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

Willow Master Development Plan

Environmental Impact Statement

FINAL

Volume 6: Appendices E.8 through E.16

August 2020

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

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

Estimated Total Costs Associated with Developing and Producing this EIS: $6,668,400

Mission

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

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

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Willow Master Development Plan

Appendix E.8
Water Resources Technical Appendix

August 2020

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cfs	cubic feet per second
CPAI	ConocoPhillips Alaska, Inc.
HDD	horizontal directional drilling
MBI	Michael Baker International
mm	millimeters
NAVD88	North American Vertical Datum of 1988
NWS	National Weather Service
Project	Willow Master Development Plan Project
RM	river mile
USGS	U.S. Geological Survey
VSM	vertical support member
WSE	water surface elevation

Glossary Terms

Bottom-fast ice – Ice that is attached to the waterbody or sea floor and is relatively uniform in composition and immobile during winter (also known as bedfast, ground-fast, fast, shorefast, or landfast ice).

Discharge – The rate at which a given volume of water passes a given location within a specific period of time (e.g., cubic feet per second or gallons per minute).

Rolligon – A type of wheeled, low-impact off-road vehicle frequently used on the North Slope for tundra or snow travel; it can be configured to suit a variety of industrial and construction needs.

Stage – The vertical height of the water above an established but usually arbitrary point. Sometimes zero stage corresponds to the riverbed but more often to just an arbitrary point.

Water surface elevation – The elevation of the water surface of a river, lake, or stream above an established reference or vertical datum.

1.0 WATER RESOURCES

1.1 General Flow Characteristics of Rivers and Streams in the Analysis Area

Freeze-up often begins with ice forming along the shoreline and ice pans floating down the river. As freeze-up continues, the ice cover spreads across the stream and in shallow locations the entire water column freezes. Stream flow during the winter on the North Slope is generally so low that it is not measurable and is often nonexistent. In late May or early June there is a rapid rise in **discharge** resulting from snowmelt runoff, a period generally referred to as spring breakup. More than half the annual discharge for a stream can occur during spring breakup, a period of several days to a few weeks. Extremely large areas can be inundated in a matter of days as a result of rapid snowmelt combined with ice- and snow-blocked channels. Most streams continue to flow through the summer but at substantially lower discharges. Rainstorms can increase streamflow temporarily, but they are seldom sufficient to produce a discharge comparable to that which occurs during the average spring breakup. Streamflow rapidly declines in most streams shortly after the onset of freeze-up in September and ceases in most streams by December.

1.1.1 Influence of Climate Change on Flow

Although climate change is occurring, it is unknown how it might impact flood-peak magnitude and frequency in the Arctic. The National Weather Service (NWS) evaluated the potential for statistically significant trends in the 1-day and 1-hour annual maximum daily precipitation data for Alaska (for stations that had at least 40 years of data), which are often used to predict flood-peak discharge (Perica, Kane et al. 2012). There was no trend in 1-hour annual maximum precipitation for the 12 stations with 40 years of record. Of the 154 stations with 40 years of 1-day annual maximum precipitation data, 85% had no statistically significant trends, 8% had a positive trend, and 7% had a negative trend. Spatial maps did not reveal any spatial cohesiveness in positive and negative trends.

U.S. Geological Survey (USGS) evaluated the flood-peak data set used to develop regression equations to predict flood-peak discharge throughout Alaska (Curran, Barth et al. 2016). Statistically significant trends were detected at 43 of the 387 stream gages evaluated. Of the 43 stream gages with significant trends, 22 had increasing trends and 21 had decreasing trends.

Although precipitation levels are projected to increase, the longer, warmer summers may increase evapotranspiration. An increase in evapotranspiration may result in a net loss in surface water by the end of the summer season, which could affect the size, depth, and areal extent of thaw lakes. Increases in winter precipitation may have some effect on lake recharge and peak snowmelt runoff in rivers and streams.

1.2 Hydrology of Rivers and Streams in the Willow Area

1.2.1 Colville River

The Colville River is the largest north-flowing river in the U.S. and drains an area of about 23,600 square miles. It originates in the DeLong Mountains of the Brooks Range and generally follows a west-east flow corridor until reaching Umiat, where it turns north and flows into Harrison Bay in the Beaufort Sea.

Discharge and **stage** data are available for several locations on the Colville River. The closest gaging stations to Ocean Point (approximately river mile [RM] 46.5) are at Umiat (RM 117) and Monument 1 (RM 26.5), Figure 3.8.2. Although neither of these existing gages measures winter flow at Ocean Point, Umiat is more closely representative of Ocean Point than Monument 1 because Umiat is upstream of the influence of saltwater intrusion and tidal backwatering from the Colville River Delta and Monument 1 is not. Seventeen years of stage and discharge have been measured at the USGS Umiat gaging station 15875000 (Tables E.8.1 and E.8.2). The average monthly mean discharge at Umiat in winter (December through April) ranged from 84 to 3.1 cubic feet per second (cfs) from 2002 to 2019 (USGS 2020b), as shown in Table E.8.1. (The range of mean monthly discharge for December through April was 132.2 to 0.0 cfs; Table E.8.1.) During that time, the minimum recorded average daily winter discharge varied from 0.0 cfs (2003 through 2009) to 20.0 cfs (2019) (USGS 2020b). The annual spring peak discharge occurred between May 21 and June 10, with a median date of June 1. The time from the last day of minimum flow to the annual spring discharge varied between 12 and 47 days, with a median time of 23 days. The annual spring peak discharge varied from 73,000 to 268,000 cfs, with a median of 184,500 cfs. Note that the Colville River is more than 2,000 feet wide at Umiat and that by late winter the flow is contained to a very small channel within that width. In other words, the ice across 99% of the channel is frozen to the bottom, but somewhere within that width there is a very small channel with flow.

Table E.8.1. Colville River Mean Monthly Discharge (cubic feet per second) at Umiat

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	ND	ND	ND	ND	ND	ND	ND	ND	21,030	7,221	844	100.1
2003	3.6	0	0	0	690	65,690	24,030	31,800	12,760	10,490	560	72.6
2004	6.9	2.2	0.2	0	40,890	24,940	15,310	24,870	12,060	557	142	56.6
2005	20.8	4.2	< 0.1	0	12,830	72,480	13,920	4,143	6,014	1,169	200	104.5
2006	18.4	0.1	0	0	22,010	37,120	21,940	33,560	6,229	2,667	325	80.0
2007	27.9	11.7	0.9	0	4,179	50,530	12,140	17,820	7,511	874	177	72.6
2008	21.1	0.7	0	0	17,260	46,530	12,900	10,770	1,867	560	207	72.9
2009	15.0	0	0	3.0	36,940	45,050	13,890	13,440	13,750	1,775	418	95.2
2010	36.5	13.9	1.7	0.5	17,280	48,760	10,370	15,720	6,213	1,248	454	132.2
2011	35.5	9.7	1.1	0.4	37,790	31,190	13,170	11,330	11,940	1,958	375	93.5
2012	29.2	11.0	1.9	0.5	16,680	41,910	16,970	14,860	27,440	3,678	145	45.9
2013	16.4	3.9	2.0	1.0	6,434	83,970	10,530	10,290	11,750	1,475	509	130.7
2014	25.9	9.3	6.0	6.0	33,290	72,180	29,820	10,130	16,140	1,215	217	89.9
2015	45.2	29.0	16.8	12.0	62,410	17,010	8,243	22,250	11,550	1,504	276	65.5
2016	24.4	10.1	5.7	2.8	47,460	32,660	14,540	27,290	15,310	4,868	405	64.4
2017	16.0	3.8	1.2	1.0	12,070	26,220	13,110	36,370	25,900	6,403	448	86.5
2018	24.9	11.9	7.1	6.0	12,220	47,610	26,970	30,330	23,280	3,122	343	67.1
2019	40.9	30.2	22.6	20.0	36,180	18,370	12,380	38,990	15,500	ND	ND	ND
Average monthly mean discharge Sep 2002 to Sep 2019	**24.0**	**8.9**	**3.9**	**3.1**	**24,500**	**44,800**	**15,900**	**20,800**	**13,700**	**2,987**	**356**	**84.1**
Average monthly mean discharge Sep 2010 to Sep 2019	**29.5**	**13.3**	**6.6**	**5.0**	**28,181**	**41,988**	**15,610**	**21,756**	**16,502**	**2,830**	**352.4**	**86.2**

Source: USGS 2020b
Note: ND (no data); < (less than); Sep (September). No incomplete data have been used for statistical calculations.

Table E.8.2. Summary of Annual Minimum and Spring Peak Discharge for the Colville River at Umiat

Year	First Date of Minimum Flow (month/day)	Last Date of Minimum Flow (month/day)	Minimum Flow Discharge (cfs)	Annual Spring Peak Stage Date (month/day)	Annual Spring Peak Discharge (cfs)	Minimum Flow to Spring Peak Discharge (days)
2003	1/19	5/08	0	6/10	213,000	33
2004	3/06	5/09	0	5/24	222,000	15
2005	3/02	5/04	0	6/08	161,000	35
2006	2/04	5/09	0	5/30	173,000	21
2007	3/11	5/17	0	6/05	183,000	19
2008	2/07	5/16	0	5/28	108,000	12
2009	1/29	4/21	0	6/07	152,000	47
2010	3/20	5/19	0.5	6/01	186,000	13
2011	3/21	4/23	0.3	5/29	230,000	36
2012	3/22	5/15	0.5	6/02	177,000	18
2013	4/04	5/22	1.0	6/04	243,000	13
2014	3/01	5/05	6.0	5/31	195,000	26
2015	3/31	5/08	12.0	5/21	268,000	13
2016	4/12	4/30	2.5	5/25	193,000	25
2017	3/06	5/09	1.0	6/02	73,000[a]	24
2018	3/30	5/04	6.0	6/01	112,000	28
2019	3/24	5/02	20.0	5/25	135,000	23

Source: USGS 2020b
Note: cfs (cubic feet per second)
[a] The peak discharge of 82,000 cfs occurred on 8/19.

From January 2003 through January 2009, mean monthly minimum winter flows of 0.0 cfs were recorded. From March 2010 to the present, no flows of 0.0 cfs have been recorded in the gaging station record. However, the lack of recorded 0.0 cfs flows may be due to the 2010 change in the USGS offices responsible for the site, including a difference in procedures and more frequent late-winter site visits (M. Schellekens [USGS], personal communication to Ken Karle, Hydraulic Mapping and Modeling. January 31, 2020).

Direct stream discharge measurements are required to create a gaging station rating curve, which converts stage (water height) into discharge. The USGS maintains a database of 155 discharge measurements made at Colville

River Gaging Station 15875000 at Umiat between March 1, 1953, and October 18, 2019. December through April winter measurements are provided in Table E.8.3 (USGS 2020b).

Table E.8.3. Winter Field Discharge Measurements at Umiat, U.S. Geological Survey Gaging Station 15875000

Measurement Number	Date	Streamflow (cfs)	Ice Cover	Measurement Rating[a]
1	4/1/1953	0	Yes	Unspecified
15	12/2/2003	197	Yes	Poor
16	2/23/2004	2.2	Yes	Poor
26	12/1/2004	85.1	Yes	Poor
27	1/12/2005	23.4	Yes	Fair
44	12/4/2006	118	Yes	Fair
45	1/22/2007	22.4	Yes	Poor
46	3/27/2007	0	Yes	Good
52	12/12/2007	81.0	Yes	Fair
64	1/18/2009	12.3	Yes	Poor
71	2/11/2010	17.4	Yes	Poor
77	3/4/2011	2.6	Yes	Poor
78	3/30/2011	0.3	Yes	Poor
89	3/4/2012	3.8	Yes	Fair
97	1/8/2013	21.7	Yes	Poor
98	3/2/2013	2.6	Yes	Poor
106	1/21/2014	17.9	Yes	Poor
107	3/1/2014	4.4	Yes	Poor
108	3/31/2014	6.4	Yes	Poor
116	1/12/2015	46.0	Yes	Poor
117	4/15/2015	11.9	Yes	Poor
124	1/26/2016	16.2	Yes	Poor
125	3/14/2016	5.4	Yes	Poor
126	4/18/2016	2.3	Yes	Fair
134	3/14/2017	1.0	Yes	Poor
141	1/16/2018	24.0	Yes	Poor
142	4/16/2018	5.7	Yes	Poor
149	2/10/2019	31.4	Yes	Poor
150	3/27/2019	19.7	Yes	Poor

Source: USGS 2020b

Notes: cfs (cubic feet per second). Table shows all the published data from December through April data for the time period listed for USGS Gaging Station 15875000.

