in the Analysis Area

Habitat[a]	Description	Special Status Species Use	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	Yes	2	1,838.8
Riverine Complex	Mosaic of moist to wet sedge and shrub types, water, and barrens along flooded streams and associated floodplains	Yes	3	1,702.5
River or Stream	Permanently flooded channels large enough to be mapped as separate units	No	4	8,197.8
Salt-Killed Tundra	Coastal low-lying areas where salt water from storm surges has killed the original vegetation and is being colonized by salt-tolerant vegetation	Yes	3	434.4
Tapped Lake with Low-Water Connection	Same as Tapped Lake with High-Water Connection except connected to adjoining surface waters even at low water	No	5	2,234.2
Human Modified[b]	Area with vegetation, soil, or water significantly disturbed by human activity	Yes	7	4,103.9
Tidal Flat Barrens	Nearly flat, barren mud or sand periodically inundated by tidal waters; may include small areas of partially vegetated mud or sand	Yes	7	131.8
Brackish Water	Coastal ponds and lakes that are flooded periodically by salt water during storm surges	Yes	10	205.8
Tapped Lake with High-Water Connection	Lakes that were breached and drained by a migrating river channel and permafrost thaw; tapped lakes are subject to river stages and discharge and are connected only during flood or high-water events	Yes	10	4,547.7
Shallow Open Water without Islands	Waterbody lacking emergent vegetation with depths less than 6.6 feet (2 m)	Yes	11	10,609.1
Barren	Area without vegetation and not normally inundated	Yes	12	10,254.9
Deep Open Water without Islands	Waterbody lacking emergent vegetation with a depth of at least 6.6 feet (2 m) and lacking islands or polygonized margins	Yes	12	34,743.9
Deep Open Water with Islands or Polygonized Margins	Waterbody with depths of at least 6.6 feet (2 m) with islands or with polygonized wetlands forming a complex shoreline	Yes	14	25,366.2
Shallow Open Water with Islands or Polygonized Margins	Waterbody lacking emergent vegetation with depths less than 6.6 feet (2 m) with islands or polygonized wetlands forming a complex shoreline (Willow Master Development Plan Environmental Impact Statement, Section 3.9, *Wetlands and Vegetation*)	Yes	14	7,482.9
Grass Marsh	Ponds and lake margins with the emergent grass *Arctophila fulva* (pendant grass); shallow water depths (less than 3.3 feet [1 m]); tends to have abundant invertebrates, good escape cover for birds, and is of high importance to many waterbirds	Yes	15	1,922.7
Moist Tussock Tundra	Gentle slopes and ridges of coastal deposits and terraces, pingos, and the uplifted centers of older drained lake basins; vegetation is dominated by tussock-forming plants, most commonly *Eriophorum vaginatum*; associated with high-centered polygons of low or high relief	Yes	18	134,610.2
Salt Marsh	Complex assemblage of small brackish ponds, halophytic sedges and willows, and barren patches on stable mudflats usually associated with river deltas	Yes	21	1,280.5
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 Sedge Marsh and Grass Marsh	Yes	21	4,608.5
Open Nearshore Waters	Shallow estuaries, lagoons, and embayments along the Beaufort Sea coast	Yes	22	91,980.9
Deep Polygon Complex	Area permanently flooded with water more than 1.6 feet (0.5 m) deep, frequently with emergent sedge in margins, deep polygon centers, and well-developed polygon rims	Yes	25	1,317.9
Sedge Marsh	Permanently flooded waterbodies dominated by the emergent sedge *Carex aquatilis*; typically, emergent sedges occur in water < 1.6 feet (0.5 m) deep	Yes	25	9,174.6
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	Yes	27	35,913.6
Tall, Low, or Dwarf Shrub	Both open and closed stands of low (≤4.9 feet [1.5 m] high) and tall (>4.9 feet [1.5 m] high) willows along riverbanks and *Dryas* tundra on upland ridges and stabilized sand dunes	Yes	27	26,796.0

Habitat[a]	Description	Special Status Species Use	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 m]) but generally free of surface water during summer	Yes	36	104,580.4
Nonpatterned Wet Meadow	Analogous to Sedge Meadow or Shrub Meadow; lowland areas, typically flooded in spring but lacking polygons or other terrain relief features	Yes	39	30,086.3
Patterned Wet Meadow	Lowland areas with low-centered polygons that are flooded in spring and 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	Yes	44	68,913.7
Total High Use Acres		NA	NA	374,652.3
Unmapped	Unknown	Unknown	Unknown	566,836.3
Total	**NA**	NA	**NA**	**1,189,875.3**

Source: See sources for Table E.11.1.

Note: 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.

m (meters); NA (not applicable).

[a] More information on these habitat types is provided in Willow Master Development Plan Environmental Impact Statement, Section 3.9.

[b] Used by one Special Status Species, peregrine falcon, and several species of passerines, raptors, and shorebirds that nest on structures or gravel.

Table E.11.3. Spectacled Eider Habitat Preference and Use

Habitat	NE NPR-A Pre-breeding Use (%)[a]	NE NPR-A Pre-breeding Availability (%)	NE NPR-A Pre-breeding Preference[b]	Colville Pre-breeding Use (%)[a]	Colville Pre-breeding Availability (%)	Colville Pre-breeding Preference[b]	NE NPR-A Nesting[c] Use (%)	Colville Nesting[c] Use (%)
Open Nearshore Water[d]	**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	**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	**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	–	–
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: Bolding denotes preference during pre-breeding or use during nesting. "–" (no data); NA (not applicable); NE NPR-A (northeast National Petroleum Reserve in Alaska); ns (not significant). Totals may be up to 0.2 due greater or less due to rounding.

[a] Use = (groups / total groups) × 100.

[b] Significance calculated from 1,000 simulations at $\alpha = 0.05$; avoid = significantly less use than availability, ns = not significant (use proportional to availability), prefer = significantly greater use than availability for pre-breeding eider groups recorded on aerial surveys (Johnson, Parrett et al. 2018a, 2019).

[c] Not all habitats were available in nest search areas; different areas were searched in different years; therefore, total availability of habitat is not presented. Habitats used by nesting spectacled eiders (n = 173 nests) on the Colville River Delta and in the NE NPR-A (n = 11 nests) were collected across multiple study sites (Johnson, Burgess et al. 2014).

[d] Post-breeding habitat is included because it is essential during post-fledging, pre-molting, and migration.

1.2 Comparison of Alternatives: Birds*

Effects to birds are detailed by habitat type and action alternative in Tables E.11.4 through E.11.11.

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	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)
Unmapped Area	NA	0.0	0.0	0.0	0.0
Dune Complex	2	0.9	0.7	0.7	1.0
Riverine Complex	3	0.9	0.9	0.8	0.5
River or Stream	4	0.6	0.3	0.5	0.6
Salt-Killed Tundra	4	0.0	0.0	0.0	0.0
Tapped Lake with Low-Water Connection	5	0.0	0.0	0.0	0.0
Human Modified	7[b]	0.4	0.4	0.4	0.3
Tidal Flat Barrens	7	0.0	0.0	0.0	0.0
Brackish Water	10	0.0	0.0	0.0	0.0
Tapped Lake with High-Water Connection	10	0.0	0.0	0.0	0.0
Shallow Open Water without Islands	11	2.7	2.5	3.1	2.4
Barren	12	0.8	0.1	0.5	0.8
Deep Open Water without Islands	12	0.0	0.3	0.0	0.0
Deep Open Water with Islands or Polygonized Margins	14	0.0	0.0	0.0	0.0
Shallow Open Water with Islands or Polygonized Margins	14	0.3	1.0	2.7	0.2
Grass Marsh	15	0.0	0.5	0.0	0.0
Moist Tussock Tundra	18	278.1	287.1	270.2	254.5
Salt Marsh	21	0.0	0.0	0.0	0.0
Young Basin Wetland Complex	21	0.1	0.0	0.1	0.1
Open Nearshore Waters	22	0.0	0.0	0.0	0.0
Deep Polygon Complex	25	0.0	0.0	0.0	0.0
Sedge Marsh	25	3.7	11.5	8.1	3.2
Old Basin Wetland Complex	27	26.5	39.9	23.9	18.9
Tall, Low, or Dwarf Shrub	27	26.2	23.1	41.1	24.1
Moist Sedge-Shrub Meadow	36	61.4	71.2	49.6	47.0
Nonpatterned Wet Meadow	39	16.0	31.1	19.2	11.1
Patterned Wet Meadow	44	65.6	75.2	62.1	64.7
Total high-use acres (> 20 species)	**NA**	**199.4**	**252.0**	**204.1**	**168.3**
Total acres	**NA**	**484.2**	**545.8**	**483.1**	**428.6**

Note: NA (not applicable). Numbers may differ slightly with other reported values in the Willow Master Development Plan Environmental Impact Statement due to rounding. Acres of habitat lost is presented for bird habitats only; thus, the total gravel footprint may differ from the 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 the risk of collisions with vehicles (possible negative effect).

Table E.11.5. Acres of Bird Habitats Permanently Altered by Excavation*

Habitat	Habitat Use (1 to 44 species)[a]	Constructed Freshwater Reservoir[b]	Tiŋmiaqsiuġvik Mine (Alternatives B)	Tiŋmiaqsiuġvik Mine (Alternatives C and D)	Tiŋmiaqsiuġvik Mine (Alternatives E)
Deep Open Water without Islands	12	1.5	0.0	0.0	0.0
Moist Tussock Tundra	18	0	72.4	119.1	68.0
Sedge Marsh	25	0.0	1.4	1.8	1.4
Tall, Low, or Dwarf Shrub	27	1.6	0.0	1.9	0.0
Moist Sedge-Shrub Meadow	36	4.6	40.9	62.1	40.9
Nonpatterned Wet Meadow	39	7.0	0.0	0.0	0.0
Patterned Wet Meadow	44	1.7	4.8	4.9	4.8
Total high-use acres (> 20 species)	**NA**	**14.9**	**47.1**	**70.7**	**47.1**
Total acres	**NA**	**16.4**	**119.5**	**189.8**	**115.1**

Note: NA (not applicable). Acres apply to all action alternatives; habitat would be altered to become water habitat. Acres of habitat altered is presented for bird habitats only; thus, the total excavation footprint may differ from the total direct habitat alteration, as some areas may not be bird habitat. Numbers may differ slightly with other reported values in the Willow Master Development Plan Environmental Impact Statement due to rounding.
[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]Alternatives B, C, and D only; there would be no constructed freshwater reservoir under Alternative E.

Table E.11.6. 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	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)
Unmapped Area	NA	0.0	0.0	0.0	0.0
Dune Complex	2	11.4	8.3	8.3	11.4
Riverine Complex	3	16.6	20.5	15.5	12.1
River or Stream	4	13.9	8.5	10.5	13.8
Salt-Killed Tundra	4	0.0	0.0	0.0	0.0
Tapped Lake with Low-Water Connection	5	0.0	0.0	0.0	0.0
Human Modified	7[b]	1.1	1.1	1.1	0.1
Tidal Flat Barrens	7	0.0	0.0	0.0	0.0
Brackish Water	10	0.0	0.0	0.0	0.0
Tapped Lake with High-Water Connection	10	0.0	0.0	0.0	0.0
Shallow Open Water without Islands	11	35.1	32.6	23.1	28.2
Barren	12	10.3	2.5	6.8	9.7
Deep Open Water without Islands	12	11.8	17.8	11.5	14.9
Deep Open Water with Islands or Polygonized Margins	14	7.2	4.4	7.2	11.0
Shallow Open Water with Islands or Polygonized Margins	14	18.3	16.9	20.9	14.3
Grass Marsh	15	0.1	0.8	0.1	2.1
Moist Tussock Tundra	18	1,581.5	1,715.4	1,269.9	1,397.4
Salt Marsh	21	0.0	0.0	0.0	0.0
Young Basin Wetland Complex	21	1.3	1.8	1.3	1.0
Open Nearshore Waters	22	0.0	0.0	0.0	0.0
Deep Polygon Complex	25	0.0	0.0	0.0	0.0
Sedge Marsh	25	62.5	69.4	38.4	60.2
Old Basin Wetland Complex	27	262.8	293.3	175.7	174.1
Tall, Low, or Dwarf Shrub	27	277.4	235.2	277.4	210.7
Moist Sedge-Shrub Meadow	36	405.0	363.7	264.3	311.9
Nonpatterned Wet Meadow	39	165.1	168.7	154.5	111.7

Habitat	Habitat Use (1 to 44 species)[a]	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)
Patterned Wet Meadow	44	567.0	505.9	404.3	469.2
Total high-use acres (> 20 species)	**NA**	**1,741.1**	**1,638.0**	**1,315.9**	**1,338.8**
Total acres	**NA**	**3,448.4**	**3,466.8**	**2,690.8**	**2,853.8**