[a] The measurement rating is used to describe the relationship between stage (water surface elevation) and discharge. An equation is used to describe the curve, since it changes constantly as the riverbed changes. Winter measurements are not used to help construct the measurement rating curve, as the stage measurements are unreliable due to the presence of ice. The measurement rating is not a rating of the accuracy of the data.

Downstream from Umiat, the probability of having flow in every month of the year increases as the drainage area increases. Similarly, the magnitude of the flow is likely to increase roughly proportional to the drainage area increase. Thus, when the average monthly mean April flow is 3.1 cfs at Umiat, where the drainage area is approximately 13,860 square miles, the average monthly mean April flow may be 1.5 times than that near Nuiqsut (4.7 cfs), where the drainage area is 20,670 square miles. Therefore, the flow at Ocean Point is likely higher than the flow at Umiat.

Ocean Point is located at a distinct transition of the Colville River channel pattern. Starting approximately 40 miles upriver from Ocean Point, the Colville, joined by several tributaries within the reach (Anaktuvuk River, Kogosukruk River, and Kikiakrorak River), flows north in a wide floodplain with two dissimilar side-by-side channel patterns. The main channel system on the west side includes interconnected distributary channels within a sparsely vegetated floodplain that includes depositional longitudinal and transverse bars. On the right side, multiple smaller channels take the form of serpentine (scroll) meanders, with extensively developed riparian vegetation. Five miles upstream from Ocean Point, the river enters a sweeping 180-degree right-hand bend. At Ocean Point, the river transitions to a single meandering channel, although remnant abandoned channels are readily apparent in aerial imagery. The river remains primarily in a single channel for another 20 miles to the east and northeast before entering the Colville River Delta.

Available data specific to the Colville River at Ocean Point are summarized in Table 3.8.4. Although the data are limited, Ocean Point has been used as a **rolligon** crossing for a number of years by various users (users are described in Section 3.14, *Land Ownership and Use*) because the area is shallow and has the potential for **bottom-fast ice**.

Table E.8.4. Water Data for the Colville River at Ocean Point

Date	Flow or Ice Conditions	Water Temperature (degrees C)	Salinity (ppt)	Source
December 10, 2007	Ice not grounded, approximately 2 to 3 feet water depth under the ice.	NC	NC	J. Winters [ADF&G], personal communication to DOWL. January 16, 2020.
April 4, 2019	Grounded ice to 0.7-foot water depth, 0.5 to 6.2 feet ice thickness.	NC	NC	CPAI 2019b
September 5, 2019	28,900 cubic feet per second. Open channel conditions. Average water depth 5.7 feet.	9.8 to 10.0	0.1	MBI 2019
December 31, 2019[a]	Ice grounded near both banks. Floating ice thickness is 2.8 feet. Approximately 1.2 to 2.2 feet of water under the ice. Velocity is 0.15 to 0.25 feet per second.	0.1	0.2	CPAI 2019b
February 25, 2020[a]	Ice grounded at both banks and in the middle of the channel. Water columns are less than 1.3 feet deep. Floating ice thickness is 4.6 feet.	0.4	0.26	CPAI 2020, MBI 2020a

Note: ADF&G (Alaska Department of Fish and Game); C (Celsius); CPAI (ConocoPhillips Alaska, Inc.); NC (not collected); ppt (parts per thousand). Data collected at similar, but not the same, locations near Ocean Point.
[a] More data for this date are provided in Table E.8.5.

Michael Baker International (MBI) collected field data at two potential crossing locations on the Colville River near Ocean Point (Figure E.8.1). Data included cross-sectional river bottom profiles, discharge, velocity, water depth, **water surface elevation** (WSE), site conditions, and general in situ water quality parameters (Michael Baker International 2019). Soil active layer depths were also investigated for both banks of each crossing. Table E.8.5 summarizes the discharge measurements for Ocean Point at two locations and the coincident discharge at USGS Gaging Station 15875000 at Umiat.

Table E.8.5. Summary of Discharge Data Collected at Ocean Point in 2019 and 2020

Ocean Point Transect	Date	Time	Measured Width (feet)	Measured Area (square feet)	Average Velocity (feet/second)	Measured Discharge (cfs)	Coincident Discharge at USGS Gaging Station 15875000 (cfs)
1	September 5, 2019	2:50 p.m.	1,270	7,570	3.0	29,068	19,800
6 (8.5 miles downstream of Transect 1)	September 5, 2019	4:50 p.m.	1,803	6,189	2.83	28,874	19,600
1	December 31, 2019	12:00 p.m.	650	880	0.15	135	Unavailable
1	February 25, 2020	Unavailable	304	228	0.04	9	Unavailable

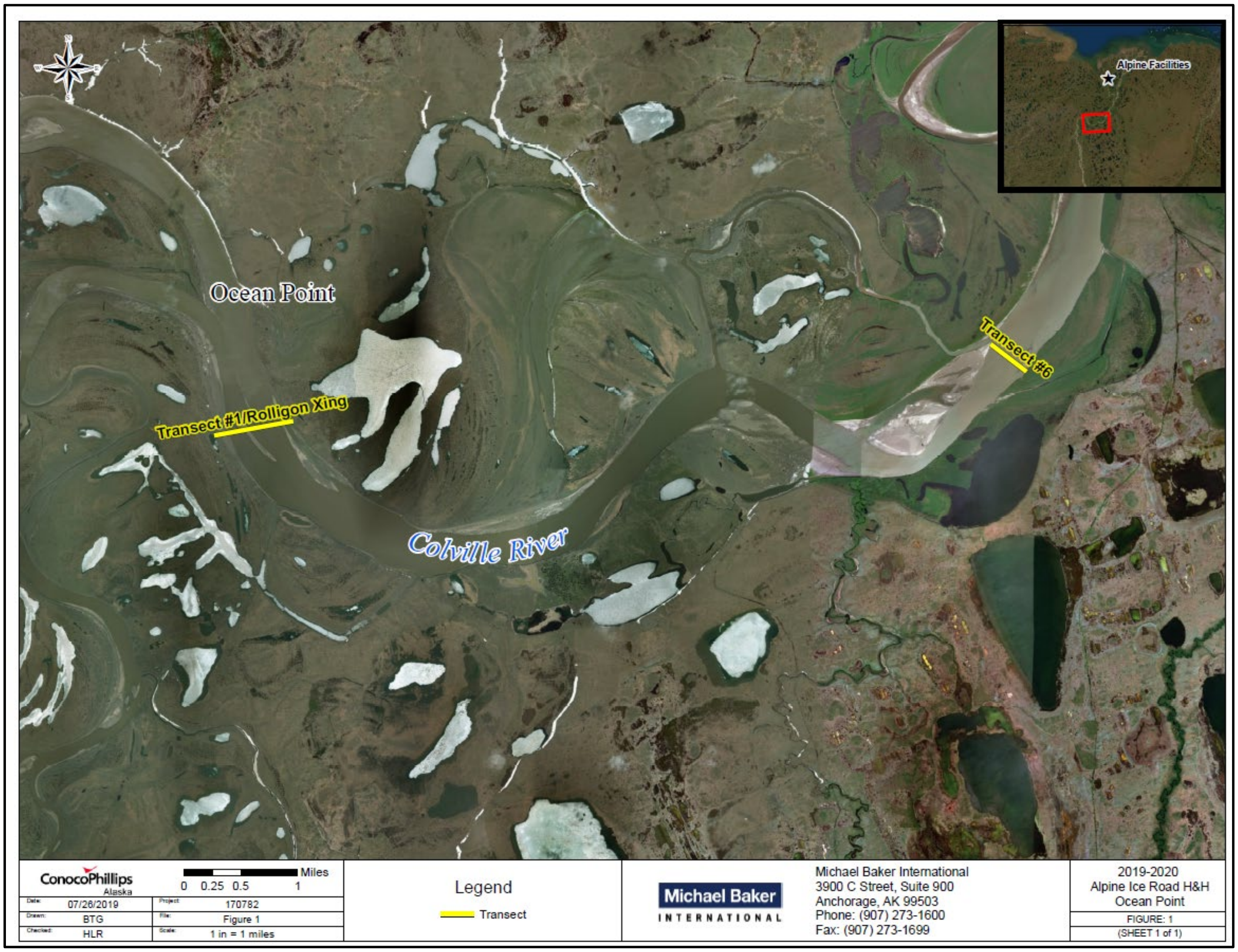
Source: MBI 2019, 2020b; USGS 2020a
Note: cfs (cubic feet per second); USGS (U.S. Geological Survey).

Based on the data available for Ocean Point and Umiat, discharge at Ocean Point was estimated using the drainage-area ratio method (Emerson, Vecchia et al. 2005) commonly used to estimate individual streamflow discharges for sites where no streamflow data are available using data from one or more nearby gaging stations (Table E.8.6). More information on how this estimate was developed in is Karle (2020), provided as Appendix E.8B, *Ocean Point Technical Memorandum*.

Table E.8.6. Estimated Colville River Mean Monthly Discharge (cubic feet per second) at Ocean Point

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
43.7	19.7	9.8	7.4	41,710	62,140	23,100	32,200	24,420	4,190	521.6	127.6

Note: Estimate based on mean monthly discharge at Umiat, 2010–2019 (USGS 2020a) using the drainage-area ratio method (Emerson, Vecchia et al. 2005).



Source: MBI 2019

Figure E.8.1. Ocean Point Data Collection Locations

1.2.2 Fish Creek (Uvlutuuq and Iqalliqpik Channels)

Fish Creek (Uvlutuuq and Iqalliqpik) has its headwater in the Arctic foothills and flows into Harrison Bay just east of the Colville River Delta. It has a drainage area of approximately 836 square miles, including its major tributaries: Judy (Kayyaaq) Creek, Judy (Iqalliqpik) Creek, and the Ublutuoch (Tiŋmiaqsiuġvik) River (Figure 3.8.1). The Willow Master Development Plan Project (Project) would cross or come near to all of these tributaries, which are described below. The Uvlutuuq channel of Fish Creek is upstream of the confluence with Judy (Iqalliqpik) Creek, and the Iqalliqpik channel of Fish Creek is downstream of the confluence.

The Project would cross Fish (Uvlutuuq) Creek at approximately RM 55.5, where the bankfull width is approximately 330 feet, the average bankfull depth is approximately 4.5 feet, and the depth to thalweg is approximately 6.4 feet (CPAI 2018b).

Spring breakup stage and discharge have been measured in Fish (Uvlutuuq) Creek for 17 years at RM 32.4 (Table E.8.7) (J. Aldrich [Arctic Hydrologic Consultants], personal communication to Richard Kemnitz [BLM]. September 11, 2018), about 22.8 RMs downstream from the proposed infrastructure. During that time, water began to flow between May 12 and June 5, with a median date of May 27. The annual peak discharge occurred between May 23 and June 18, with a median date of June 9. In 6 out of 17 years the peak stage occurred earlier and was higher than the stage at the time of the peak discharge. The largest difference between the peak stage and the stage at the peak discharge was 1.51 feet. The time from the beginning of flow to the peak discharge varied between 6 and 24 days, with a median time of 11 days. The annual peak discharge varied from 2,040 to 5,400 cfs, with a median of 3,370 cfs. Freeze-up data were collected in 14 of the 17 years. During that time, freeze-up occurred between October 4 and October 30, with a median date of October 17.

Table E.8.7. Summary of Annual Peak Stage and Annual Peak Discharge for Fish (Uvlutuuq) Creek at River Mile 32.4

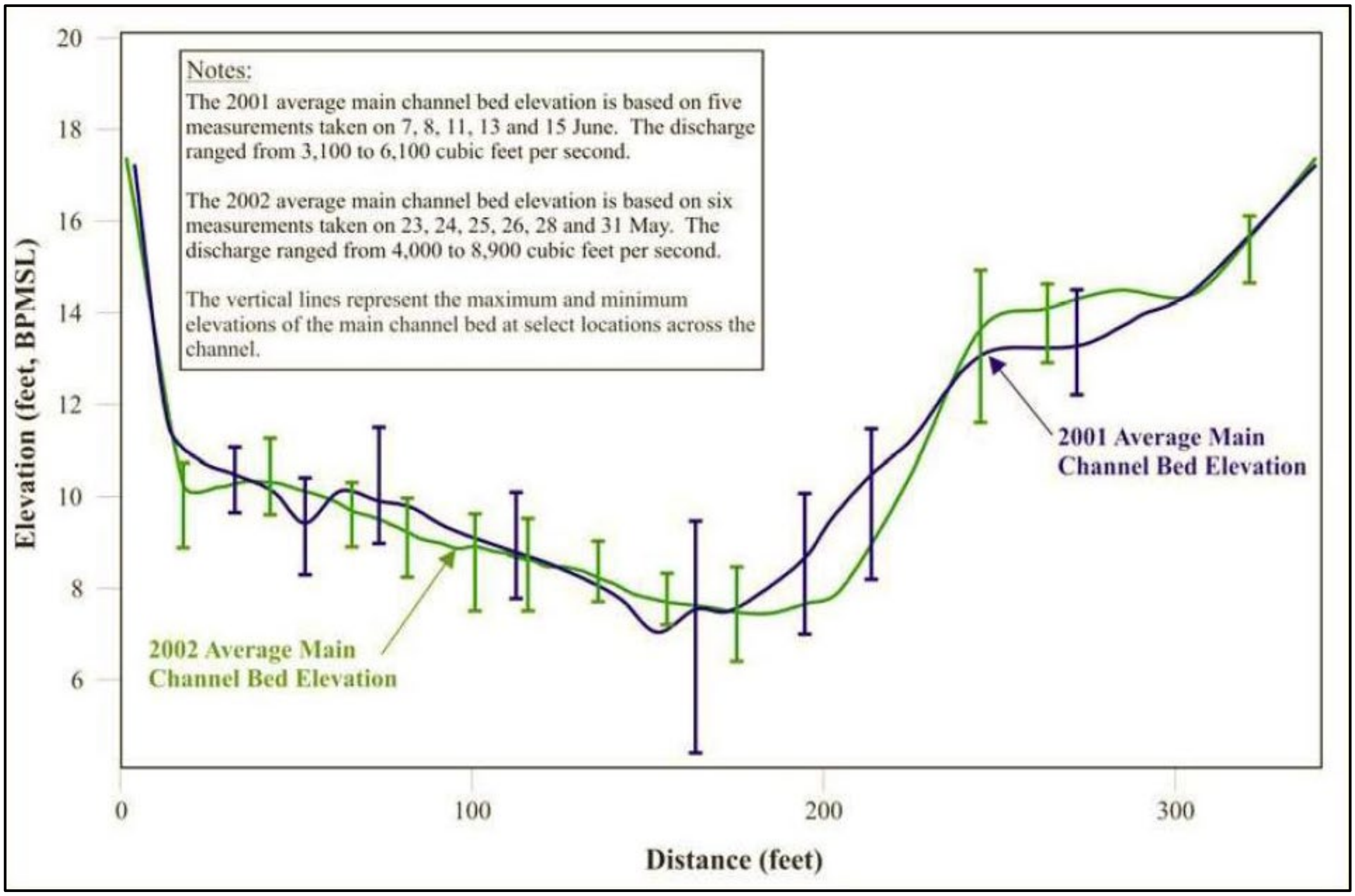
Year	Date Flow Begins (m/d)	Date of Freeze-Up (m/d)	Annual Peak Stage Date (m/d)	Annual Peak Stage (ft)	Annual Peak Stage Discharge (cfs)	Annual Peak Discharge Date (m/d)	Annual Peak Discharge Stage (ft)	Annual Peak Discharge (cfs)	Zero Flow to Peak Q (days)
2001	6/5	N/A	6/15	22.25	3,640	6/15	22.25	3,640	10
2002	5/17	N/A	5/27	22.42	3,685	5/27	22.42	3,685	10
2003	6/1	10/7 e	6/12	23.87	3,470	6/12	23.87	3,470	11
2004	6/2	10/30 e	6/9	23.48	4,410	6/9	23.48	4,410	7
2005	6/5	10/10 e	6/6	21.74	1,040	6/1	21.44	2,800	13
2006	5/27	10/16 e	6/12	21.72	3,170	6/12	21.72	3,170	16
2007	5/31	10/17 e	6/9	20.57	2,200	6/9	20.57	2,200	9
2008	5/23	10/4 e	6/6	20.12	2,270	6/6	20.12	2,270	14
2009	5/21	10/13	6/3	21.49	3,240	6/3	21.49	3,240	13
2010	6/1	10/8	6/9	23.50	3,730	6/9	23.50	3,730	8
2011	5/28	10/23	6/3	23.12	2,120	6/8	21.61	2,610	11
2012	5/25	10/20	6/6	22.25	2,720	6/11	21.93	3,510	17
2013	5/31	10/17	6/12	23.98	5,400	6/12	23.98	5,400	12
2014	5/15	10/17	5/20	22.35	2,290	6/8	21.77	3,370	24
2015	5/17	10/8	5/23	24.14	4,830	5/23	24.14	4,830	6
2016	5/12	10/21	5/27	20.10	1,470	5/31	20.08	2,040	19
2017	5/27	N/A	6/2	21.00	1,510	6/7	20.96	2,740	11

Source: J. Aldrich [Arctic Hydrologic Consultants], personal communication to Richard Kemnitz [BLM]. September 11, 2018
Note: cfs (cubic feet per second); d (day); e (estimate); ft (feet); m (month); N/A (not available); Q (discharge). Coordinates of the site (NAD27): 70.2706, -151.8692.

Both the Iqalliqpik and Uvlutuuq channels of Fish Creek are relatively low gradient and highly sinuous. Undercut stream banks and bank sloughing are common along the outside of meander bends (URS Corporation 2003). The riverbed appears to be very mobile. The river banks and bed of Fish Creek (both Iqalliqpik and Uvlutuuq channels) are composed of a mixture of sand and silt, with a median riverbed grain size of 0.13 millimeter (mm) at RM 25.1 and 0.037 mm at RM 32.4 (URS Corporation 2001). During the 2001 spring breakup, the maximum observed change in riverbed elevation was 5 feet at RM 25.1 and 7 feet at RM 32.4 (URS Corporation 2001). During the 2002 spring breakup, the maximum observed change in riverbed elevation was 3 feet at RM 25.1 and 1 foot at RM 32.4 (URS Corporation 2003). Figures E.8.2 and E.8.3 present the average riverbed elevation in 2001 and 2002 at RM 25.1 and RM 32.4, respectively. Also shown is the extent of the deviations from the average during those years.

On May 26, 2002, the discharge, suspended sediment load, and bedload were all measured at RM 25.1. The discharge was 8,900 cfs (the same as the annual peak discharge recorded the day before); the bedload was 423 tons per day; the suspended sediment load was 8,400 tons per day; and the total sediment load was computed to be 8,800 tons per day (URS Corporation 2003). The concentration of suspended sediment was 349 milligrams per liter. Approximately 6.1% of the bedload was composed of organic material (URS Corporation 2003). The median diameter of the mineral portion of the bedload was 0.12 mm and the specific gravity of the mineral portion of the bedload was 2.640 (URS Corporation 2003).

The daily changes in the channel bed that were recorded during the 2001 and 2002 breakups suggest that the bed is easily eroded, moved, and shaped by the flow (URS Corporation 2003). The interaction of the water-sediment mixture and the sand bed can create different bed configurations, such as ripples, dunes, transition, and antidunes. The type of bed form present affects both the hydraulic roughness and the rate of sediment transport, which affects the water velocity, the depth of the scour, and the WSE. At RM 25.1, dunes are probably present at discharges of 3,100 to 4,800 cfs (URS Corporation 2003). At discharges between 6,100 and 8,900 cfs, both dunes and antidunes are probably present (URS Corporation 2003). The antidunes are probably confined to the deepest and/or fastest portions of the channel (URS Corporation 2003). As the discharge increases beyond 6,100 cfs, the portion of the bed covered by antidunes is likely to increase (URS Corporation 2003). At RM 32.4, both ripples and dunes are probably present at discharges of 1,500 to 2,300 cfs (URS Corporation 2003). At discharges between 3,100 and 3,700 cfs, dunes are probably the predominant bed form.



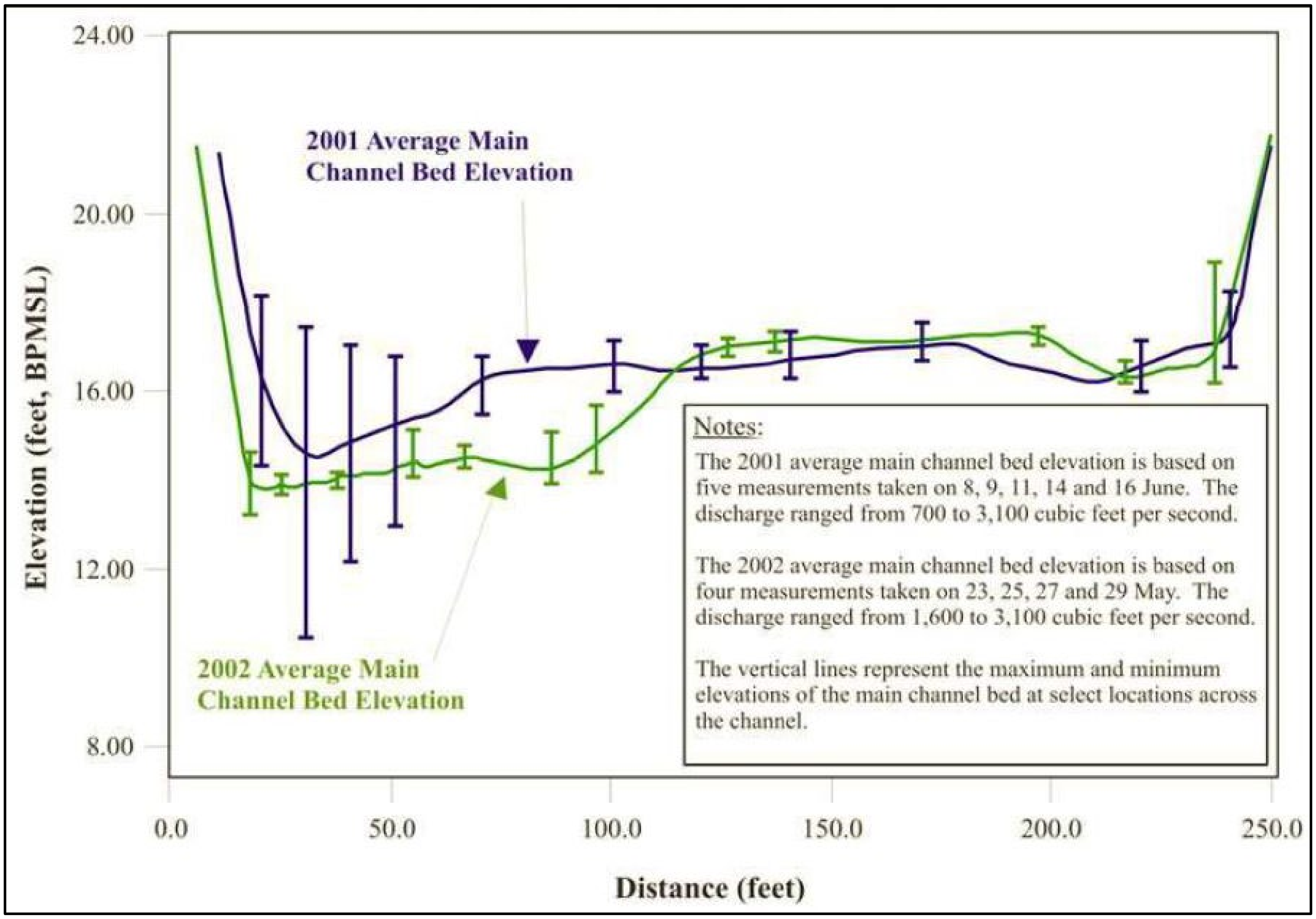
Source: URS Corporation 2003

Figure E.8.2. Average Riverbed Elevation in Fish (Iqalliqpik) Creek at River Mile 25.1, 2001 and 2002

Discharge and water surface slope measurements, along with surveyed cross-sections and a water surface profile model, were used to estimate hydraulic roughness in the channel on a particular day during spring breakup using data collected in both 2001 and 2002. At RM 25.1, the channel hydraulic roughness on the day of the measurements was 0.021 in both 2001 and 2002 (URS Corporation 2003). At RM 32.4, the channel hydraulic roughness on the day of the measurements was 0.028 in 2001 and 0.030 in 2002 (URS Corporation 2003). At RM 43.3, the channel hydraulic roughness on the day of the measurements was 0.027 in both 2001 and 2002. Although the values probably change from day to day during breakup and from year to year, the computed values are within the range of values one would expect when dunes and antidunes are present on the riverbed (0.014–0.035). Computations of hydraulic roughness based on measured discharge and water surface slope, and normal depth computations, on 5 to 6 days during breakup in both 2001 and 2002 suggested a slightly bigger range in hydraulic roughness values, but the values are still within the range one would expect when dunes and antidunes are present (URS Corporation 2003).