Note: NA (not applicable). Acres of habitat altered is presented for bird habitats only; thus, the total dust shadow may differ from the total indirect habitat alteration, as some areas may not be bird habitat. Acreage is located within 100 meters of gravel infrastructure.
[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. 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	Alternative E: Four-Pad Alternative
Unmapped Area	NA	0.0	0.0	0.0	0.0
Dune Complex	2	15.8	11.8	11.8	15.7
Riverine Complex	3	60.6	68.5	50.5	45.6
River or Stream	4	170.2	166.9	172.3	169.5
Salt-Killed Tundra	4	0.0	0.0	0.0	0.0
Tapped Lake with Low-Water Connection	10	1.2	1.2	1.2	1.2
Human Modified	7[b]	171.6	171.6	189.2	155.9
Tidal Flat Barrens	7	0.0	0.0	0.0	0.0
Brackish Water	10	0.0	0.0	0.0	0.0
Tapped Lake with High-Water Connection	10	32.6	32.6	32.6	32.6
Shallow Open Water without Islands	11	325.8	330.7	324.8	291.5
Barren	12	180.8	172.1	177.1	180.5
Deep Open Water without Islands	12	352.7	376.3	371.7	432.1
Deep Open Water with Islands or Polygonized Margins	14	167.3	160.2	178.0	148.5
Shallow Open Water with Islands or Polygonized Margins	14	141.7	143.7	155.3	127.6
Grass Marsh	15	39.5	40.3	37.0	32.1
Moist Tussock Tundra	18	6,472.0	6,941.5	6,330.4	5,858.5
Salt Marsh	21	44.4	44.4	44.4	44.3
Young Basin Wetland Complex	21	144.5	145.0	142.9	154.6
Open Nearshore Waters	22	0.0	0.0	0.0	0.0
Deep Polygon Complex	25	79.5	79.5	79.5	82.7
Sedge Marsh	25	391.3	397.8	330.7	317.1
Old Basin Wetland Complex	27	1,499.4	1,575.9	1,438.8	1,323.3
Tall, Low, or Dwarf Shrub	27	1,026.6	976.9	978.1	821.9
Moist Sedge-Shrub Meadow	36	3,498.9	3,463.9	3,114.0	3,120.2
Nonpatterned Wet Meadow	39	1,188.9	1,207.9	1,201.3	1,120.5
Patterned Wet Meadow	44	2,937.2	2,965.5	2,803.1	2,561.4
Total high-use acres (by >20 species)	**NA**	10,810.7	10,856.8	10,132.8	9,546.0
Total acres	**NA**	18,942.5	19,474.2	18,164.7	17,037.3

Note: NA (not applicable). Disturbance zone estimated as 656 feet (200 meters) beyond the perimeter of gravel infrastructure, pipelines, Oliktok Dock improvements, and screeding (summer 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 the risk of collisions with vehicles (possible negative effect).

Table E.11.8. 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	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
Freshwater ice infrastructure (vegetation damage and soil compaction) (acres)	4,557.3	5,608.0	7,164.8	4,026.8	859.6	1,756.1	666.6
Multi-season ice pads (acres)[a]	30.0	30.0	30.0	30.0	0.0	0.0	0.0
Freshwater use (millions of gallons)	1,662.4	1,914.3	2,286.3	1,478.7	307.9	572.0	257.2

[a] Acres of multi-season ice pads are also included in the total ice infrastructure in row 1.

Table E.11.9. Estimated Numbers of Birds of the Focal Species in the 656-Foot (200-meter) Disturbance Zone around Project Infrastructure*

Species	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access Road	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
Spectacled eider	2.2	2.3	2.2	2.2	NA	NA	< 0.1
Yellow-billed loon	6.3	6.5	6.0	5.8	NA	NA	< 0.1

Note: NA (not applicable, disturbance zone is in marine waters). Eider calculations in the Willow area are based on average density (0.028 eiders per square mile) / detection error (0.75) × total area (square miles) from Table E.11.6. Eider calculations in the Kuparuk area are based on the average density (0.165 eiders per square mile) with the same detection error (0.75). Average densities in the Willow area are from Shook, Parrett et al. 2020 and in Kuparuk from Attanas and Shook 2020; detection error is from Wilson, Stehn et al. 2017. Yellow-billed loon calculations are based on average density (0.21 loons per square mile) × total area (square miles) from Table E.11.6. Detection error is unavailable for yellow-billed loons. The average density in the analysis area is from Shook, Parrett et al. 2020.

Table E.11.10. 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	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
Nests (unique sites) within 1 mile of infrastructure	25	23	24	19	ND	ND	ND
Number of lakes with nests within 1 mile of infrastructure	11	10	10	8	ND	ND	ND
Number of breeding lakes (with nests or broods) within 1,625 feet (495 m) of infrastructure	6	6	5	4	ND	ND	ND
Number of additional lakes with adults (not associated with nests or broods) within 1,625 ft of infrastructure	6	6	7	5	ND	ND	ND

Sources: Johnson, Parrett et al. (2019), Shook, Parrett et al. (2020); additional data on nests from Bureau of Land Management and U.S. Fish and Wildlife Service registry.
Note: m (meters); ND (no data). Distances of 1 mile from a nest and 1,625 feet from an occupied lake are stipulated as no development areas in required operating procedure E-11. Multiple unique nest sites may occur, usually in different years, on any one lake within 1 mile of proposed infrastructure.

Table E.11.11. Acres of Spectacled Eider Preferred Habitat Affected by Action Alternative and Module Delivery Option*

Effect	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
Direct habitat loss	111.1	150.6	111.0	97.3	0.0	0.0	1.2
Direct habitat alteration (excavation)	15.2	15.2	15.2	4.8	0.0	0.0	0.0
Indirect habitat alteration (dust shadow)	1,068.7	1,042.1	794.7	826.4	0.0	0.0	4.8[a]
Disturbance zone[b]	6,940.8	7,105.6	6,791.0	6,385.3	0.0	0.0	2.0

Note: Preferred habitats are described in Table E.11.3.

[a] For areas where existing roads would be widened, calculations did not include the existing road's dust shadow.

[b] 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

January 2023

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List of Acronyms

ACP	Arctic Coastal Plain
BLM	Bureau of Land Management
CAH	Central Artic Herd
EIS	Environmental Impact Statement
GMT	Greater Mooses Tooth
GMT-1	Greater Mooses Tooth 1
IAP	Integrated Activity Plan
km^2	square kilometers
LS	lease stipulations
m	meters
NPR-A	National Petroleum Reserve in Alaska
Project	Willow Master Development Plan Project
ROP	required operating procedure
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 20 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*.

1.1.1 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 the availability of anthropogenic food (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 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 National Petroleum Reserve in Alaska (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; Welch, Prichard et al. 2021). 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.

1.1.3 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) and regularly occur as far downstream as Ocean Point, south of Nuiqsut (Zhou, Tape et al. 2020). In late spring, parturient cows often disperse into smaller drainages of the Colville, Chandler, Itkillik, and Anaktuvuk rivers to calve. A portion of the moose population may disperse short distances away from the primary river drainages onto the tundra to utilize the beaded streams and shallow lakes during summer (Klimstra and Daggett 2020). Moose have been recorded sporadically near Fish Creek and Judy (Kayyaaq and Iqalliqpik) Creek in the Willow area (Lawhead, Prichard et al. 2009; Lawhead, Prichard, Macander et al. 2014; Welch, Prichard et al. 2021).

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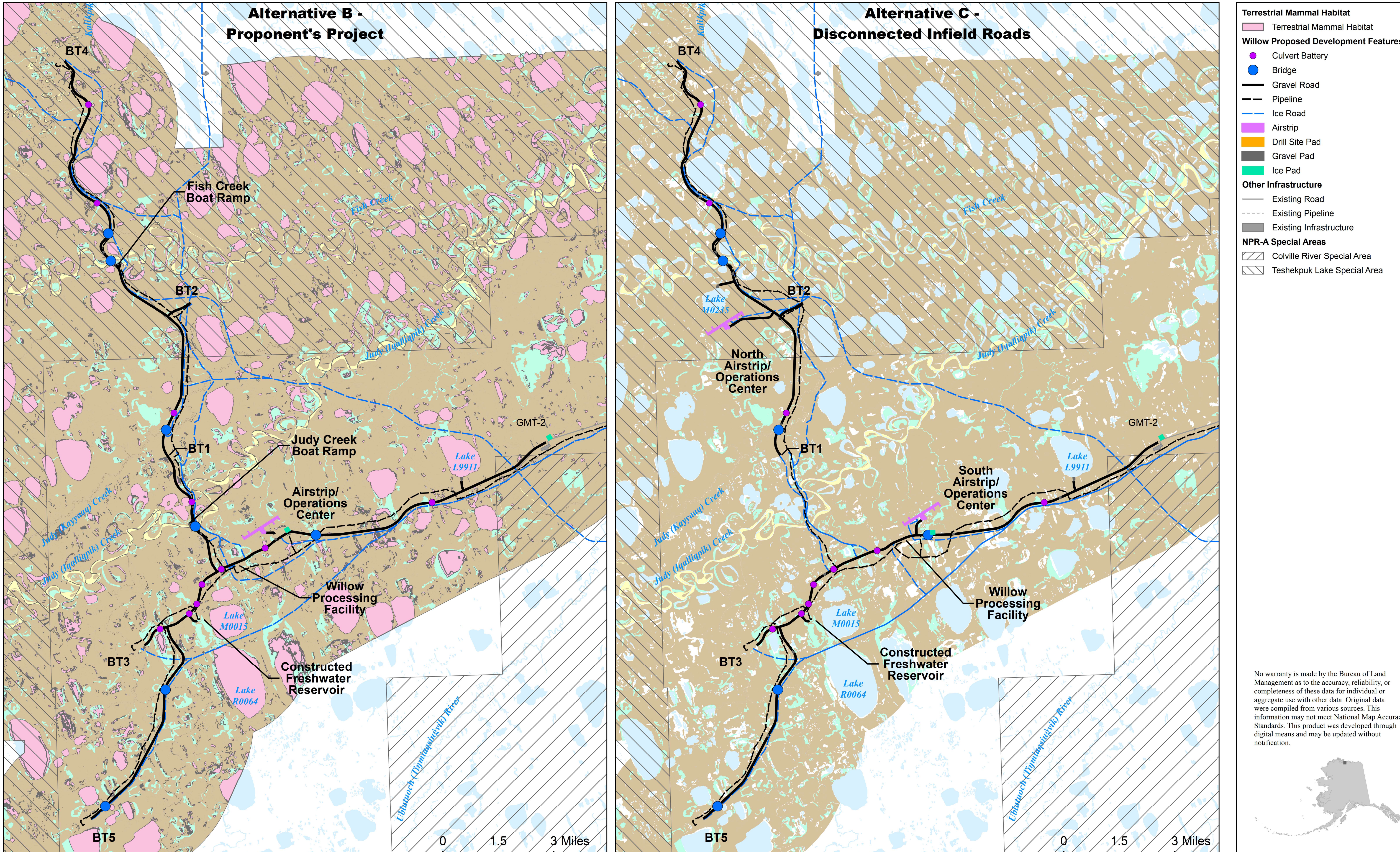