Seventeen years of summer flow data is available for Fish (Uvlutuuq) Creek at RM 32.4 (J. Aldrich [Arctic Hydrologic Consultants], personal communication to Richard Kemnitz [BLM]. September 11, 2018) . A summary of the available mean monthly discharge data is provided in Table E.8.8.

In 2018, a monitoring site was established at RM 55.5 (Michael Baker Jr. Inc. 2018). Observations during the 2018 spring breakup indicated the peak stage (46.25 feet [North American Vertical Datum of 1988]) occurred 0.5 hour after the peak discharge (4,400 cfs; WSE 46.03 feet NAVD88) and at a time when the channel was not impacted by snow or ice within the channel at the monitoring site (Michael Baker Jr. Inc. 2018). This suggests that the peak stage was due to backwater, possibly due to an ice jam downstream. Prior to the peak discharge, WSEs at the monitoring site had been impacted by snow and ice in the channel and an ice jam (Michael Baker Jr. Inc. 2018). It was also noted that the riverbed was mobile during spring breakup (Michael Baker Jr. Inc. 2018). Figure E.8.4 presents a cross-section of the channel showing the discharge measurement. In general, the WSE decreased throughout the summer but increased in early September in response to a rain event (Michael Baker Jr. Inc. 2018). Maximum and minimum summer WSEs were 43.17 feet NAVD88 (fall rainfall peak) and 40.74 feet NAVD88.



Source: URS Corporation 2003

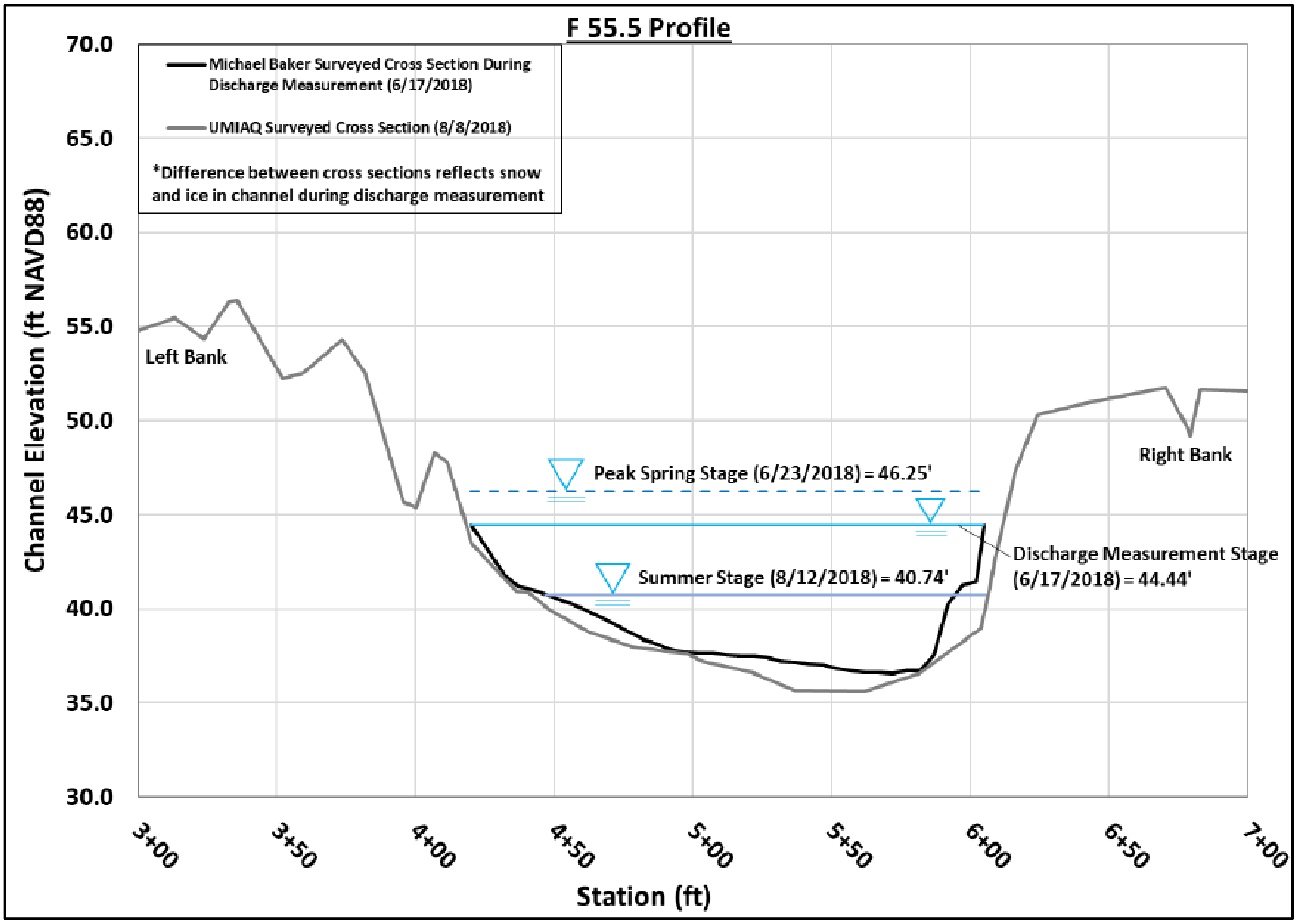
Figure E.8.3. Average Riverbed Elevation in Fish (Uvlutuuq) Creek at River Mile 32.4, 2001 and 2002

Table E.8.8. Mean Monthly Discharge (cubic feet per second) in Fish (Uvlutuuq) Creek at River Mile 32.4

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	–	–	–	–	–	1,761	697	412	298	242	208	173
2002	137	104	70	35	808	1,118	526	252	259	230	199	168
2003	137	107	77	47	16	1,620	633	391	341	173	25	0
2004	0	0	0	0	0	2,311	732	331	298	196	38	0
2005	0	0	0	0	0	1,484	750	282	171	44	6	0.2
2006	0	0	0	0	47	1,643	555	298	210	132	40	2
2007	0	0	0	0	0	10,004	259	66	37	12	0.1	0
2008	0	0	0	0	112	911	224	113	73	17	0	0
2009	0	0	0	0	432	1,684	405	179	196	63	5	0
2010	0	0	0	0	0	1,719	532	321	191	59	3	0
2011	0	0	0	0	37	1,600	437	206	185	120	28	2
2012	0	0	0	0	15	1,748	459	240	256	185	25	0
2013	0	0	0	0	0.6	2,617	803	439	386	293	27	0
2014	0	0	0	0	753	2,014	877	353	282	190	31	0.7
2015	0	0	0	0	1424	1,637	402	203	165	62	19	0.6
2016	0	0	0	0	325	1,085	372	245	518	352	45	1
2017	0	0	0	0	91	1,555	486	619	846	806	262	14

Source: J. Aldrich [Arctic Hydrologic Consultants], personal communication to Richard Kemnitz [BLM]. September 11, 2018
Note: "–" (no data).

Observations during the 2019 spring breakup indicated the peak stage of 44.71 feet NAVD88 and an estimated peak discharge of 5,100 cfs, both on May 28. Summer stage levels generally remained below peak spring stage. During a late summer precipitation event, stage crested at levels observed near the end of spring breakup. The minimum recorded summer stage was 40.08 feet NAVD88 on July 20, and the highest recorded summer stage was 42.59 feet NAVD88 on August 29 (Michael Baker International 2020b).



Source: Michael Baker Jr. Inc. 2018

Figure E.8.4. Cross-Section on Fish (Uvlutuuq) Creek at River Mile 55.5

Table E.8.9 presents flood-peak magnitude and frequency estimates for Fish (Uvlutuuq) Creek at RM 55.5 based on the Curran et al. (2003) USGS 2003 regression equations (Michael Baker Jr. Inc. 2018).

Table E.8.9. Flood Magnitude and Frequency in Fish (Uvlutuuq) Creek at River Mile 55.5

Percent Chance of Exceedance in Any Given Year (%)	Recurrence Interval (years)	Annual Peak Discharge (cfs)
50	2	10,400
20	5	15,200
10	10	18,200
4	25	21,800
2	50	24,400
1	100	26,900

Source: Michael Baker Jr. Inc. 2018

Spring breakup observations have also been made at the following sites:

- RM 0.7 in 2001 (URS Corporation 2001), 2002 (URS Corporation 2003), 2005 (Michael Baker International 2005), and 2006 (Michael Baker International 2007)
- RM 10.3 in 2005 (Michael Baker International 2005) and 2006 (Michael Baker International 2007)
- RM 11.7 in 2001 (URS Corporation 2001) and 2002 (URS Corporation 2003)
- RM 12.6 in 2001 (URS Corporation 2001) and 2002 (URS Corporation 2003)
- RM 18.4 in 2001 (URS Corporation 2001) and 2002 (URS Corporation 2003)
- RM 25.1 in 2005 (Michael Baker International 2005) and 2006 (Michael Baker International 2007)
- RM 32.4 in 2005 (Michael Baker International 2005) and 2006 (Michael Baker International 2007)
- RM 43.3 in 2001 (URS Corporation 2001) and 2002 (URS Corporation 2003)

Hydraulic designs on Fish (Uvlutuuq) Creek should consider the flood-peak data that have been collected on Fish (Uvlutuuq) Creek at RM 32.4, the highly mobile bed, the impact of ice and snow on annual peak WSEs, and the riverbed forms and hydraulic roughness likely to be present at the design discharge. In developing flood-peak magnitude and frequency estimates on streams in the Fish (Uvlutuuq) Creek basin, the 17 years of data collected at RM 32.4 should be considered. Single-station flood-peak magnitude and frequency analyses could be conducted with these data to estimate the flood-peak magnitude and frequencies at RM 32.4. A best estimate of the flood-peak magnitude and frequency at RM 32.4 could then be developed from a weighted average based on the uncertainty associated with estimates from each of two methods: the single-station frequency analysis and the Shell regression equations[1] (Arctic Hydrological Consultants and ERM 2015). The weighted average estimate would then be extrapolated to other locations within the basins as a proportion of the Shell regression equation estimate.

Since the hydraulic roughness is changing throughout spring breakup, when designing structures on this river it would be prudent to consider a range of hydraulic roughness values. Higher hydraulic roughness values will provide estimates with high WSEs and lower velocities. Lower hydraulic roughness values will provide estimates with lower WSEs and higher velocities. Both conditions are important when designing structures within the channel and floodplain.

1.2.2.1 Willow Creek 8

Willow Creek 8 is a tributary of Fish (Uvlutuuq) Creek. It has a meandering, incised channel with intermittent deep, beaded pools (Michael Baker Jr. Inc. 2018). The infield road for all action alternatives would cross Willow Creek 8 at the MBI TBD_6 and SW22 monitoring sites, about 1.7 and 3 RMs upstream of the Fish (Uvlutuuq) Creek confluence, respectively (Michael Baker Jr. Inc. 2018). At the SW22 crossing, Willow Creek 8 has a poorly defined channel in a low-lying area of polygon troughs connecting Lake M0305 to an unnamed lake to the south (Michael Baker Jr. Inc. 2018). At TBD_6, the Willow Creek 8 channel is incised and well defined. At TBD_6, the bankfull width is approximately 32 feet and the average bankfull depth is approximately 4.8 feet (CPAI 2018b). Monitoring sites TBD_6 and SW22 were established in 2018.

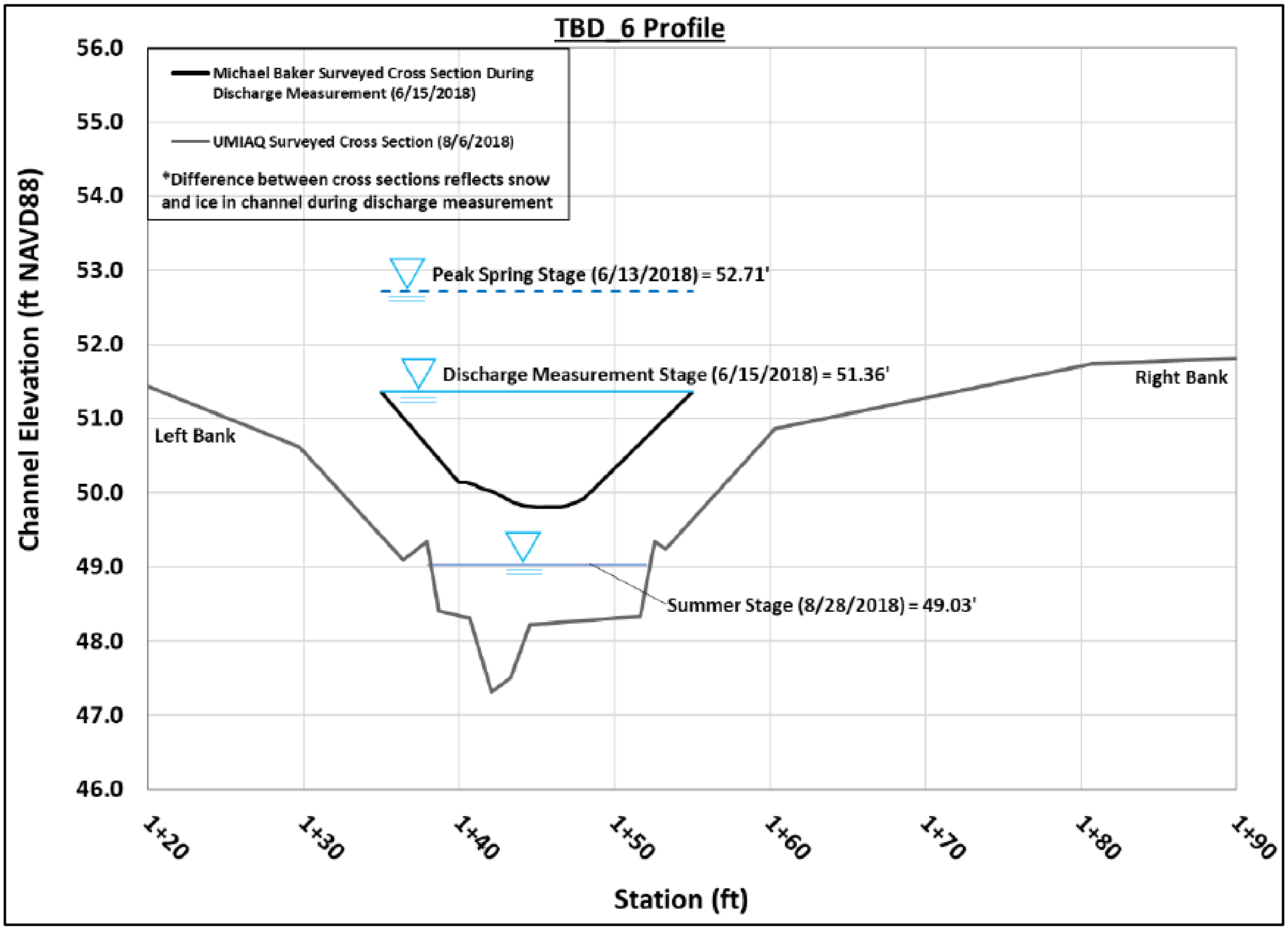
Due to low relief and the wide area of possible flow paths, the SW22 gage was not placed in the main flow path, and neither peak stage nor peak discharge information was collected during the 2018 spring breakup (Michael Baker Jr. Inc. 2018). At TBD_6, the peak stage was 52.71 feet NAVD88 and occurred on June 13. At the time of the peak stage there was snow and ice in the channel and overbank flooding (Michael Baker Jr. Inc. 2018). It is likely that the peak stage occurred prior to the peak discharge (Michael Baker Jr. Inc. 2018). The date and magnitude of the peak discharge were not recorded.

Figure E.8.5 shows a cross-section of the channel at TBD_6, including a cross-section from a June 15, 2018, discharge measurement, and the 2018 spring peak stage. The difference in the cross-sections, and the difference between the June 13 and 15 WSEs, is an indication of the magnitude of the impact of snow and ice on the peak stage and during the likely time of the peak discharge.

In general, the stage at TBD_6 fell throughout the summer except for fluctuations due to summer precipitation events (Michael Baker Jr. Inc. 2018). At the end of the summer monitoring season, the stage increased due to a late summer precipitation event (Michael Baker Jr. Inc. 2018). However, the stage remained well below the spring breakup peak stage throughout the summer (Michael Baker Jr. Inc. 2018). The maximum and minimum summer stages at TBD_6 were 50.18 feet and 49.03 feet NAVD88, respectively (Michael Baker Jr. Inc. 2018).

During the 2019 spring breakup, the TBD_6 peak stage was 53.72 feet NAVD88 on May 29. A discharge of 90 cfs was measured on May 30. The measured summer stage levels remained well below the spring breakup peak stage. The stage fluctuations reflected summer precipitation events. The minimum recorded summer stage was 49.07 feet NAVD88 on July 30 and the highest recorded summer stage was 50.96 feet NAVD88 on August 28 (Michael Baker International 2020b).

[1] The Shell regression equations are suggested rather than the 2003 USGS regression equations because considerably more North Slope river data were used to prepare the Shell regression equations than the USGS regression equations.



Source: Michael Baker Jr. Inc. 2018

Figure E.8.5. Cross-Section of Willow Creek 8 at Monitoring Site TBD_6

1.2.2.2 Judy (Iqalliqpik) Creek

Judy (Iqalliqpik) Creek has its headwater in the Arctic foothills and flows into Fish (Iqalliqpik) Creek at RM 26. Much of the Project infrastructure would be within the Judy (Iqalliqpik) Creek basin; Alternatives B (Proponent's Project) and D (Disconnected Access) would cross the main stem of Judy (Iqalliqpik) Creek at approximately RM 21.4 (Michael Baker Jr. Inc. 2018). At RM 21.4, the bankfull width is approximately 175 feet and the average bankfull depth is approximately 2.0 feet (CPAI 2018b). Several tributaries of Judy (Iqalliqpik) Creek are also crossed by the infrastructure: Judy (Kayyaaq) Creek, Willow Creek 1, Willow Creek 2, Willow Creek 3, Willow Creek 4, and Willow Creek 4A.

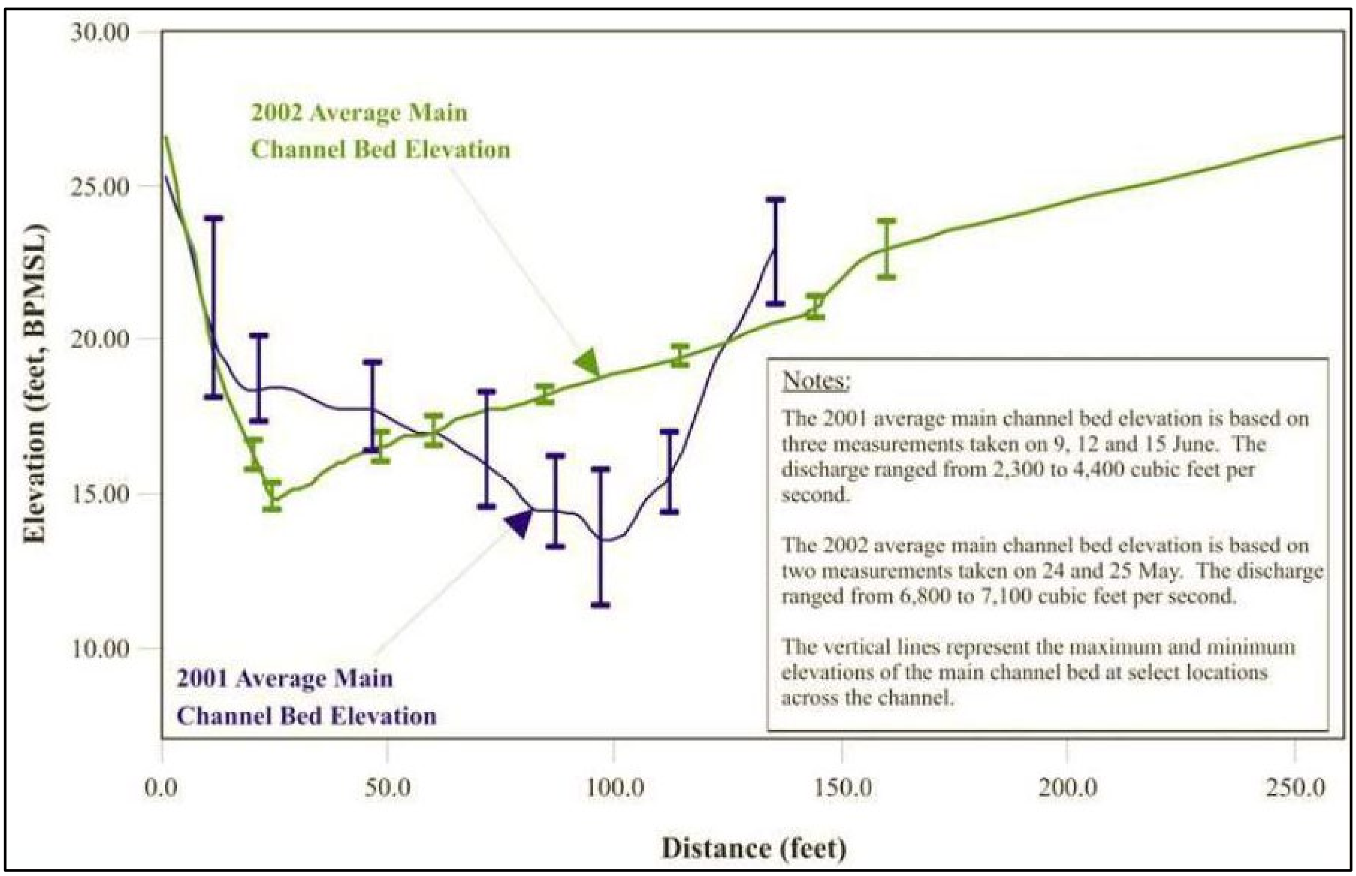
The spring breakup stage and discharge have been measured on the main stem of Judy (Iqalliqpik) Creek for 17 years at RM 7 (J. Aldrich [Arctic Hydrologic Consultants], personal communication to Richard Kemnitz [BLM]. September 11, 2018) , about 13.3 RMs downstream from the proposed infrastructure (Table E.8.10). The date on which water began to flow during that time was between May 11 and June 5, with a median date of May 26. The annual peak discharge occurred between May 18 and June 10, with a median date of June 5. In 6 out of 17 years the peak stage occurred earlier and was higher than the stage at the time of the peak discharge. The largest difference was 2.39 feet. The time from the beginning of flow to the peak discharge varied between 1 and 12 days, with a median time of 8 days. The annual peak discharge varied from 2,250 to 9,210 cfs, with a median of 4,770 cfs. Freeze-up data were collected in 14 of the 17 years. During that time, freeze-up occurred between September 20 and October 11, with a median date of September 26.

Judy (Iqalliqpik) Creek has a relatively low gradient and a highly sinuous channel. Undercut stream banks and bank sloughing are common along the outside of meander bends (URS Corporation 2003). The Judy (Iqalliqpik) Creek riverbed appears to be very mobile. The river banks and bed are composed of a mixture of sand and silt, with a median riverbed grain size of 0.17 mm at RM 7 (URS Corporation 2001). During the 2001 spring breakup, the maximum observed change in riverbed elevation at RM 7 was 5 feet (URS Corporation 2001). During the 2002 spring breakup, the maximum observed change in riverbed elevation at RM 7 was 2 feet (URS Corporation 2003). Figure E.8.6 presents the average riverbed elevation in 2001 and 2002 at RM 7 and the deviations from average during those years.