Figure E.12.1A

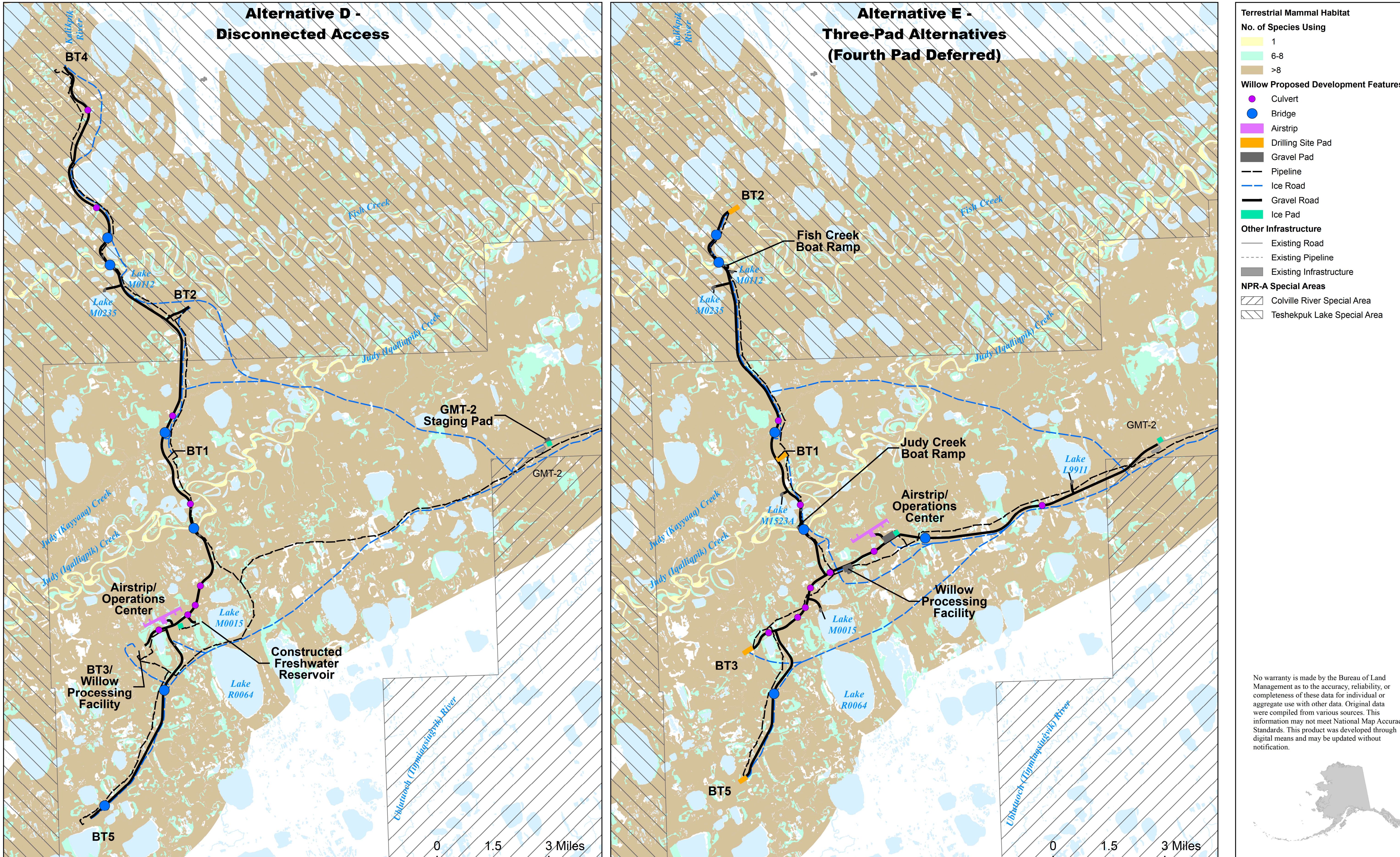

Figure E.12.1B

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, SAMA 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, SEMA, SAMA	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
Canada lynx	*Lynx canadensis*	TLDS, especially along riverine corridors	Very rare, recent sightings near Willow Project, increasing abundance along Colville River, cyclical population.	Tape, Christie et al. 2016; Welch, Prichard et al. 2022
Caribou	*Rangifer tarandus*	Foraging: MSSM, MTT, TLDS, OBWC, YBWC, PWM, RICO Insect relief: BAR, HUMO, SKT, RICO, DUCO, TFB, SAMA	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, SEMA, SAMA	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, SAMA	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, SEMA, SAMA	Uncommon; in habitats supporting lemmings and voles but fluctuating in abundance with those species	Bee and Hall 1956; MacDonald and Cook 2009
Moose	*Alces americanus*	TLDS	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; groups rarely observed near the Project area	Arthur and Del Vecchio 2009, 2013b; Danks and Klein 2002; Gustine, Barboza et al. 2011; Wilson and Klein 1991; Lenart 2015c
Muskrat	*Ondatra zibethicus*	RS, GRMA, SAMA	Unknown distribution or abundance, multiple sightings near Nuiqsut	BLM 2019; MacDonald and Cook 2009
Root/tundra vole	*Microtus oeconomus*	Wetter habitats than singing vole: OBWC, YBWC, PWM, NPWM, MTT, RICO, SEMA, SAMA	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

Common Name	Scientific Name	Habitat Use	Relative Abundance in Analysis Area	References
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, SEMA, SAMA	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); GRMA (Grass Marsh); 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); RS (River or Stream); SAMA (Salt Marsh); SEMA (Sedge Marsh); SKT (Salt-Killed Tundra); TFB (Tidal Flat Barrens); TLDS (Tall, Low, or Dwarf Shrub); YBWC (Young Basin Wetland Complex). Habitats are defined in Section 3.9, *Wetlands and Vegetation*, and Table E.12.2 below. Habitat use is depicted in Figure E.12.1.

1.1.4 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 Creek drainage (Jonah Nukapigak, Nuiqsut resident, personal communication to CPAI. June 6, 2018). Two groups were observed west of the Colville River in 2021 (Welch, Prichard et al. 2022). The current population is reportedly stable or slowly increasing (Arthur and Del Vecchio 2013a; Lenart 2021) and 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).

1.1.5 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).

1.1.6 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).

1.1.7 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.

1.1.8 Canada Lynx*

Lynx were first observed during Alaska Department of Fish and Game moose surveys along the Colville River in 1998 (Tape, Christie et al. 2016). This and subsequent observations document the northern range expansion of lynx as a result of the range expansion of snowshoe hare (*Lepus americanus*), the principal prey of lynx (Tape, Christie et al. 2016). Multiple lynx were observed in the oilfields east of the Project or along the lower Colville River during 2021 (Welch, Prichard et al. 2022). These sightings included a lynx crossing the Ublutuoch

(Tiŋmiaqsiuġvik) River north of the GMT-1 road in late June 2021 (J. McFarland, Owl Ridge Inc., pers. comm., Welch, Prichard et al. 2022). On the ACP, lynx are most likely to use areas with tall shrubs where snowshoe hares are more likely to be present, but lynx have cyclical populations and individual lynx will disperse long distances across many types of habitats (Vanbianchi, Gaines et al. 2018). Snowshoe hares require a mean riparian shrub height of at least 4.1–4.5 feet (1.24–1.36 meters [m]) to provide adequate browse (Tape, Christie et al. 2016), so the recent climate-related increase in shrubs in the Arctic has allowed snowshoe hare to expand its range north. Snowshoe hare observations occurred as far north as the Colville River Delta by 1993.

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
Grass Marsh	Ponds and lake margins with the emergent grass *Arctophila fulva* (pendant grass). Shallow water depths (less than 3.3 feet).	1
Rivers and Streams	Permanently flooded channels large enough to be mapped as separate units.	1
Tidal Flat Barrens	Nearly flat, barren mud or sand periodically inundated by tidal waters; may include small areas of partially vegetated mud or sand	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
Sedge Marsh	Permanently flooded waterbodies dominated by the emergent sedge *Carex aquatilis*. Typically, emergent sedges occur in water < 1.6 feet deep.	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
Salt Marsh	Complex assemblage of small brackish ponds, halophytic sedges and willows, and barren patches on stable mudflats usually associated with river deltas.	10
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.	12
Tall, Low, or Dwarf Shrub	Woody plants that are smaller than trees and have several main stems arising at or near the ground.	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 Master Development Plan 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)	Muskrat	Canada Lynx	No. Species Using Habitat
Barren	IR	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Grass Marsh	–	–	–	–	–	–	–	–	–	–	–	–	–	U	–	1
Rivers and Streams	–	–	–	–	–	–	–	–	–	–	–	–	–	U	–	1
Salt-Killed Tundra	IR	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Tidal Flat Barrens	IR	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1
Human Modified	IR	–	–	F, D	F, D	–	–	–	–	–	–	–	–	–	–	3
Nonpatterned Wet Meadow	–	–	–	–	–	–	–	U	–	–	U	U	U	–	–	6
Sedge Marsh	–	–	–	–	–	–	–	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
Salt Marsh	IR	–	–	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	–	–	U	13
Moist Sedge-Shrub Meadow	F	F	–	F, D	F, D	U	U	–	U	–	–	U	U	–	–	12

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 Applicable Lease Stipulations and Required Operating Procedures*

All the existing lease stipulations (LS) and required operating procedures (ROPs) 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 LS and ROPs that would apply to Project actions on Bureau of Land Management (BLM) managed lands and are intended to mitigate impacts to terrestrial mammals from development activity (BLM 2022). The LS and ROPs 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. In 2021, BLM was directed to reevaluate the 2020 NPR-A Integrated Activity Plan (IAP). The NPR-A IAP re-evaluation resulted in the issuance of a new NPR-A IAP Record of Decision. Full text of the requirements is provided in BLM (2022).

Table E.12.4. Summary of Required Operating Procedures Intended to Mitigate Impacts to Terrestrial Mammals*

ROP	Description or Objective	Requirement/Objective
ROP 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.
ROP 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.	Lessees/permittees shall prepare and implement a comprehensive waste management plan for all phases of exploration and development, including seismic activities. The plan shall be submitted to the AO for approval, as part of a plan of operations or other similar permit application. Waste generation shall be addressed in the following order of priority: 1) prevention and reduction, 2) recycling, 3) treatment, and 4) disposal. The plan shall consider the following requirements: a. The plan shall identify precautions that are to be taken to avoid attracting wildlife to food and garbage. b. Requirements prohibit the burial of garbage. Users shall have a written procedure to ensure that the handling and disposal of putrescible waste will be accomplished in a manner that prevents the attraction of wildlife. All putrescible waste shall be incinerated, backhauled, or composted in a manner approved by the AO. All solid waste, including incinerator ash, shall be disposed of in an approved waste-disposal facility. The burial of human waste is prohibited. c. BLM requires all pumpable solid, liquid, and sludge waste be disposed of by injection in accordance with EPA, DEC, and AOGCC regulations and procedures. d. BLM prohibits wastewater discharges or disposal of domestic wastewater into bodies of water, including wetlands, unless authorized by a National Pollutant Discharge Elimination System or State permit.
ROP A-8	Minimize conflicts resulting from interaction between humans and bears during oil and gas activities.	Lessees will prepare and implement bear-interaction plans to minimize conflicts between bears and humans. These plans shall include measures to: a. Minimize attraction of bears to the drill sites. b. Organize layout of buildings and work sites to minimize human-bear interactions. c. Warn personnel of bears near or on work sites and identify proper procedures to be followed. d. Establish procedures, if authorized, to discourage bears from approaching the work site. e. Provide contingencies in the event bears do not leave the site or cannot be discouraged by authorized personnel. f. Discuss proper storage and disposal of materials that may be toxic to bears. g. Provide a systematic record of bears on the work site and in the immediate area.

ROP	Description or Objective	Requirement/Objective
ROP C-1	Protect grizzly bear, polar bear, and marine mammal denning and/or birthing locations.	a. Grizzly bear dens: Cross-country use of vehicles, equipment, and oil and gas activity is prohibited within 0.5 mile of occupied grizzly bear dens, unless protective measures are approved by BLM. b. Polar bear dens: Cross-country use of vehicles, equipment, and oil and gas activity is prohibited within 1 mile of known or observed polar bear dens, unless alternative protective measures are approved by BLM. c. To limit disturbance around known polar bear dens, implement the following: 1. Onshore activities in known or suspected polar bear denning habitat during the denning season (approximately November to April) must make efforts to locate occupied polar bear dens. All observed or suspected polar bear dens must be reported to USFWS prior to the initiation of activities. 2. Permittees must observe a 1-mile operational exclusion zone around all known polar bear dens during the denning season (or until the female and cubs leave the areas). Should previously unknown occupied dens be discovered, work must cease and USFWS must be contacted for guidance. Potential actions may range from cessation or modification of work to conducting additional monitoring. 3. Use the den habitat map developed by USGS. 4. Restrict activity timing to limit disturbance around dens. d. To limit disturbance of activities to seal lairs in the nearshore area (< 9.8-foot water depth): 1. Prior to the initiation of winter seismic surveys on marine ice, the permittee will conduct a sound source verification test approved by BLM and NMFS. 2. For all activities: i. Maintain airborne sound levels of equipment below 100 db re 20 µPa at 66 feet. ii. On-ice operations after May 1 will employ a full-time protected species observer on vehicles to ensure that all basking seals are avoided by vehicles by at least 500 feet and will ensure that all equipment with airborne noise levels are operating at distances from observed seals that allow for the attenuation of noise to levels below 100 decibels. iii. Sea ice trails must not be greater than 12 feet wide. iv. No unnecessary equipment or operations will be placed or used on sea ice.
ROP 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 AO. The plan shall consider: a. Locations outside the active flood plain. b. Design of gravel mine sites within active flood plains to serve as water reservoirs for future use. c. Potential use of the site for enhancing fish and wildlife habitat. d. Potential storage and reuse of sod/overburden for the mine site or at other disturbed sites on the North Slope.
ROP E-9	Avoidance of human-caused increases in populations of predators of ground nesting birds.	a. Lessee shall use best available technology to prevent facilities from providing nesting, denning, or shelter sites for ravens, raptors, and foxes. The lessee shall provide the AO with an annual report on the use of facilities by ravens, raptors, and foxes as nesting, denning, and shelter sites. b. Feeding wildlife is prohibited.
ROP M-4	Minimize loss of individuals of, and habitat for, mammalian species designated as Sensitive by BLM in Alaska.	If a development is proposed in an area that provides potential habitat for the Alaska tiny shrew, the development proponent would conduct surveys at appropriate times of the year and in appropriate habitats in an effort to detect the presence of the shrew. The results of these surveys will be submitted to BLM with the application for development.

Source: BLM 2022

Note: AO (authorized officer); AOGCC (Alaska Oil and Gas Conservation Commission); BLM (Bureau of Land Management); DEC (Alaska Department of Environmental Conservation); EPA (U.S. Environmental Protection Agency); ROP (required operating procedure); USGS (U.S. Geological Survey).

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 Habitat Loss or Alteration

Alternative B would permanently remove 619.8 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. The mine site pit and CFWR (Alternatives B, C, and D) 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 3,448.4 acres of terrestrial mammal habitats within 328 feet (100 m) of gravel infrastructure (3,120.5 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 ROP 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 Creek and Judy (Kayyaaq and Iqalliqpik) Creek are suitable for bear dens in the analysis area. Ongoing coordination with agency biologists monitoring radio-collared bears in the region would provide precise 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). Wolves are also likely to avoid areas of human activity. Changes in wolf and wolverine distribution as well as the presence of development, could alter harvest effort and locations for these species. Changes in caribou distribution could have indirect effects of wolf and wolverine distribution.

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. Collision rates for terrestrial mammals in the Alpine and GMT developments from 2015 to June 2021 ranged from one to seven collisions per year with a total of 25 reported collisions. Collisions were mostly with foxes (16 red foxes, 3 arctic foxes, and 3 unknown species of fox), but collisions with one wolverine, one muskrat, and one caribou were also reported. 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 and near Deadhorse. 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; therefore, if red foxes have access to anthropogenic food, it could result in an increase in red fox numbers and a decline of Arctic fox numbers. Increases in mortality of **ungulate** calves by 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 ROPs 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 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 or Option*

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	Alternative E: Three-Pad Alternative (Fourth Pad Alternative)	Option 3: Colville River Crossing
Unmapped Area	NA	554,264.5	0	0	0	0	0
Barren	1	10,253.3	0.8	0.1	0.5	0.8	0
Grass Marsh	1	1,922.4	0	0.5	0	0	0
Rivers and Streams	1	8,198.0	0.6	0.3	0.5	0.6	0
Salt-Killed Tundra	1	434.2	0	0	0	0	0
Tidal Flat Barrens	1	131.8	0	0	0	0	0
Human Modified	3[b]	4,103.2	0.4	0.4	0.4	0.3	1.0
Nonpatterned Wet Meadow	6	30,084.9	23.0	38.1	26.2	11.0	0.4
Sedge Marsh	6	9,174.0	5.1	13.3	9.9	4.6	0
Dune Complex	7	1,838.6	0.9	0.7	0.7	1.0	0
Riverine Complex	8	1,721.5	0.9	0.9	0.8	0.5	0
Young Basin Wetland Complex	9	4,608.6	0.1	0	0.1	0.1	0
Moist Tussock Tundra	10	134,697.4	350.5	406.2	389.4	322.5	0.8
Old Basin Wetland Complex	10	35,914.2	26.5	39.9	23.9	18.9	0.4
Patterned Wet Meadow	10	68,916.6	72.1	81.8	68.7	68.8	0.5
Salt Marsh	10	1,282.9	0	0	0	0	0
Tall, Low, or Dwarf Shrub	12	26,795.0	27.8	26.6	44.6	24.1	0
Moist Sedge-Shrub Meadow	13	104,599.9	106.9	137.9	116.3	87.9	1.9
Total high-use habitat acres	**NA**	376,814.6	**583.9**	**692.4**	**643.0**	**522.3**	**3.6**
Total acres	**NA**	998,941.0	**615.6**	**746.7**	**682.0**	**541.1**	**5.0**

Note: NA (not applicable). All action alternatives include acres lost from the mine site. Options 1 and 2 would not result in habitat loss for terrestrial mammals and are not included in this table. Total acres of terrestrial mammal habitat loss may differ from total gravel footprint because not all areas that would be filled are used by terrestrial wildlife.

[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 or Option*

Habitat	Habitat Value (1 to 13)[a]	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 3: Colville River Crossing
Unmapped Area	NA	0	0	0	0	2.2
Barren	1	10.3	2.5	6.8	9.7	0
Grass Marsh	1	0.1	0.8	0.1	2.1	0
Rivers and Streams	1	13.9	8.5	10.5	13.8	0
Human Modified	3[b]	1.1	1.1	1.1	0.1	0
Nonpatterned Wet Meadow	6	165.1	168.7	154.5	111.7	1.0
Sedge Marsh	6	62.5	69.4	38.4	60.2	0
Dune Complex	7	11.4	8.3	8.3	11.4	0
Riverine Complex	8	16.6	20.5	15.5	12.1	0.1
Young Basin Wetland Complex	9	1.3	1.8	1.3	1.0	0

Habitat	Habitat Value (1 to 13)[a]	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 3: Colville River Crossing
Moist Tussock Tundra	10	1,581.5	1,715.4	1,269.9	1,397.4	6.4
Old Basin Wetland Complex	10	262.8	293.3	175.7	174.1	0.7
Patterned Wet Meadow	10	567.0	505.9	404.3	469.2	3.0
Salt Marsh	10	0	0	0	0	<0.1
Tall, Low, or Dwarf Shrub	12	277.4	235.2	277.4	210.7	0.4
Moist Sedge-Shrub Meadow	13	405.0	363.7	264.3	311.9	13.6
Total high-use habitat acres	**NA**	**3,095.0**	**3,115.3**	**2,392.9**	**2,564.3**	**24.1**
Total acres	**NA**	**3,376.0**	**3,395.1**	**2,628.1**	**2,785.4**	**27.4**

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). Options 1 and 2 would not result in habitat alteration by dust, gravel spray, thermokarsting, or impoundments for terrestrial mammals and are not included in this table. Total acres altered by dust may differ among resources because not all habitats are used by all resources (e.g., birds use different habitats than terrestrial mammals, and thus the total acres affected would be different).

[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. 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	Alternative E: Three-Pad Alternative (Fourth Pad Deferred)	Option 1: Proponent's Module Transfer Island	Option 2: Point Lonely Module Transfer Island[a]	Option 3: Colville River Crossing	Analysis Area
Spring migration	1.13	1.17	1.03	0.88	<0.01	<0.01	<0.01	6.01
Calving	0.66	0.69	0.61	0.48	<0.01	<0.01	<0.01	9.87
Calving (maternal females only)	0.60	0.61	0.54	0.42	<0.01	<0.01	<0.01	11.87
Post-calving	0.48	0.50	0.43	0.31	<0.01	<0.01	<0.01	13.07
Mosquito season	0.20	0.20	0.19	0.09	0.01	<0.01	<0.01	15.36
Oestrid fly season	0.86	0.89	0.79	0.61	0.01	<0.01	<0.01	10.26
Late summer	1.48	1.53	1.36	1.12	0.01	<0.01	<0.01	8.07
Fall migration	1.48	1.52	1.32	1.18	<0.01	<0.01	<0.01	6.88
Winter	1.12	1.16	1.00	0.92	<0.01	<0.01	<0.01	5.27

Source: ABR Inc. 2022

Note: < (less than). 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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Willow Master Development Plan

Appendix E.13
Marine Mammals Technical Appendix

January 2023

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List of Acronyms

ASAMM	Aerial Surveys of Arctic Marine Mammals
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BWASP	Bowhead Whale Aerial Survey Project
CRD	Colville River Delta
dB	decibels
dBA	A-weighted decibels
dB re 1 μPa	decibels referenced to 1 microPascal
CBS	Chukchi/Bering Sea
DPS	distinct population segment
EIS	Environmental Impact Statement
Hz	hertz
kHz	kilohertz
km	kilometers
m	meter
MLLW	mean lower low water
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service
NPRW	North Pacific right whale
Project	Willow Master Development Plan Project
rms	root-mean-square
SBS	Southern Beaufort Sea
TL	transmission loss
USDOT	U.S. Department of Transportation
USFWS	U.S. Fish and Wildlife Service

1.0 MARINE MAMMALS

This appendix contains additional information on species and applicable underwater noise concepts and methodologies used in the development of the Willow Master Development Plan Project (Project) Environmental Impact Statement (EIS), Section 3.13, *Marine Mammals*.

1.1 Marine Mammals and Critical Habitats Protected under the Endangered Species Act

Descriptions of marine mammals that may be affected by the Project are summarized below, full descriptions are in Bureau of Land Management (BLM) (2019b, 2020), Bureau of Ocean Energy Management (BOEM) (2018), and National Marine Fisheries Service (NMFS) (2016).

1.1.1 Baleen Whales

1.1.1.1 Blue Whale

There are two stocks of blue whales (*Balaenoptera musculus*) in the North Pacific: the Eastern North Pacific stock and the Western/Central North Pacific stock. Individuals from both stocks may be found in Alaska. Blue whales primarily eat krill and generally occur in areas with high concentrations of krill. Blue whales feed at the surface and at depths over 328.1 feet (100 meters [m]). This may be tied to coastal upwelling that creates high concentrations of phytoplankton (Bailey, Mate et al. 2009) or because of vertical movements of prey through the water column (NMFS 2018a). Foraging habitat for the Western/Central North Pacific stock includes areas southwest of Kamchatka, south of the Aleutians, and in the Gulf of Alaska during the summer months (Stafford 2003). For the Eastern North Pacific stock, the U.S. west coast is one of the most important feeding areas in summer and fall; feeding to the north and south of this area has increased in recent years (Carretta, Forney et al. 2018). Blue whales could be encountered along the barge transit route in the Gulf of Alaska and the southern Bering Sea. They have not been reported in the Chukchi or Beaufort seas and thus would not occur near Oliktok Dock.

There is no critical habitat designated for blue whales.

1.1.1.2 Bowhead Whales*

There are four stocks of bowhead whale (*Balaena mysticetus*) recognized globally by the International Whaling Commission, but only the Western Arctic stock, also referred to as the Bering-Chukchi-Beaufort stock or the Bering Sea stock, is found in Alaskan waters (Muto, Helker et al. 2021). Bowhead whales could be encountered along the barge transit route in fall as they migrate west across the Beaufort and Chukchi seas (Muto, Helker et al. 2021).

NMFS' 2016 Effects of Oil and Gas Activities in the Arctic Ocean: Final Environmental Impact Statement provided a detailed analysis of bowhead whale distribution in the Beaufort Sea during summer-fall aerial surveys through the Bowhead Whale Aerial Survey Project (BWASP) (NMFS 2016). That analysis is incorporated here by reference. BWASP was funded by the Minerals Management Service/BOEM and BLM annually from 1979 to 2010 to study the autumn migration of bowhead whales through the Alaskan Beaufort Sea. Although the project was aimed toward understanding bowhead whales, data were collected on all marine mammals sighted. In 2007, the NMFS National Marine Mammal Laboratory began coordinating BWASP. In 2011, an interagency agreement between BOEM and the National Marine Mammal Laboratory combined BWASP with the Chukchi Offshore Monitoring in Drilling Area project, which employed aerial surveys for marine mammals in the Chukchi Sea, under the auspices of a single survey called Aerial Surveys of Arctic Marine Mammals (ASAMM) (Clarke, Christman et al. 2012).

Results from the ASAMM surveys show that bowhead whales generally migrate to the east in spring, generally prior to when barges would be transiting the analysis area (Clarke, Brower et al. 2020). Bowhead whales have been reported all summer in Harrison Bay, although they generally remain outside of the barrier islands in waters over 65 feet (20 m) in depth. Results from the ASAMM surveys indicated that the mean water depth preferred by bowhead whales during summer in the western Beaufort Sea between 2012 and 2017 was 200 feet (61 m) and the mean distance from shore was 21 miles (34 kilometers [km]) (Clarke, Brower et al. 2020). In the fall, data indicated that the mean distance from shore from 1989 through 2018 was 19.7 miles (31.7 km) in the western Beaufort Sea (Clarke, Brower et al. 2020). Although bowhead whales have been seen closer to shore and near

Oliktok Dock on occasion, they are not expected to be near Oliktok Dock due to the area's shallow waters and the general preference of bowhead whales to occupy deeper waters.

There is no critical habitat designated for bowhead whales.

1.1.1.3 Fin Whale

Fin whales (*Balaenoptera physalus*) of the Northeast Pacific stock can be found in the Chukchi Sea, in the Sea of Okhotsk, around the Aleutian Islands, and in the Gulf of Alaska (Muto, Helker et al. 2021). Surveys conducted along the Bering Sea shelf indicated fin whales were the most common large whale sighted, with whales distributed in an area of high productivity along the edge of the eastern Bering Sea continental shelf and in the middle shelf area (Friday, Waite et al. 2012; Friday, Zerbini et al. 2013; Springer, McRoy et al. 1996). Fin whales feed on krill, small schooling fish (e.g., herring, capelin, sand lance), and squid in summer. The whales fast in the winter while they migrate to warmer waters. Fin whales could be encountered along the barge transit route in the Gulf of Alaska and the Bering and Chukchi seas. Fin whales have not been reported in the Beaufort Sea, and thus would not occur near Oliktok Dock.