Table E.8.10. Summary of Annual Peak Stage and Discharge for Judy (Iqalliqpik) Creek at River Mile 7

Year	Date Flow Begins (m/d)	Date of Freeze-Up (m/d)	Annual Peak Stage Date (m/d)	Annual Peak Stage (ft)	Annual Peak Stage Discharge (cfs)	Annual Peak Discharge Date (m/d)	Annual Peak Discharge Stage (ft)	Annual Peak Discharge (cfs)	Zero Flow to Peak Q (days)
2001	6/5	N/A	6/10	27.11	N/A	6/10	27.11	5,590	5
2002	5/18	N/A	5/25	26.81	N/A	5/25	26.81	7,150	7
2003	5/31	9/25	6/6	28.00	N/A	6/6	25.61	4,720	7
2004	5/18	9/26	5/26	28.55	N/A	6/5	26.62	4,770	8
2005	6/2	9/26	6/6	27.47	N/A	6/10	25.99	4,400	8
2006	5/26	10/5	5/30	26.00	N/A	6/7	24.97	3,930	12
2007	5/26	9/23	6/5	25.40	N/A	6/5	25.40	4,560	10
2008	5/22	9/29	5/29	24.93	N/A	5/29	24.93	3,850	7
2009	5/18	9/23	5/27	25.16	N/A	5/28	24.78	2,250	10
2010	6/2	9/26	6/8	27.95	N/A	6/8	27.95	9,210	6
2011	5/30	10/1	5/31	30.05	N/A	5/31	29.66	5,480	1
2012	5/26	10/9	6/5	26.86	N/A	6/5	26.86	6,950	10
2013	5/31	9/26	6/9	26.86	N/A	6/9	26.86	6,300	10
2014	5/14	10/10	5/18	30.07	N/A	5/18	30.07	5,410	4
2015	5/18	9/20	5/22	29.21	N/A	5/22	29.21	5,990	4
2016	5/11	10/11	5/22	26.21	N/A	5/22	26.21	4,010	11
2017	5/26	N/A	6/3	25.85	N/A	6/3	25.85	4,070	8

Source: J. Aldrich (Arctic Hydrologic Consultants), personal communication to Richard Kemnitz (BLM). September 11, 2018
Note: cfs (cubic feet per second); d (day); e (estimate); ft (feet); m (month); N/A (not available); Q (discharge); RM (river mile). The coordinates of the site (NAD27): 70.2206, -151.8352).



Source: URS Corporation 2003

Figure E.8.6. Average Riverbed Elevation for Judy (Iqalliqpik) Creek at River Mile 7, 2001 and 2002

The daily changes in the channel bed that were recorded during the 2001 and 2002 breakups suggest that the bed is easily eroded, moved, and shaped by the flow (URS Corporation 2003). At RM 7, dunes are probably present at discharges on the order of 2,300 cfs (URS Corporation 2003). At discharges between 3,200 and 7,000 cfs, both dunes and antidunes are probably present (URS Corporation 2003). The antidunes are probably confined to the deepest and/or the fastest portions of the channel (URS Corporation 2003). At discharges above 7,000 cfs, it is likely that antidunes cover the bed (URS Corporation 2003).

Discharge and water surface slope measurements, along with surveyed cross-sections and a water surface profile model, were used to estimate hydraulic roughness in the channel on a particular day during spring breakup using data collected in both 2001 and 2002. At RM 7 the channel hydraulic roughness on the day of the measurements was 0.014 in 2001 and 0.024 in 2002 (URS Corporation 2003). At RM 13.8 the channel hydraulic roughness on the day of the measurements was 0.020 in 2001 and 0.024 in 2002 (URS Corporation 2003). Although the values probably change from day to day during breakup and from year to year, the computed values are within the range of values one would expect when dunes and antidunes are present on the riverbed (0.014–0.035). Computations of hydraulic roughness based on measured discharge and water surface slope, and normal depth computations, at RM 7 on several different days suggest that in 2001 the hydraulic roughness during ice- and snow-impacted conditions varied from 0.022 to 0.028 (URS Corporation 2003). Similar computations during open-water conditions in 2001 and 2002 suggest that the hydraulic roughness varies from 0.13 to 0.022.

Seventeen years of summer flow data is available for Judy (Iqalliqpik) Creek at RM 7 (J. Aldrich [Arctic Hydrologic Consultants], personal communication to Richard Kemnitz [BLM]. September 11, 2018) . A summary of the available mean monthly discharge data is provided in Table E.8.11.

Table E.8.11. Mean Monthly Discharge (cubic feet per second) in Judy (Iqalliqpik) Creek at River Mile 7

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	–	–	–	–	–	1,448	175	175	176	129	78	26
2002	0	0	0	0	1,273	492	285	166	155	110	66	22
2003	0	0	0	0	1	1,306	307	171	214	60	0.9	0
2004	0	0	0	0	493	1,786	263	155	221	51	3	0
2005	0	0	0	0	0	1,717	271	72	63	13	0	0
2006	0	0	0	0	93	1,559	164	133	85	38	4	0
2007	0	0	0	0	1	879	65	21	14	2	0	0
2008	0	0	0	0	334	775	91	65	42	4	0	0
2009	0	0	0	0	513	904	103	90	166	38	3	0
2010	0	0	0	0	0	1,718	149	220	113	18	1	0
2011	0	0	0	0	250	1,473	167	81	151	65	3	0
2012	0	0	0	0	64	1,785	132	82	161	86	3	0
2013	0	0	0	0	6	2,537	264	170	186	93	8	0
2014	0	0	0	0	1,044	1,469	310	134	166	85	8	0
2015	0	0	0	0	1,268	650	128	89	110	12	0	0
2016	0	0	0	0	977	570	106	139	358	308	41	0
2017	0	0	0	0	165	1,557	144	512	753	600	73	3

Source: J. Aldrich (Arctic Hydrologic Consultants), personal communication to Richard Kemnitz (BLM). September 11, 2018
Note: "–" (no data).

At RM 13.8, spring breakup peak WSEs have been measured periodically since 2001 (Table E.8.12).

Table E.8.12. Historical Peak Stage in Judy (Iqalliqpik) Creek at River Mile 13.8

Year	Peak Stage (feet BPMSL)	Date
2019	35.81	5/27
2018	37.09	6/6
2017	34.68	6/4
2006	35.56	5/30
2005	37.25	6/4
2004	–	–
2003	36.58	6/6
2002	35.86	5/25
2001	39.66	6/7

Note: "–" (no data); BPMSL (British Petroleum Mean Sea Level). Table adapted from Table 4.3 in Michael Baker Jr. Inc. (2018).

Observations made during the 2018 spring breakup at RM 13.8 indicated the peak stage (37.09 feet NAVD88) occurred prior to the peak discharge (4,100 cfs; WSE 36.37 feet NAVD88). On the day of the peak discharge, some intermittent ice floes were observed and considerable snow was present along each bank, but no bottom-fast ice was observed (Michael Baker Jr. Inc. 2018). It was also noted that the riverbed was mobile on both the day of the peak discharge and 10 days after the peak discharge, and that on the later date a moving bed velocity averaging 0.7 feet per second was observed (Michael Baker Jr. Inc. 2018). In 2019, recorded stage data revealed multiple spikes followed by declines in stage, indicating ice jams and associated backwater releases upstream of the J13.8 reach.

At RM 21.4, spring breakup monitoring was conducted in 2017, 2018, and 2019 (CPAI 2018a; Michael Baker International 2020a; Michael Baker Jr. Inc. 2018). In 2017, the peak stage was recorded as 90.2 feet (arbitrary datum; [CPAI 2018a]); in 2018, the peak stage was recorded as 51.24 feet NAVD88 (Michael Baker Jr. Inc. 2018); and in 2019, the peak stage was recorded as 49.80 feet NAVD88 (Michael Baker International 2020a). In 2018, it was noted that the channel bed was highly mobile during spring breakup (Michael Baker Jr. Inc. 2018). Summer stage was measured in 2018 and indicated that the stage fluctuated with precipitation, but water levels remained below the peak spring breakup stage (Michael Baker Jr. Inc. 2018). The stage increased at the end of the summer monitoring period due to a late summer precipitation event. Maximum and minimum summer WSEs in 2018 were 47.49 feet NAVD88 (fall rainfall peak) and 44.78 feet NAVD88. In 2019, a late summer precipitation event caused the stage to crest to levels observed near the end of spring breakup. The peak summer stage was 49.8 feet on May 27.

Table E.8.13 presents flood-peak magnitude and frequency estimates for Judy (Iqalliqpik) Creek at RM 13.8 based on the Curran et al. (2003) USGS 2003 regression equations (Michael Baker Jr. Inc. 2018).

Table E.8.13. Flood Magnitude and Frequency in Judy (Iqalliqpik) Creek at River Mile 13.8

Percent Chance of Exceedance in Any Given Year (%)	Recurrence Interval (years)	Annual Peak Discharge (cubic feet per second)
50	2	7,400
20	5	10,900
10	10	13,100
4	25	15,800
2	50	17,700
1	100	19,500

Source: Michael Baker Jr. Inc. 2018

Spring breakup observations have also been made at the following sites:

- RM 16.5 in 2017 (CPAI 2018a)
- RM 31.0 in 2001 (URS Corporation 2001)

Hydraulic designs on Judy (Iqalliqpik) Creek should consider the flood-peak data that have been collected on Judy (Iqalliqpik) Creek at RM 7, the highly mobile bed, the impact of ice and snow on annual peak WSEs, and the riverbed forms and hydraulic roughness likely to be present at the design discharge. In developing flood-peak magnitude and frequency estimates on streams in the Judy (Iqalliqpik) Creek basin, the 17 years of data collected at RM 7 should be considered. A single-station flood-peak magnitude and frequency analyses could be conducted with these data to estimate the flood-peak magnitude and frequencies at RM 7. A best estimate of the flood-peak magnitude and frequency at RM 7 could then be developed from a weighted average, based on the uncertainty associated with estimates from each of two methods: the single-station frequency analysis, and the Shell regression equations[2] (Arctic Hydrological Consultants and ERM 2015). The weighted average estimate would then be extrapolated to other locations within the basins as a proportion of the Shell regression equation estimate.

Since the hydraulic roughness is changing throughout spring breakup, when designing structures on this river it would be prudent to consider a range of hydraulic roughness values. Higher hydraulic roughness values would provide estimates with higher WSEs and lower velocities. Lower hydraulic roughness values would provide estimates with lower WSEs and higher velocities. Both conditions are important when designing structures within the channel and the floodplain.

1.2.2.2.1 Judy (Kayyaaq) Creek

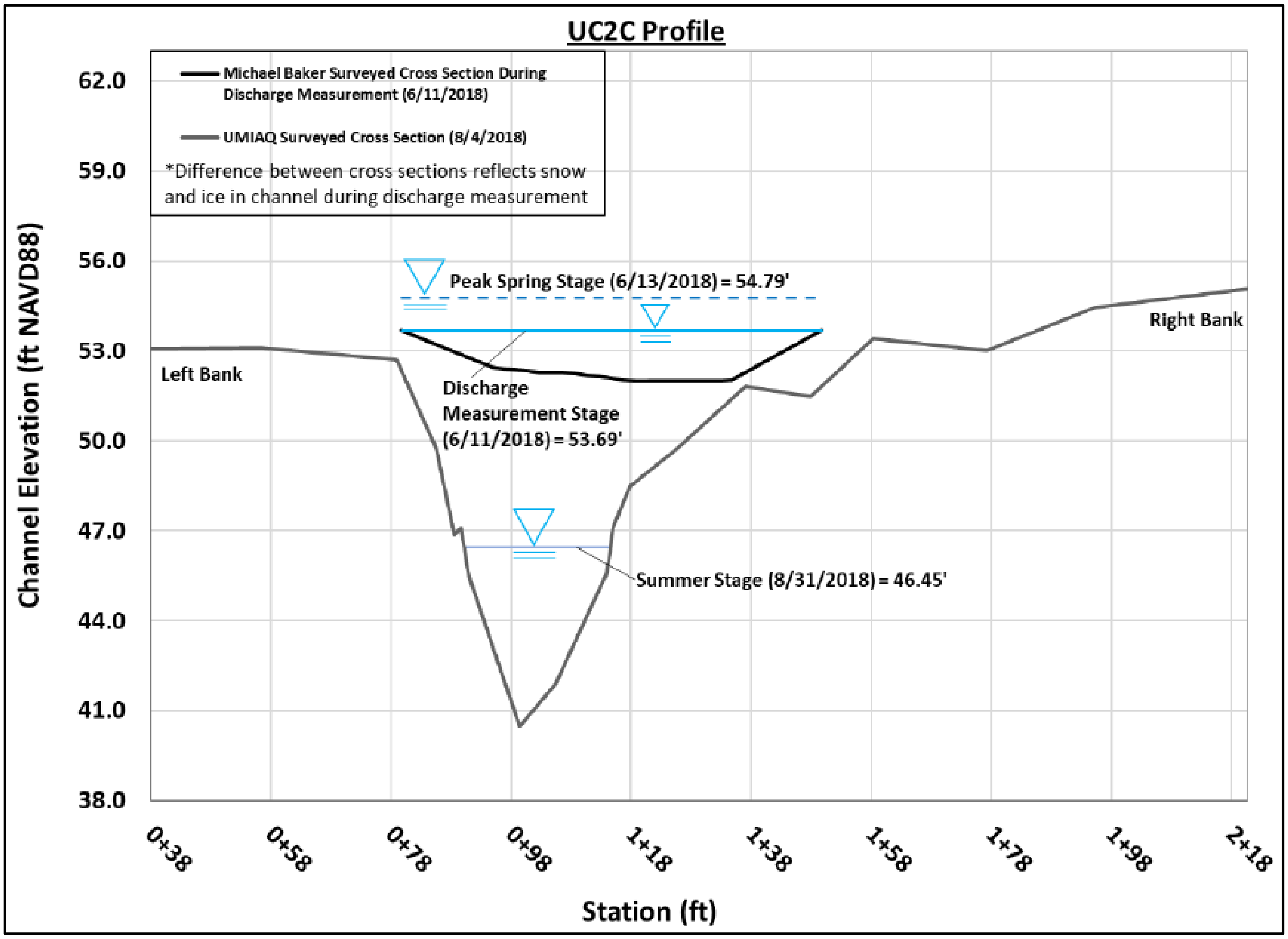
Judy (Kayyaaq) Creek is a tributary to Judy (Iqalliqpik) Creek. It has a highly sinuous and incised channel: over 8 feet from the top of the bank to the streambed and typically about 30 feet wide (Michael Baker Jr. Inc. 2018). The