There is no critical habitat designated for fin whales.

1.1.1.4 Humpback Whale*

Three distinct population segments (DPSs) of humpback whale (*Megaptera novaeangliae*) occur in Alaska: the Western North Pacific DPS, the Mexico DPS, and the Hawaii DPS. Research indicates movement between winter and spring locations off Asia, including several island chains in the western North Pacific, primarily to Russia, as well as the Bering Sea and the Aleutian Islands during the summer months (Muto, Helker et al. 2021). The Mexico DPS of humpback whale winters in Mexico and migrates to diverse feeding areas. Summer feeding areas for this DPS include the Aleutian Islands; the Bering, Chukchi, and Beaufort seas; the Gulf of Alaska; southeast Alaska and northern British Columbia; southern British Columbia and Washington; and Oregon and California. Humpback whales could be encountered along the barge transit route in the Bering and Chukchi seas; there is a very low potential for encounters in the Beaufort Sea as there are only a few sightings of humpback whales east of Point Barrow. Humpback whales are not expected to occur near Oliktok Dock.

The National Marine Fisheries Service (NMFS) issued a final rule designating critical habitat for the endangered Western North Pacific DPS and the Mexico DPS in Alaska waters in 2021, partially encompassing the southernmost extent of the barge transit route near Dutch Harbor (86 FR 21082). Threats and vulnerabilities identified for this stock of humpback whales include natural and anthropogenic factors such as shipping traffic, military sonars, harmful algal blooms (Geraci, Anderson et al. 1989), climate change–related changes in prey distribution, fishing equipment entanglements, vessel strikes, and oil and gas–related activities (Muto, Helker et al. 2021).

1.1.1.5 North Pacific Right Whale

Historically, and prior to commercial whaling activities, North Pacific right whales (NPRWs) (*Eubalaena japonica*) were found in the Gulf of Alaska, the eastern Aleutian Islands, the south-central Bering Sea, the Sea of Okhotsk, and the Sea of Japan (Muto, Helker et al. 2021). The majority of NPRW sightings have occurred from approximately 40 degrees north to 60 degrees north latitude. Most sightings of right whales in the past 20 years have been in the southeastern Bering Sea, with a few in the Gulf of Alaska (Muto, Helker et al. 2021). NPRWs could be encountered along the barge transit route in the Bering Sea. There is critical habitat for NPRW in the barge transit route, but the route will be designed to avoid critical habitat. NPRWs have not been reported in the Beaufort Sea and thus will not occur near Oliktok Dock.

Critical habitat for NPRWs was designated in 2006 and is located in the Gulf of Alaska and the Bering Sea (NMFS 2006). Principal habitat requirements for right whales are areas of dense concentrations of prey, such as large species of zooplankton (Clapham, Shelden et al. 2006). Potential threats to right whale habitat are linked to commercial shipping and fishing vessel activity. Fishing activity increases the risk of entanglement, while shipping activities increase the risk of vessel strikes and oil spills in right whale habitat.

1.1.1.6 Gray Whale

Two stocks of gray whale (*Eschrichtius robustus*) occur in Alaska—the Western North Pacific stock and the Eastern North Pacific stock. They feed during the summer and fall in the Okhotsk Sea off northeastern Sakhalin

Island, Russia, and southeastern Kamchatka in the Bering Sea (Muto, Helker et al. 2021). Some gray whales observed feeding off Sakhalin and Kamchatka migrate during winter to the west coast of North America in the eastern North Pacific while others migrate to areas off Asia in the western North Pacific (Muto, Helker et al. 2021). The western stock of gray whale could be encountered along the barge transit route in the Bering and Chukchi seas. The gray whales reported in the Beaufort Sea are likely from the eastern stock of gray whale, which are not listed. Therefore, the western stock will not occur near Oliktok Dock.

There is no critical habitat designated for gray whales.

1.1.2 Toothed Whales

1.1.2.1 Sperm Whale

Sperm whales (*Physeter macrocephalus*) are one of the most widely distributed marine mammal species; however, their population was depleted by commercial whaling over a period of more than 100 years. The North Pacific stock of sperm whales is widely distributed in the North Pacific, generally south of latitude 62 degrees north (Muto, Helker et al. 2021). Extensive numbers of female sperm whales have been documented in the western Bering Sea and the Aleutian Islands (Ivashchenko, Brownell Jr et al. 2014; Mizroch and Rice 2006). Males have been found in the Gulf of Alaska, the Bering Sea, and the waters around the Aleutian Islands in summer (Ivashchenko, Brownell Jr et al. 2014; Mizroch and Rice 2013). Sperm whales could be encountered along the barge transit route in the Gulf of Alaska and Bering Sea. They have not been reported in the Chukchi or Beaufort seas, so they will not occur near Oliktok Dock.

There is no critical habitat designated for sperm whales.

1.1.3 Pinnipeds

1.1.3.1 Bearded Seal*

The Bering Sea stock of bearded seals (*Erignathus barbatus*) (Muto, Helker et al. 2021) are benthic feeders, preferring relatively shallow waters with drifting pack ice, where they feed on clams, shrimp, crabs, squid, and fish (Kovacs 2009). Hence, bearded seals typically prefer water depths of 80 to 250 feet (24 to 76 m) in the Beaufort Sea (Stirling, Kingsley et al. 1982). Bearded seals are closely associated with sea ice, and they prefer ice that is constantly in motion, which naturally creates open areas of water. They prefer broken, drifting pack ice but also use bottom-fast ice (Burns 1983; Kelly 1988).

During winter, bearded seals sometimes concentrate around consistently open leads in the ice and near the edge of pack ice (Kovacs 2009). Sea ice is important for reproduction, molting, and breeding (Cameron, Bengtson et al. 2010). Bearded seals pup on ice in late April or early May, mate after pups are weaned two to three weeks later, and molt in May and June (Kelly 1988). The primary predator of bearded seals is the polar bear.

As seasonal sea-ice cover retreats in the spring, bearded seals travel northward from the Bering Sea to the Chukchi and Beaufort seas and then back to the Bering Sea in fall and winter, when the ice begins to form again (Cameron, Bengtson et al. 2010). Bearded seals are less common in the Beaufort Sea, where only a few overwinter (Burns 1983; MacIntyre, Stafford et al. 2013). Most of the population disperses widely throughout northern Alaska waters in the open-water season, when some move into the Beaufort Sea (Burns 1983). Suitable habitat in the Beaufort Sea appears to be more limited than in the Chukchi Sea, which supports a higher rate of productivity than the Beaufort Sea (Bengston, Hiruki-Raring et al. 2005).

During the open-water season, bearded seals have been documented in Harrison Bay offshore from the Project, albeit in much lower numbers than ringed seals (LGL Alaska Research Associates Inc. 2008, 2011; Tetra Tech EC Inc. 2005, 2006, 2007); and a few bearded seals have been documented in the waters near Oliktok Point (LGL Alaska Research Associates Inc. 2008, 2011). Bearded seals are uncommon in the shallow waters near the Colville River Delta (CRD) because they tend to prefer drifting ice offshore (Seaman 1981).

NMFS designated critical habitat off the Alaska coast for the bearded seal Beringia distinct population segment in the waters of the Bering, Chukchi, and Beaufort seas on April 1, 2022 (87 FR 19232). Bearded seal critical habitat includes marine waters within the Bering, Chukchi, and Beaufort seas, extending from the nearshore boundary, defined by the 9.8-foot (3-meters) isobath relative to mean lower low water (MLLW), to varying offshore limits within the U.S. economic exclusion zone. The easternmost coastal boundary is along the Alaska/Canada border, and the southernmost coastal boundary is near the mouth of the Kolovinerak River.

Physical and biological features identified as essential to the conservation of the bearded seal and used to determine the extent of bearded seal critical habitat in the Bering, Chukchi, and Beaufort seas include:

1. Sea ice habitat suitable for whelping and nursing, which is defined as areas with waters 656 feet (200 meters) or less in-depth containing pack ice of at least 25% concentration and providing bearded seals access to those waters from the ice.
2. Sea ice habitat suitable as a platform for molting, which is defined as areas with waters 656 feet (200 meters) or less in-depth containing pack ice of at least 15% concentration and providing bearded seals access to those waters from the ice.
3. Access to primary prey resources to support bearded seals which are found in waters 656 feet (200 meters) or less in depth containing benthic organisms, including epifaunal and infaunal invertebrates, and demersal fishes.

1.1.3.2 Ringed Seal*

The Arctic stock of ringed seals (*Pusa hispida*) (Muto, Helker et al. 2021) typically inhabit waters greater than 16 feet (4.9 m) deep. Thus, they are not abundant in the nearshore waters immediately off the CRD and barrier islands but are more common farther offshore in Harrison Bay (Seaman 1981). Ringed seals can winter on bottom-fast ice (Kelly, Bengtson et al. 2010), a habitat not used by other seal species. Ringed seals are strongly associated with sea ice; thus, changes in ice conditions influence their movements, foraging, reproductive behavior, and vulnerability to predation (Kelly, Bengtson et al. 2010). Arctic ringed seals use sea ice for resting, pupping, and molting; they rarely come ashore (Kelly, Badajos et al. 2010; Kelly, Bengtson et al. 2010).

Ringed seals move northward as ice cover recedes, spend summer far offshore (over 100 miles in some years), and return southward as ice advances in fall (Seaman 1981). Ringed seals forage in the open sea on fish, crustaceans, zooplankton, and invertebrates (Harwood, Smith et al. 2012; Kovacs 2007). The ringed seal is the primary prey species for polar bears and also is preyed on by Arctic foxes.

In 2014, NMFS published a proposed rule to designate critical habitat for the Arctic subspecies of ringed seal in the northern Bering, Chukchi, and Beaufort seas (NMFS 2014). In 2021, NMFS issued a revision to the proposed designation (86 FR 1452).

NMFS designated critical habitat off the Alaska coast for the ringed seal Arctic subspecies in waters of the Bering, Chukchi, and Beaufort seas on April 1, 2022 (87 FR 19232). Ringed seal critical habitat generally includes marine waters within the Bering, Chukchi, and Beaufort seas, extending from the nearshore boundary, defined by a 9.8-foot (3-meter) isobath relative to MLLW, to varying offshore limits within the U.S. economic exclusion zone. The easternmost coastal boundary is along the Alaska-Canada border, and the southernmost coastal boundary is near Cape Romanzof.

The features identified as essential to the conservation of the ringed seals and used to determine the extent of ringed seal Critical Habitat in the Bering, Chukchi, and Beaufort seas (87 FR 19232) include:

1. Snow-covered sea-ice habitat suitable for the formation and maintenance of subnivean birth lairs used for sheltering pups during whelping and nursing, which is defined as waters 9.8 feet (3 meters) or more in depth (relative to MLLW) containing areas of seasonal landfast (shorefast) ice or dense, stable pack ice, that have undergone deformation and contain snowdrifts of sufficient depth to form and maintain birth lairs (typically at least 1.8 feet [54 cm] deep);
2. Sea-ice habitat suitable as a platform for basking and molting, which is defined as areas containing sea ice of 15% or more concentration in waters 9.8 feet (3 meters) or more in depth (relative to MLLW); and
3. Access to primary prey resources to support Arctic ringed seals, which are defined to be small, often schooling, fishes, in particular Arctic cod, saffron cod, and rainbow smelt; and small crustaceans, in particular, shrimps and amphipods.

1.1.3.3 Steller Sea Lion

Steller sea lion (*Eumetopias jubatus*) habitat extends around the North Pacific Ocean rim from northern Japan, the Kuril Islands and the Okhotsk Sea, through the Aleutian Islands and the Bering Sea, along Alaska's southern coast, and south to California (Figure 16; Muto, Helker et al. 2021). The western DPS breeds on rookeries in Alaska, from Prince William Sound west through the Aleutian Islands. There are more than 100 haulout and rookery sites within the Steller sea lion range in western Alaska, with centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands. Outside of the breeding season, during late May to early July, large numbers of individuals, both male and female, disperse widely. Steller sea lions are commonly found from nearshore habitats to the continental shelf and slope (Muto, Helker et al. 2018). Steller sea lions will be encountered in the southern part of the barge transit route along the Aleutian Islands and the Bering Sea. They do not inhabit the Chukchi or Beaufort seas, so they will not occur near Oliktok Dock.

Designated critical habitat includes all of the major Steller sea lion rookeries and major haulouts identified in the listing notice (NMFS 1993) and associated terrestrial, air, and aquatic zones. Critical habitat includes a terrestrial zone that extends 3,000 feet (0.9 km) landward from each major rookery and major haulout and an air zone that extends 3,000 feet (0.9 km) above the terrestrial zone of each major rookery and major haulout. For each major rookery and major haulout located west of 144 degrees west, critical habitat includes an aquatic zone (or buffer) that extends 20 nautical miles (37 km) seaward in all directions. Critical habitat also includes three large offshore foraging areas: the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area (NMFS 1993). NMFS has also prohibited vessel entry within 3 nautical miles (6.5 km) of all Steller sea lion rookeries west of 150 degrees west. At the time of preparation of the Supplemental EIS, NMFS was reviewing existing Steller sea lion critical habitat to consider any new and pertinent sources of information since the 1993 designation.