[2] The Shell regression equations are suggested rather than the 2003 USGS regression equations because considerably more North Slope river data was used to prepare the Shell regression equations than the USGS regression equations.

UC2A, UC2B and UC2C gaging stations were established at approximately RM 8.4, 10.2, and 13.0, respectively (Michael Baker Jr. Inc. 2017). The UC2C gaging station is located where the infield road (for all action alternatives) would cross Judy (Kayyaaq) Creek (Michael Baker Jr. Inc. 2017), about 13 miles upstream from the confluence with Judy (Iqalliqpik) Creek. At RM 13.0 (UC2C gage) the bankfull width is approximately 20 feet and the average bankfull depth is approximately 5.5 feet (CPAI 2018b). Spring breakup and the summer stage have been monitored in both 2017 and 2018.

In both 2017 and 2018, the channel was full of wind-blown snow prior to the start of breakup (Michael Baker Jr. Inc. 2017, 2018). In 2017, it was reported that water began flowing on top of the drifted snow at all of the monitoring stations and then cut a channel down through the wind-blown snow (Michael Baker Jr. Inc. 2017). It was also stated that in 2017 the peak stage at all of the monitoring stations was elevated above bankfull by snow and ice in the channel and that the peak stage probably did not occur at the same time as the peak discharge (Michael Baker Jr. Inc. 2017). At UC2C the peak stage in 2017 was 99.88 feet (arbitrary datum) and occurred on May 30 (Michael Baker Jr. Inc. 2017). In 2018, the peak stage at UC2C was 54.78 feet NAVD88 and occurred on June 13 (Michael Baker Jr. Inc. 2018). In 2018, the peak stage was believed to have occurred at the same time as the peak discharge (Michael Baker Jr. Inc. 2018). At the time of the peak stage, “overbank flooding and minimal impedance from snow” was reported (Michael Baker Jr. Inc. 2018). However, since an observer could probably not have seen through 13-plus feet of water (Figure E.8.7), it seems unknown whether or not the peak stage and/or the stage at the peak discharge were impacted by snow and ice in the bottom of the channel. No estimate for the 2018 peak discharge was provided (Michael Baker Jr. Inc. 2018). Bankfull conditions with some overbank flooding in low-lying areas persisted through at least June 18.

Figure E.8.7 presents a surveyed cross-section at UC2C and a cross-section taken during a spring breakup discharge measurement (Michael Baker Jr. Inc. 2018). The difference between the cross-sections, and the difference between the WSE’s on June 11 and 13, represents the impact of snow and ice in the channel on the WSE.



Source: Michael Baker Jr. Inc. 2018

Figure E.8.7. Cross-Section of Judy (Kayyaaq) Creek at Gaging Station UC2C

In both 2017 and 2018, the summer stage fluctuated with precipitation, but water levels remained below the spring breakup peak stage. The maximum and minimum stages recorded at UC2C during summer 2017 were 93.1 feet and 90.85 feet, respectively (both based on an arbitrary datum). The maximum and minimum stages recorded at UC2C during the summer of 2018 were 47.81 feet and 46.45 feet NAVD88, respectively. In both years, the stage increased in the beginning of September as a result of precipitation events.

1.2.2.2.2 Willow Creek 1

Willow Creek 1 is a tributary of Judy (Iqalliqpik) Creek. Alternatives B (Proponent's Proposal) and C (Disconnected Infield Roads) would cross Willow Creek 1 between Lake R0060 and Lake M0016, which is also where the W1S monitoring site is located in a poorly defined, low-lying area (Michael Baker Jr. Inc. 2018).

The 2018 spring breakup peak stage at W1S was 79.16 feet NAVD88 and occurred on June 6 (Michael Baker Jr. Inc. 2018). The 2019 spring breakup peak stage was 79.25 feet NAVD88 and occurred on May 28 (Michael Baker International 2020a). Throughout the entire breakup monitoring periods for both 2019 and 2020, no distinguishable channel or discernible flow was identified near W1S, and the peak stage was probably the result of ponded local melt (Michael Baker International 2020a; Michael Baker Jr. Inc. 2018). During the summer, small stage fluctuations associated with summer precipitation were recorded, but water levels remained below the spring breakup peak stage (Michael Baker Jr. Inc. 2018). The 2018 maximum and minimum summer stages at W1S were 78.59 feet NAVD88 and 78.39 feet NAVD88, respectively (Michael Baker Jr. Inc. 2018). During summer 2018, no defined channel or flow was observed, only standing water (Michael Baker Jr. Inc. 2018).

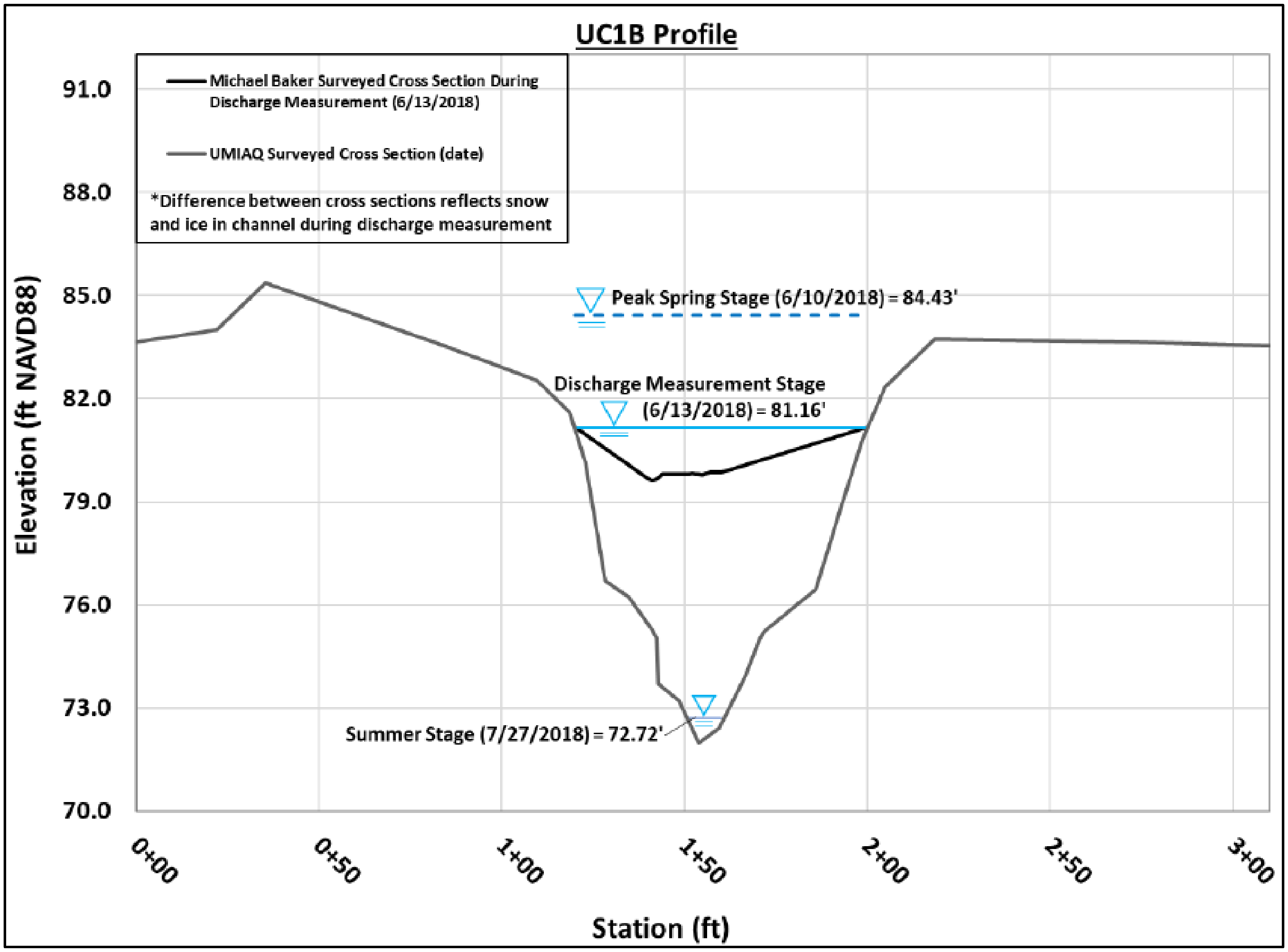
1.2.2.2.3 Willow Creek 2

Willow Creek 2 is a tributary of Judy (Iqalliqpik) Creek. Willow Creek 2 has a highly sinuous, deeply incised, beaded channel (Michael Baker Jr. Inc. 2018). It is over 10 feet from the top of the bank to the streambed and has a typical channel width of 20 feet (Michael Baker Jr. Inc. 2017). Alternatives B (Proponent's Proposal) and C (Disconnected Infield Roads) would cross Willow Creek 2 at RM 4.5, and the UC1B monitoring site is located on Willow Creek 2 at the proposed crossing (Michael Baker Jr. Inc. 2018). At RM 4.5, the bankfull width is approximately 4.5 feet and the average bankfull depth is approximately 2.5 feet (CPAI 2018b). Spring breakup and summer stage were monitored at UC1B in 2017, 2018, and 2019.

In 2017, 2018, and 2019, the channel was full of wind-blown snow prior to the start of breakup (Michael Baker International 2020a; Michael Baker Jr. Inc. 2017, 2018). In all 3 years, it was reported that water began flowing on top of the drifted snow and then cut a channel down through the wind-blown snow (Michael Baker International 2020a; Michael Baker Jr. Inc. 2017, 2018). In all 3 years, peak stage was reportedly affected by snow and ice in the channel, and peak stage did not coincide with the peak discharge (Michael Baker International 2020a; Michael Baker Jr. Inc. 2017, 2018). In 2017, the peak stage at UC1B occurred on May 30 at 96.87 feet (arbitrary datum) (Michael Baker Jr. Inc. 2017). In 2018, the peak stage at UC1B occurred on June 10 at 84.42 feet NAVD88 (Michael Baker Jr. Inc. 2018). A spring peak discharge was not recorded in either year. In 2019, the peak stage at CU1B occurred on May 26. The measured discharge on June 1 was 110 cfs (Michael Baker International 2020a).

Figure E.8.8 presents a surveyed cross-section at UC1B and a cross-section taken during a spring breakup discharge measurement (Michael Baker Jr. Inc. 2018). The difference between the cross-sections, and the difference between the WSEs on June 11 and 13, represents the impact of snow and ice in the channel on the WSE.