The portion of the barge transit route near Dutch Harbor is located within designated critical habitat.

1.1.4 Other Marine Mammals

1.1.4.1 Northern Sea Otter

The southern barge transit route near Dutch Harbor, Unalaska, is within the range of the Southwest Alaska DPS (Southwest DPS) of northern sea otter (*Enhydra lutris kenyoni*). Northern sea otters occur in nearshore coastal waters along the U.S. north Pacific Rim, from the Aleutian Islands to California (USFWS 2014b). The Southwest DPS occurs along the western shore of lower Cook Inlet; throughout the Alaska Peninsula and Bristol Bay coasts; and along the Aleutian, Barren, Kodiak, and Pribilof islands (USFWS 2014b). Northern sea otters are non-migratory and occur year-round in nearshore coastal waters, typically within 131.2 feet (40 m) of depth to maintain consistent access to benthic foraging habitat (Riedman and Estes 1990). Although individuals can cover long distances, greater than (>) 160 miles (> 100 km), movement is generally restricted by geography, energy requirements, and social behavior, and individuals tend to remain within a home range of less than (<) 11.6 square miles (<30 square km; Riedman and Estes 1990; Garshelis and Garshelis 1984).

The Eastern Aleutian critical habitat unit also occurs in the southern barge transit route near Dutch Harbor. The critical habitat is characterized as all the nearshore marine environment, ranging from the mean high tide line to the 65.6-foot (20-m) depth contour as well as waters occurring within 328.1 feet (100 m) of the mean high tide line (74 FR 51988).

1.1.4.2 Polar Bear

Denning habitat is an important factor for success of polar bears (*Ursus maritimus*), and it is a parameter often used to describe effects to the species. Polar bears may den on land or on ice. Only pregnant females den during the winter, typically entering the den in October or November and leaving in late March or April (Lentfer and Hensel 1980). Males and nonbreeding females remain active through the winter. Terrestrial dens are excavated in compacted snowdrifts adjacent to coastal banks of barrier islands and mainland bluffs, river or stream banks, and other areas with steep topographic relief to catch drifting snow (Durner, Amstrup et al. 2003). Between Utqiaġvik (Barrow) and the Kavik River (east of Prudhoe Bay), 95% of dens occupied by radio-collared bears were located within 5 miles (8 km) of the coast (Durner, Douglas et al. 2009); historical reports of dens found by other methods demonstrate some females den farther inland (Durner, Fischbach et al. 2010; Seaman 1981).

Polar bear critical habitat was designated by the U.S. Fish and Wildlife Service (USFWS) in 2011 (75 FR 76086). The three units of critical habitat in the analysis area (Figure 3.13.1) are as follows:

- **Sea-Ice Critical Habitat:** Used for feeding, breeding, denning, and movements; comprises U.S. territorial waters extending from the mean high-tide line seaward over the continental shelf to the 984-foot (300-m) depth contour.
- **Terrestrial Denning Critical Habitat:** Occurs along the northern coast of Alaska, where there are coastal bluffs or riverbanks suitable for capturing and retaining snowdrifts of sufficient depth to sustain maternal dens through winter, as described by Durner et al. (2001). Between the Kavik River and Utqiaġvik, terrestrial denning critical habitat occurs within 5 miles (8 km) of the mainland coast.

- **Barrier Island Critical Habitat:** Used for denning, refuge from human disturbance, and movements along the coast; comprises barrier islands and associated mainland spits, includes a "no disturbance zone" extending 1 mile (1.6 km) around all designated barrier-island habitat. (The no disturbance zone does not automatically preclude Project activities from occurring within it.)

Existing human-made structures and the land on which they were located on the effective date of the final critical habitat designation (75 FR 76086) are excluded from critical habitat. In addition, seven specific areas were excluded: the communities of Utqiaġvik and Kaktovik and five U.S. Air Force radar sites—Point Barrow, Point Lonely, Oliktok Point, Bullen Point, and Barter Island.

Because of topography and the distribution of suitable habitat characteristics across the landscape, not all portions of terrestrial denning critical habitat are suitable for denning. Thus, the U.S. Geological Survey mapped common denning habitat characteristics to describe suitable potential terrestrial denning habitat (Blank 2012; Durner, Amstrup et al. 2001; Durner, Simac et al. 2013) along the Beaufort Sea coast, as shown in Figures 3.13.1 and 3.13.2.

The analysis area is populated by the Southern Beaufort Sea (SBS) and Chukchi/Bering Sea (CBS) stocks of polar bears, which are classified as depleted under the Marine Mammal Protection Act (MMPA) and listed as threatened under the ESA (USFWS 2021a, 2021b). Polar bears occur in low densities throughout their range, and life-history characteristics including high longevity, late maturity, and few offspring, as well as remote habitat, contribute to difficulty in obtaining accurate abundance estimates (USFWS 2019a, 2019b).

The SBS and CBS populations have experienced substantial depletion because of overharvest in the 1960s, and have since undergone periodic cycles of growth and decline. Bromaghin, McDonald et al. (2015) estimated the SBS stock to be composed of 907 animals in 2010, based on consistent population declines since 1986 (USFWS 2017). In 2010, the USFWS reported a CBS stock population estimate of 2,000 individuals based on extrapolation of aerial survey and den detection data collected during the late 1990s; however, updated population modeling performed by Regehr et al. (2018) estimated an abundance of 2,937 bears (95% confidence interval [CI] = 1,552–5,944).

The SBS stock abundance is believed to be steadily declining because of negative impacts of sea ice loss on habitat availability and body condition (USFWS 2017). Although the CBS stock has experienced additional pressure from high harvest rates in Russia (Regehr, Hostetter et al. 2018; USFWS 2010), recent work by Regehr, Hostetter et al. (2018) demonstrates average-to-high reproductive parameters for the CBS stock since 1986, which suggests the population may be experiencing a productive trend.

1.2 Marine Mammals Protected under the Marine Mammal Protection Act

1.2.1 Baleen Whales

1.2.1.1 Minke whale

There are two stocks of minke whale (*Balaenoptera acutorostrata*) in U.S. waters: the Alaska stock and the California/Oregon/Washington stock. The Alaska stock is relatively common in the Bering and Chukchi seas through fall and in the inshore waters of the Gulf of Alaska (Muto, Helker et al. 2019). They are scattered throughout coastal, middle shelf, and outer shelf/slope oceanographic domains and appear to be migratory in the northern regions. No human mortality or serious injury of minke whales was reported to NMFS and a population estimate is not available for the stock. Minke whales feed by side-lunging into schools of prey (plankton, krill, small schooling fish). Minke whales could be encountered along the barge transit route in the Gulf of Alaska, and the Bering and Chukchi seas. They have not been reported in the Beaufort Sea, so they will not occur near Oliktok Dock.

1.2.2 Toothed Whales

1.2.2.1 Baird's beaked whale

Baird's beaked whales (*Berardius bairdii*) are the largest members of the beaked whale family and are found throughout the North Pacific Ocean. There are two stocks defined in the U.S.: the California/Oregon/Washington stock and the Alaska stock. In the Bering Sea and the Okhotsk Sea, Baird's beaked whales arrive in April–May, are observed throughout the summer, and decrease by October (Muto, Helker et al. 2019). Their winter distribution is unknown, although they have been acoustically detected from November through January in the northern Gulf of Alaska. They prefer cold, deep oceanic waters but may also be found nearshore along continental shelves. They make long, deep dives lasting from 11 to 30 minutes, diving to depths of 2,500 to 4,000 feet (762 to 1,219 m), feeding on deep sea fish, crustaceans, and cephalopods. Baird's beaked whales could be encountered along the barge transit route in the Gulf of Alaska and the Bering Sea. They have not been reported in the Chukchi or Beaufort seas, so they will not occur near Oliktok Dock.

1.2.2.2 Beluga Whale

Beluga whales (*Delphinapterus leucas*) in Arctic Alaska belong to the Beaufort Sea stock or the Eastern Chukchi Sea stock (Muto, Helker et al. 2021). They use waters in the eastern Beaufort Sea but stay farther offshore than bowhead whales, typically beyond the shelf break (Hauser, Laidre et al. 2014). Spring migration eastward through the Beaufort Sea is stock specific, with the Beaufort Sea stock migrating in spring (April and May) and Eastern Chukchi Sea stock migrating in summer (June and July; Suydam, Lowry et al. 2001). The Beaufort Sea stock continues on to Canadian waters, spending the summer in the eastern Beaufort Sea, the Mackenzie River Estuary, Amundsen Gulf, M'Clure Strait, and Viscount Melville Sound (Hauser, Laidre et al. 2017; Hauser, Laidre et al. 2014). The Eastern Chukchi Sea stock spends the summer primarily restricted to the continental shelf and slope north of Alaska in the northeastern Chukchi and western Beaufort seas (Hauser, Laidre et al. 2014; Stafford, Ferguson et al. 2018; Suydam 2009). The Beaufort Sea stock starts moving west and south in September, leading to an overlap of ranges for the two stocks that extends from Prince of Wales Strait in Canada westward to Herald Shoal in the Chukchi Sea (Stafford, Ferguson et al. 2018; Stafford, Nieukirk et al. 1999). The main fall migration corridor of beluga whales is over 54 nautical miles (100 km) north of the coast; however, they do occasionally approach shallow water in coastal areas, such as lagoons and river deltas, to molt or feed (Suydam 2009). Beluga whales could be encountered along the barge transit route in the Beaufort and Chukchi seas. They have been reported in Harrison Bay but typically travel outside of the barrier islands and are not expected occur near Oliktok Dock.

1.2.2.3 Cuvier's beaked whale

Cuvier's beaked whales (*Ziphius cavirostris*) have the most extensive range of all beaked whales, except in high polar waters (Muto, Helker et al. 2019). There are three recognized stocks: the Alaska stock, the California/Oregon/Washington stock, and the Hawaii stock. They range north to the northern Gulf of Alaska, the Aleutian Islands, and the Commander Islands. They prefer deep pelagic oceanic waters but may also be found nearer shore along the continental slope. They make long, deep dives lasting from 20 to 40 minutes or longer, diving at least 3,300 feet (1,006 m), feeding on cephalopods, deep sea fish, and crustaceans. Cuvier's beaked whales could be encountered along the barge transit route in the Gulf of Alaska and the Bering Sea. They have not been reported in the Chukchi or Beaufort seas, so they will not occur near Oliktok Dock.

1.2.2.4 Dall's porpoise

Dall's porpoises (*Phocoenoides dalli*) are common in the North Pacific and have been divided into two stocks: the California/Oregon/Washington stock and the Alaska stock. Dall's porpoises are widely distributed in deep oceanic water over 8,000 feet (2,500 m) and over the continental slope of the Bering Sea (Muto, Helker et al. 2019) during all months. They feed on small school fish, mid- and deep-water fish, cephalopods, and crustaceans. Dall's porpoises could be encountered along the barge transit route in the Gulf of Alaska and the Bering Sea. They have not been reported in the Chukchi or Beaufort seas, so they will not occur near Oliktok Dock.

1.2.2.5 Harbor porpoise

Harbor porpoises (*Phocoena phocoena*) are the smallest cetacean in the Arctic. The Bering Sea stock comprises 48,215 individuals that occur from the Aleutian Islands north to Point Barrow. They rarely occur near Point Barrow, although the increase in their frequency of occurrence over the past 20 years may represent a range expansion (Funk, Ireland et al. 2010; Hamilton and Derocher 2019; Whiting, Griffith et al. 2011). Harbor porpoises could be encountered along the barge transit route in the Gulf of Alaska and the Bering and Chukchi seas. They have not been reported in the Beaufort Sea, so they will not occur near Oliktok Dock.

1.2.2.6 Killer Whale

Two stocks of killer whale (*Orcinus orca*) may occur in the analysis area: the Alaska Resident stock that occurs from southeastern Alaska to the Bering Sea, and the Eastern North Pacific, Gulf of Alaska, Aleutian Islands, and

Bering Sea Transient stock that can occur in the Chukchi and Beaufort seas (Muto, Helker et al. 2021). NMFS is currently evaluating new genetic information on killer whales in Alaska that indicates the current stock structure needs to be reassessed (Muto, Helker et al. 2021). Killer whales are occasionally reported in the northeastern Chukchi Sea attacking gray and beluga whales and bearded seals, and possibly foraging on fish. They have rarely been recorded in the Beaufort Sea east of Utqiaġvik (Clarke, Brower et al. 2015; Clarke, Christman et al. 2013; Lowry, Nelson et al. 1987). Killer whales could be encountered along the barge transit route in the Bering and Chukchi seas. They have not been reported in the Beaufort Sea, so they will not occur near Oliktok Dock.

1.2.2.7 Pacific white-sided dolphin

The Pacific-white sided dolphin (*Lagenorhynchus obliquidens*) is found throughout the North Pacific, north to the Gulf of Alaska, west to Amchitka in the Aleutian Islands, and sometimes in the southern Bering Sea (Muto, Helker et al. 2019). There are three stocks; the stock that uses Alaska waters is the North Pacific stock, whose population estimate is 26,880 animals. Pacific white-sided dolphins could be encountered along the barge transit route in the Gulf of Alaska and the Bering Sea. They have not been reported in the Chukchi or Beaufort seas, so they will not occur near Oliktok Dock.

1.2.2.8 Stejneger's beaked whale

Stejneger's beaked whales (*Mesoplodon stejnegeri*) are rarely seen at sea, and the distribution is generally inferred from stranded carcasses. The species is endemic to the cold, deep waters of the southwestern Bering Sea and Gulf of Alaska (Muto, Helker et al. 2019) and is not known to enter Arctic waters. They are deep divers, feeding on deep-water fish, tunicates, and cephalopods. Stejneger's beaked whales could be encountered along the barge transit route in the Gulf of Alaska and the Bering Sea. They have not been reported in the Chukchi or Beaufort seas, so they will not occur near Oliktok Dock.

1.2.3 Pinnipeds

1.2.3.1 Pacific walrus

Pacific walruses (*Odobenus rosmarus*) are listed as a Special Status Species by BLM (2019a). They occur throughout the continental shelves of the Bering and Chukchi seas and occasionally in the East Siberian and Beaufort seas (USFWS 2014a). Aerial surveys conducted in 2006 estimated 129,000 individuals (95% confidence interval: 55,000–507,000) within the survey area (Speckman, Chernook et al. 2011). This estimate is considered to be biased low because not all areas important to walruses were surveyed (USFWS 2014a). During the winter breeding season, walruses occur in the Bering Sea in areas with thin ice, open leads, and polynyas (Fay, Kelly et al. 1984; Garlich-Miller, MacCracken et al. 2011). Most of the population of Pacific walruses summers in the Chukchi Sea, although several thousand individuals, primarily adult males, congregate at coastal haulouts in the Gulf of Anadyr, Russia; both sides of the Bering Strait; and Bristol Bay, Alaska. Historically, walruses spent the summer on sea ice cover in the Chukchi Sea, with large numbers found over Hanna Shoal in U.S. waters and near Wrangel Island in Russia (USFWS 2014a). Over the past decade, the number of walruses hauling out on land along the Alaska and Chukotka coastlines of the Chukchi Sea has increased from hundreds to > 100,000 (Garlich-Miller, MacCracken et al. 2011; Jay, Marcot et al. 2011; Kavry, Boltunov et al. 2008). Within the National Petroleum Reserve in Alaska, walruses regularly haul out on the barrier islands of Kasegaluk Lagoon and coastline in and near Peard Bay (Fischbach, Kochnev et al. 2016; Jay, Fischbach et al. 2012) (BLM 2019b, Appendix A, Map 3-24). This change in distribution within the Chukchi Sea is coincident with the accelerating loss of summer sea ice over the continental shelf (NSIDC 2012). As more walruses haul out in coastal areas, they may deplete prey resources that are readily accessible near the haulouts. Walruses rely primarily on bivalves as prey but also eat a wide variety of other benthic prey items (Sheffield and Grebmeier 2009).

Walruses could be encountered along the barge transit route in the Bering and Chukchi seas. Very few individuals have been reported in the Beaufort Sea, so they are not expected to occur near Oliktok Dock.

1.2.3.2 Ribbon Seal

Ribbon seals (*Histriophoca fasciata*) inhabit the Bering, Chukchi, and western Beaufort seas. They are relatively solitary, except when they form loose aggregations on pack ice during spring to give birth, nurse, and molt. They are rarely seen on shorefast ice or land. The estimated abundance is approximately 163,086 seals (Muto, Helker et al. 2021). Ribbon seals are an important resource for Alaska Native subsistence hunters. Ribbon seals could be encountered along the barge transit route in the Bering, Chukchi, and Beaufort seas. They are rarely found on land or in shallow waters, so they are not expected to occur near Oliktok Dock.

1.2.3.3 Spotted Seal

The Bering Sea stock of spotted seals (*Phoca largha*) may be seasonally present in the analysis area along the coast of Harrison Bay and in the CRD (BLM 2012) during winter and spring near sea ice (Quakenbush 1988) using terrestrial haulouts on mud, sand, or gravel beaches, and on sea ice in spring where, water depth does not exceed 650 feet (Muto, Helker et al. 2021). Numerous haulout sites have been identified in the CRD (USACE 2018). During winter and spring, this species is strongly associated with the presence of sea ice (Quakenbush 1988).

1.3 Noise and Marine Mammals

This section summarizes the properties of underwater noise, which are relevant to understanding the effects of noise produced by construction and operations activities on the underwater marine environment in the analysis area. This document does not provide a detailed calculation to acoustical thresholds of specific Project components proposed under the action alternatives. This detailed information would be analyzed further in a MMPA authorization request and associated Endangered Species Act Section 7 consultation.

1.3.1 Overview of Acoustics

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air or water. The disturbed particles of the medium move against undisturbed particles, causing an increase in pressure. This increase in pressure causes adjacent undisturbed particles to move away, spreading the disturbance away from its origin. This combination of pressure and particle motion makes up an acoustic wave.

The intensity of sound is characterized by decibels (dB). The mathematical definition of a decibel is the base 10 logarithmic function of the ratio of the pressure fluctuation to a reference pressure. Decibels are measured using a logarithmic scale, so sound levels cannot be added or subtracted directly. For example, if a sound's intensity is doubled, the sound level increases by 3 dB, regardless of the initial sound level. Thus, 60 dB + 60 dB = 63 dB, and 80 dB + 80 dB = 83 dB. The decibel measures the difference in orders of magnitude (× 10), so 10 dB means 10 times the power; 20 dB means 100 times the power; 30 dB means 1,000 times the power; and so on.

Because the decibel is a relative measure, any absolute value expressed in dB is meaningless without the appropriate reference. The metric that describes the change in pressure (amplitude) is the pascal (Pa), approximately equivalent to 0.0001465 pounds per square inch. In this document, all underwater sound levels are expressed in decibels referenced to 1 microPascal (dB re 1 μPa) and all airborne sound levels are expressed in dB re 20 μPa. It is possible to convert between the reference pressures—in this instance, 26 dB. However, the efficiencies of sound generation and reception in air and water differ greatly, so simply adding a constant to the underwater sound pressure level will not allow a reasonable assessment of how the sound is perceived by the receiver. Table E.13.1 summarizes terms commonly used to describe sounds.

The method commonly used to quantify airborne sounds consists of evaluating all frequencies of a sound according to a weighting system that reflects that human hearing is less sensitive at low frequencies and extremely high frequencies than at mid-range frequencies. This is called A-weighting, and the measured level is called the A-weighted decibel (dBA). Sound levels to assess potential noise impacts on terrestrial wildlife, airborne or underwater, are not weighted and measure the entire frequency range of interest, unless specified by an agency.

Hertz (Hz) is a measure of how many times each second the crest of a sound pressure wave passes a fixed point. For example, when a drummer beats a drum, the skin of the drum vibrates a number of times per second. When the drum skin vibrates 100 times per second, it generates a sound pressure wave that is oscillating at 100 Hz, and this pressure oscillation is perceived by the ear/brain as a tonal pitch of 100 Hz. Sound frequencies between 20 and 20,000 Hz (or 20 kilohertz) are within the range of sensitivity of the best human ear. The hearing sensitivities of the animals of interest in this document will be discussed for each species below.

As sound propagates out from the source, there are many factors that change the amplitude. These include the spreading of sound over a wide area (spreading loss), the loss to friction between particles that vibrate (absorption), and the scattering and reflections from objects in the path (including surface or seafloor). The total propagation, including these factors, is called the transmission loss (TL). In air, TL parameters vary with frequency and type of source, temperature, wind, source and receiver height, and ground type. Underwater, TL parameters vary with frequency and type of source, temperature, wind, sea conditions, source and receiver depth, water chemistry, and bottom composition and topography. For ease in estimating distances to agency thresholds, simple TL can be calculated using logarithmic spreading loss with the following formula:

$$TL = B * log10(R)$$

TL is transmission loss, B is logarithmic loss, and R is radius to the threshold

In air, the standard value of B is 20 (or reported as 20 log(R)), resulting in a reduction of 6 dB for every doubling of distance. For underwater TL, there are three common spreading models used by agencies: 1) cylindrical spreading for shallow water, or 10 log(R), resulting in a reduction of 3 dB for every doubling of distance; 2) spherical spreading for deeper water, or 20 log(R), resulting in a reduction of 3 dB for every doubling of distance; and 3) practical spreading, which is used when agencies have not defined the depth for the other models, or 15 log(R), resulting in a reduction of 4.5 dB for every doubling of distance.

Table E.13.1. Definition of Acoustical Terms

Term	Definition
Decibel (dB)	A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for water is 1 microPascal (µPa) and for air is 20 µPa (approximate threshold of human audibility).
Sound exposure level (SEL)	The SEL is the total noise energy produced from a single noise event and is the integration of all the acoustic energy contained within the event. SEL incorporates both the intensity and duration of a noise event. SEL is expressed in dB re 1 μPa^2-sec.
Sound pressure level (SPL)	Sound pressure is the force per unit area, usually expressed in µPa (or 20 micro newtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 m^2. The SPL is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressure exerted by the sound to a reference sound pressure. SPL is the quantity that is directly measured by a sound level meter.
Frequency, hertz (Hz) or kilohertz (kHz)	Frequency is expressed in terms of oscillations, or cycles, per second. Cycles per second are commonly referred to as Hz. Typical human hearing ranges from 20 Hz to 20,000 Hz (or 20 kHz).
Peak sound pressure (unweighted)	The peak sound pressure level is based on the largest absolute value of the instantaneous sound pressure over the measured frequency range, reported as dB re 1 µPa for underwater or dB re 20 µPa for airborne.
Root-mean-square (rms)	The rms level is the square root of the energy divided by a defined time period. For pulses, the rms has been defined as the average of the squared pressures over the time that comprises that portion of the waveform containing 90% of the sound energy for one impulse.
Ambient noise level	The ambient noise level is the background sound level, which is a composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.

1.3.2 Applicable Noise Criteria

Under the MMPA, NMFS and USFWS have defined levels of harassment for marine mammals. Level A harassment is defined as the potential to injure and Level B harassment is defined as the potential to disturb. Table E.13.2 summarizes the thresholds for assessing potential impacts on marine mammals from underwater and airborne sound.

Table E.13.2. Marine Mammal Injury and Disturbance Thresholds for Underwater and Airborne Sound

Marine Mammals	Underwater Injury Threshold (Level A) Impulsive	Underwater Injury Threshold (Level A) Non-Impulsive	Underwater Disturbance Threshold (Level B) Impulsive	Underwater Disturbance Threshold (Level B) Non-Impulsive	Airborne Threshold (Level B)
Low-frequency cetaceans	219 dB L_{pk} 183 dB SEL	199 dB SEL	160 dB rms	120 dB rms	NA
Mid-frequency cetaceans	*230 dB L_{pk}* 185 dB SEL	198 dB SEL	160 dB rms	120 dB rms	NA
High-frequency cetaceans	202 dB L_{pk} 155 dB SEL	173 dB SEL	160 dB rms	120 dB rms	NA
Phocid pinnipeds[a]	218 dB L_{pk} 185 dB SEL	201 dB SEL	160 dB rms	120 dB rms	100 dB rms
Otariid pinnipeds	232 dB L_{pk} 203 dB SEL	219 dB SEL	160 dB rms	120 dB rms	100 dB rms
Polar bears, walrus, sea otters	190 dB rms	180 dB rms	160 dB rms	160 dB rms	NA

Source: NMFS 2018

Note: All underwater sound levels are reported as decibels (dB) referenced to 1 microPascal (dB re 1 µPa) and all airborne sound levels are reported as dB re 20 µPa. Peak (L_{pk}) is the instantaneous maximum sound level; sound exposure level (SEL) is the accumulative sound energy over a 24-hour period; root-mean-square (rms) is the arithmetic mean of the squares of the measured pressure of the sound. NA (not applicable).

[a] The airborne threshold for harbor seals is 90 dB rms. The airborne threshold for all other phocid pinnipeds is 100 dB rms.

1.3.3 Airborne Acoustic Environment of the Beaufort Sea

The airborne acoustic environment is characterized in the Willow Master Development Plan Supplemental EIS, Section 3.6, *Noise*.

1.3.4 Underwater Acoustic Environment of the Beaufort Sea

The underwater acoustic environment consists of sounds from natural, biologic, and anthropogenic sources. Underwater sound levels in the ocean vary over time, as these sources fluctuate on daily, seasonal, and annual scales. Natural sources include geologic processes, earthquakes, wind, thunder, rain, waves, ice, etc. Biologic sources include marine mammals and fish. Anthropogenic sounds are those generated by humans, including vessels, scientific research equipment, aircraft, and offshore industrial activities.

The Beaufort Sea has a narrow continental shelf that drops off to the north into the Beaufort Sea Plateau, a deep basin with depths of 6,500 to 10,000 feet, allowing for the long-range propagation of high-amplitude, low-frequency sounds. All of the module delivery options are in the very shallow waters of Harrison Bay. Generally, underwater sound levels in shallow waters increase with increasing wind speed (Wenz 1962). Marine mammal vocalizations and anthropogenic sounds have been measured using seafloor-mounted passive acoustic monitoring devices since the late 1970s. The typical reported ambient levels range from 77 to 135 dB re 1 µPa (Greene Jr., Blackwell et al. 2008; LGL Alaska Research Associates Inc., Greenridge Sciences et al. 2013), with general ambient conditions at approximately 120 dB re 1 µPa. For consideration of underwater noise effects from Project-related noise sources, the analysis assessed the distance needed for a noise source to attenuate to the underwater background sound level of 120 dB re 1 µPa.

1.3.5 Description of Underwater Sound Sources

The acoustic characteristics of each of the Project activities are described in the following section and are summarized in Table E.13.3. Aspects of module transfer island construction that have the potential to incidentally harass marine mammals are the airborne noise generated by vibratory and impact pile driving or removal during winter (through bottom-fast ice), some construction activities through ice, screeding, and vessel traffic. Inland pile driving may result in airborne disturbance to polar bears.

Table E.13.3. Summary of Noise Sources

Activity	Airborne Sound Level (dBA re 20 µPa)	Underwater Sound Level (dB re 1 µPa)	Frequency	Reference
Impact driving of pipe piles	101 dBA at 50 feet	None proposed in-water for the Project	Range: 100–4,000 Hz Concentration: 125 Hz	Airborne: USDOT 2006 Underwater: Illingworth and Rodkin 2007
Vibratory driving of pipe piles	101 dBA at 50 feet	None proposed in-water for the Project	Range: 100–4,000 Hz Concentration: 125 Hz	Airborne: USDOT 2006 Underwater: Illingworth and Rodkin 2007
Vibratory pile removal	101 dBA at 50 feet	None proposed in-water for the Project	Range: 10–10,000 Hz	Airborne: USDOT 2006 Underwater: Pangerc et al. 2017
Vibratory driving of sheet piles	81 dBA at 328 feet	None proposed in-water for the Project	Range: 10–10,000 Hz Concentration: 24–25 Hz	Greene et al. 2008
Screeding (tugboat and barge)	NA	164–179 dB rms at 3.28 feet	Range: 10–10,000 Hz Concentration: 10–2,000 Hz	Blackwell and Greene 2003
Ice trenchers (bulldozer)	64.7 dBA at 328 feet	114 dB rms at 328 feet	Range: 10–8,000 Hz Concentration: 31–400 Hz	Greene et al. 2008
Grading excavators (backhoe)	78 dBA at 50 feet	125 dB rms at 328 feet	Range: 10–8,000 Hz Concentration: 31–400 Hz	Airborne: USDOT 2006 Underwater: Greene et al. 2008
Ditch Witch	76.3 dBA at 328 feet	122 dB rms at 328 feet	Range: 10-8,000 Hz Concentration: 20–400 Hz	Greene et al. 2008
General vessel operations	40 at 1,000 feet	145–175 dB rms at 3.28 feet	10–1,500 Hz	Blackwell and Greene 2003; Richardson et al. 1995; TORP Terminal LP 2009

Note: dB (decibels); dB re 1 µPa (decibels referenced to 1 microPascal); dBA (A-weighted decibels); Hz (hertz); NA (not applicable); rms (root-mean-square); USDOT (U.S. Department of Transportation).

1.3.5.1 Impact Pile Driving

The U.S. Department of Transportation (USDOT) *Construction Noise Handbook* provides a summary of equipment with measured maximum airborne sound levels at 50 feet (15 m). The handbook reports an airborne level of 101 dBA at 50 feet (15 m) for impact pile driving.

1.3.5.2 Vibratory Pile Driving and Removal

Greene et al. (2008) measured underwater sound, airborne sound, and iceborne vibrations associated with the construction of Northstar Island (~39 feet depth). For vibratory pile driving of sheet piles, they reported airborne levels of 81 dB at 328 feet (100 m), with the energy between 10 and 10,000 Hz and concentrated at 50 Hz. Airborne sound levels associated with pile removal is the same as installation.

1.3.5.3 Underwater Construction

Seabed preparation may use a barge with a screeding device. Blackwell and Greene (2003) reported a source level of 164 dB re 1 µPa rms at 3.28 (1 m) feet for the tugboat *Leo* pushing a full barge near the Port of Anchorage. The source level increased to 179 dB re 1 µPa rms at 3.28 feet (1 m) when the tugboat was using its thrusters to maneuver the barge during docking. Most of the sound energy is in the band of 100 to 2,000 Hz, with a large peak at 50 Hz. There are no measurements available in Alaska of screeding, so these levels are used as a proxy for a characterization of these activities.

In their analysis of Northstar Island, Greene et al. (2008) measured an underwater sound level of a bulldozer at 114.2 dB re 1 µPa rms at 328 feet (100 m), a backhoe at 124.8 dB re 1 µPa rms at 328 feet (100 m), and a Ditch Witch at 122 dB re 1 µPa rms at 328 feet (100 m), with the center frequency between 10 and 63 Hz. They reported that broadband sounds from these activities diminished to the median background level of 77 to 116 dB re 1 µPa rms (10 to 10,000 Hz range) at distances between 0.62 and 3.1 miles (1 and 5 km).

The measured airborne level of the bulldozer and Ditch Witch were 64.7 dB and 76.3 re 20 µPa rms at 328 feet (100 m), respectively; and airborne sound associated with the backhoe was not measured (Greene et al. (2008). The USDOT *Construction Noise Handbook* provides a summary of equipment with measured maximum levels at 50 feet. The handbook reports an airborne level of 78 dBA at 50 feet.

1.3.5.4 Vessels

Some vessels such as tugboats and cargo ships can under some circumstances generate underwater sound exceeding the non-impulsive threshold of 120 dB due largely to the continuous cavitation sound produced from the propeller arrangement of both drive propellers and thrusters. Large ships produce broadband sound pressure levels of about 170 dB re 1 µPa rms at 3.28 feet (1 m) (Blackwell and Greene 2003; Richardson, Greene et al. 1995). Thrusters have generally smaller blade arrangements operating at higher rotations per minute and therefore largely produce more cavitation sound than drive propellers.

1.3.6 Calculation of Distances to Thresholds

A detailed analysis of impacts to marine mammals would be included in the MMPA authorization request, if required. For purposes of the EIS, distances from construction activities were estimated to the 120 dB underwater and 100 dB airborne thresholds. Assuming a TL of 20 log(R) for airborne sound and 15 log(R) for underwater sound, the estimated distances to the underwater and airborne thresholds are summarized in Table E.13.4. Airborne noise from construction activities would be below the 100-dB airborne threshold within 55 feet for all activities and less than 21 feet for non–pile driving activities. Underwater noise from construction activities such as use of a backhoe, bulldozer, or Ditch Witch would be below the 120-dB threshold between 131 and 707 feet from the source. Underwater noise from vessels would be below the 120-dB threshold at 7,067 feet.

Table E.13.4. Estimates of Noise Levels to Thresholds by Activity

Activity	Distance to 100 dB airborne threshold (feet)	Distance to 120 dB underwater threshold (feet)
Impact pipe pile driving	55	None proposed in-water for the Project
Vibratory pipe pile driving	55	None proposed in-water for the Project
Vibratory sheet pile driving	37	None proposed in-water for the Project
Bulldozer	6	131
Backhoe	4	707
Ditch Witch	21	446
Vessel	NA	7,067

Note: dB (decibels); NA (not applicable).

1.4 Required Measures to Minimize Polar Bear Impacts*

CPAI would adhere to implementing a number of measures for the life of the Project which would serve to significantly reduce the potential Project impacts polar bears. These mitigation measures fall into two primary categories described in detail below:

1. Measures to avoid and minimize potential polar bear incidental harassment
2. Measures to avoid and minimize potential polar bear deterrence

These measures include all the mitigation measures that are typically required to be implemented under MMPA authorizations for both incidental take and take by deterrence (i.e., intentional, non-lethal take) of polar bears. However, implementation of these measures does not depend on future MMPA authorization, and they are part of the proposed Project.

1.4.1 Measures to Avoid and Minimize Potential Polar Bear Incidental Harassment*

The following measures summarized below would be employed to avoid and minimize potential polar bear incidental harassment:

1. Project activities would be conducted in accordance with CPAI's Polar Bear Avoidance and Interaction Plan (June 2021). A copy of this plan would be kept on-site and would be available for reference by all Project personnel.
2. All employees, contractors, and personnel performing activities for the Willow Project would observe and carry out all applicable terms and conditions currently set forth in 50 CFR 18 subpart J, Mitigation,

Monitoring, and Reporting Requirements for the 2021-2026 Beaufort Sea Incidental Take Regulations. The terms and conditions in the current set of ITRs would be implemented for the 30-year Project life.

3. All personnel would limit encounters with polar bears by being observant of approaching polar bears and by allowing polar bears to pass unhindered when possible.
4. If a polar bear interaction escalates into a life-threatening situation, MMPA section 101(c) allows, without specific authorization, the take (including lethal take) of a polar bear if such taking is necessary for self-defense or to save the life of a person in immediate danger. Such taking would be reported to USFWS and BLM as soon as possible, but no later than 48 hours after the incident.
5. Work activities would not take place within 1.0 mile of known polar bear dens without prior authorization. Two polar bear aerial infrared den detection surveys of all denning habitat within 1.0 mile of human activity would be conducted during the maternal denning period (as specified in the 2021-2026 Beaufort Sea ITR). These den detection surveys would be subject to weather restrictions or other factors but would take place from approximately November 25 – January 20). Should occupied dens be identified within 1.0 mile of Project activities at any time, work in the area will cease and BLM and USFWS Marine Mammals Management would be contacted.
6. Vessel operators would maintain the maximum distance possible and take every precaution to avoid harassment of concentrations of polar bears. Vessels would reduce speed and maintain a minimum 0.5-mile operation exclusion zone around polar bears observed on ice.
7. BLM and USFWS would be notified of changes to the Project, including changes to activities, locations, or methods, prior to implementation.

1.4.2 Measures to Avoid and Minimize Potential Polar Bear Deterrence*

The following measures would be employed to avoid and minimize potential polar bear deterrence:

1. Project activities would be conducted in accordance with CPAI's *Polar Bear Avoidance and Interaction Plan* (June 2021). A copy of this plan would be kept on site and be available for reference by all Project personnel.
2. CPAI would ensure that only trained and qualified personnel are assigned the task of polar bear deterrence. Prior to initiation of activities, a list of trained personnel responsible for deterrence and a description of their training would be submitted to USFWS Marine Mammals Management.
3. Should firearms be used for polar bear deterrence, CPAI would ensure that personnel comply with all laws and regulations regarding the carry and use of firearms.
4. Within 48 hours of occurrence, CPAI or its designated agent, would document and report to USFWS Marine Mammals Management all instances involving polar bear deterrence activities. A final report of all polar bear deterrence activities would be submitted to BLM and USFWS Marine Mammals Management.
5. Appropriate deterrence techniques would include use of (but not limited to), bear monitors, airhorns, electric fences, bear spray, acoustic recordings, vehicles, and projectiles (e.g., beanbags, rubber bullets, "cracker" shells, "bangers", and "screamers"). Deterrence techniques must not cause the injury or death of a polar bear. Any injury or death of a polar bear would be reported to BLM and USFWS Marine Mammals Management as soon as possible but no later than 48 hours after the incident.
6. Prior to conducting a deterrence activity, CPAI would:
   a. Make a reasonable effort to reduce or eliminate attractants.
   b. Secure the site, notify supervisor, and mover personnel to safety.
   c. Ensure the polar bear has escape route(s).
   d. Ensure communication with all personnel.
7. When conducting a deterrence activity, CPAI would:
   a. Never deter a polar bear for convenience or to aid Project activities. The safety and welfare of the polar bear is second only to the safety and welfare of humans in a deterrence situation.
   b. Shout at the polar bear before using projectiles or other techniques.
   c. Begin with the lowest level of force or intensity that is effective and increase the force or intensity of the technique, or use additional techniques, only as necessary to achieve the desired result.
8. After a deterrence event, CPAI would:
   a. Monitor the polar bear's movement (to ensure no return).

b. Notify supervisor and personnel when it is safe to resume work.
c. Submit a report to USFWS Marine Mammals Management within 48 hours.

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