In all 3 years, the summer stage fluctuated with precipitation but water levels remained below the spring breakup peak stage. The maximum and minimum stages recorded at UC1B during summer 2017 were 84.63 feet and 83.01 feet, respectively (both based on an arbitrary datum) (Michael Baker Jr. Inc. 2017). The maximum and minimum stages recorded at UC1B during summer 2018 were 74.43 feet and 72.72 feet NAVD88, respectively (Michael Baker Jr. Inc. 2018). The maximum and minimum stages recorded at UC1B during summer 2019 were 75.2 feet and 72.83 feet NAVD88, respectively (Michael Baker International 2020a).



Source: Michael Baker Jr. Inc. 2018

Figure E.8.8. Cross-Section of Willow Creek 2 at Monitoring Site UC1B

1.2.2.2.4 Willow Creek 3

Willow Creek 3 is a tributary of Judy (Iqalliqpik) Creek. The infield road for all action alternatives would cross Willow Creek 3 between Lake M0015 and Lake R0055, which is also where the W3S monitoring site is located in a poorly defined, low-lying area (Michael Baker Jr. Inc. 2018). At W3S, the bankfull width is approximately 18 feet and the average bankfull depth is approximately 2.0 feet (CPAI 2018b). The Willow Creek 3 basin is also where the constructed freshwater reservoir would be located for all action alternatives. The constructed freshwater reservoir would divert water from Lake M0015.

The 2018 spring breakup peak stage at W3S was 84.13 feet NAVD88 and occurred on June 4 (Michael Baker Jr. Inc. 2018). The peak stage was affected by ice and snow but may have been the result of pooled local melt rather than flowing water (Michael Baker Jr. Inc. 2018). Eight days later (stage about 83.65 feet NAVD88), areas inundated by snowmelt and low-velocity flow were observed (Michael Baker Jr. Inc. 2018). During summer, small stage fluctuations associated with summer precipitation were recorded, but water levels remained below the spring breakup peak stage (Michael Baker Jr. Inc. 2018). The maximum and minimum summer stages at W3S were 83.40 feet and 82.86 feet NAVD88, respectively (Michael Baker Jr. Inc. 2018). Low-velocity flow through a poorly defined, ephemeral channel was observed on July 9 (Michael Baker Jr. Inc. 2018).

The 2019 spring breakup peak stage at WS3 was 88.49 feet NAVD88 and occurred on June 2 (Michael Baker International 2020a). Aerial observations at the time showed widespread meltwater and saturated snow across the Willow Creek 3 drainage, with no defined drainage channel (Michael Baker International 2020a). Discharge during spring breakup was measured twice. The May 30 discharge measurement of 5 cfs was classified as poor based on the influence of ice and snow in the channel. The June 2 discharge measurement of 16 cfs was classified as fair after water had receded from the peak stage and multiple flow paths had been established in the snow (Michael Baker International 2020a). During summer, water levels remained below the spring breakup stage and minimal stage fluctuations with summer precipitation events were recorded. The maximum and minimum summer stages at W3S were 87.78 feet and 87.24 feet NAVD88, respectively (Michael Baker International 2020a).

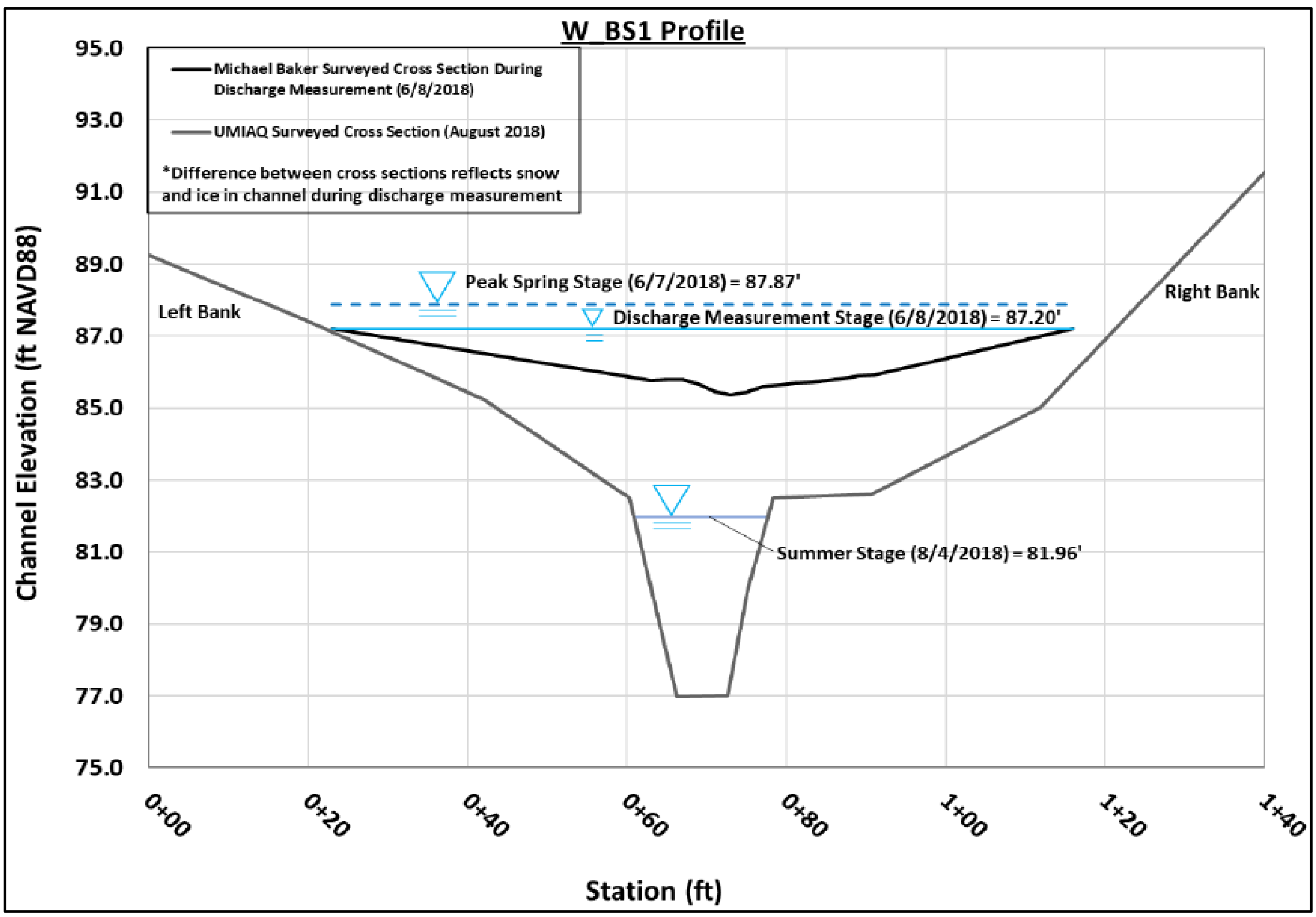
1.2.2.2.5 Willow Creek 4

Willow Creek 4 is a tributary of Judy (Iqalliqpik) Creek. It has an incised channel with intermittent, deep, beaded pools (Michael Baker Jr. Inc. 2018). The infield road for all action alternatives would cross Willow Creek 4 at RM 9, which is also the location of the W_BS1 monitoring site. At RM 9, the bankfull width is approximately 26 feet and the average bankfull depth is approximately 2.7 feet (CPAI 2018b). The W4 monitoring site is located at RM 5.2, adjacent to the Bear Tooth drill site 3/Willow Processing Facility pad.

The 2018 spring breakup peak stage at W_BS1 was 87.87 feet NAVD88 and occurred on June 7 (Michael Baker Jr. Inc. 2018). The 2018 spring breakup peak stage at W4 was 96.38 feet (arbitrary datum) and also occurred on June 7 (Michael Baker Jr. Inc. 2018). Both peaks occurred after a short, rapid rise in the WSE of 1.5 to 2 feet, and snow and ice within the channel affected the peak WSE at both sites. The timing and magnitude of the peak discharge were not recorded.

The 2019 spring breakup peak stage at W_BS1 was 87.38 feet NAVD88 and occurred on May 26 (Michael Baker International 2020a). The 2019 spring breakup peak stage at W4 was 94.21 feet (arbitrary datum) and occurred on May 26. The upstream gage, W_BS1, recorded the peak stage about 3 hours prior to the peak stage at the downstream gage, W4 (Michael Baker International 2020a).

Figure E.8.9 presents a surveyed cross-section at W_BS1 and a cross-section taken during a spring breakup discharge measurement (Michael Baker Jr. Inc. 2018). The difference between the cross-sections, and the difference between the WSE's on June 11 and 13, represents the impact of snow and ice in the channel on the WSE.



Source: Michael Baker Jr. Inc. 2018

Figure E.8.9. Cross-Section of Willow Creek 4 at Monitoring Site W_BS1

During the summers of both 2018 and 2019, the stage fluctuated with summer precipitation at both monitoring sites, but the water levels remained well below the spring breakup peak stage (Michael Baker International 2020a; Michael Baker Jr. Inc. 2018). The stage at the end of the summer monitoring season for both years increased due to late summer precipitation. The maximum and minimum summer stages at W4 for 2018 were 87.96 feet (arbitrary datum) and 85.11 feet (arbitrary datum), respectively (Michael Baker Jr. Inc. 2018), and for 2019 were 86.47 feet and 84.99 feet (arbitrary datum), respectively (Michael Baker International 2020a). The maximum and minimum summer stages at W_BS1 for 2018 were 83.79 feet and 81.96 feet NAVD88, respectively (Michael Baker Jr. Inc. 2018), and for 2019 were 85.46 feet and 82.29 feet (arbitrary datum), respectively (Michael Baker International 2020a).

1.2.2.2.6 Willow Creek 4A

Willow Creek 4A is a tributary of Willow Creek 4. The infield road for all action alternatives would cross Willow Creek 4A at MBI Monitoring Site W_S1, established in 2018. The channel near W_S1 is beaded and has defined banks. It has a bankfull width of approximately 24 feet and an average bankfull depth of approximately 4.5 feet (CPAI 2018b).

The 2018 spring breakup peak stage at W_S1 was 101.93 feet NAVD88 and occurred on June 8 (Michael Baker Jr. Inc. 2018). It was affected by snow and ice in the channel (Michael Baker Jr. Inc. 2018). At the time of the peak stage, the meltwater was confined by saturated snow, and the stage rose 1.5 feet in about 3 hours (Michael Baker Jr. Inc. 2018). The timing and magnitude of the peak discharge were not recorded.

In general, the stage fell throughout the summer except for fluctuations due to summer precipitation events (Michael Baker Jr. Inc. 2018). At the end of the summer monitoring season, the stage increased due to a late summer precipitation event (Michael Baker Jr. Inc. 2018). However, the stage remained well below the spring breakup peak stage throughout the summer (Michael Baker Jr. Inc. 2018). The maximum and minimum summer stages at W_S1 were 98.67 feet and 98.22 feet NAVD88, respectively (Michael Baker Jr. Inc. 2018).

The 2019 spring breakup peak stage at W_S1 was 101.89 feet NAVD88 on May 27 (Michael Baker International 2020a). Minor overbank flooding was noted in low-lying areas and adjacent polygon troughs, with stranded ice above the reach of the bank.

Summer stage levels fell except for fluctuations due to summer precipitation events. The stage increased to a maximum level of 99.68 feet on August 29 due to a notable precipitation event and the minimum stage was 98.77 feet on July 18 (Michael Baker International 2020a).

1.2.2.3 Ublutuoch (Tiŋmiaqsiuġvik) River

The Ublutuoch (Tiŋmiaqsiuġvik) River has its entire drainage basin on the Arctic Coastal Plain and flows into Fish (Iqalliqpik) Creek at RM 10. It has a drainage area of approximately 248 square miles, of which approximately 15% is covered by lakes (URS Corporation 2003). Two gravel mine site options are located in the Ublutuoch (Tiŋmiaqsiuġvik) River drainage basin, one on each side of the Ublutuoch (Tiŋmiaqsiuġvik) River. The downstream boundary of the gravel mine site analysis area would cross the Ublutuoch (Tiŋmiaqsiuġvik) River at approximately RM 13.9.

Spring breakup stage and discharge have been measured on the main stem of the Ublutuoch (Tiŋmiaqsiuġvik) River for 17 years at RM 13.7, about 0.2 RM downstream from the downstream boundary of the gravel mine site study area (Table E.8.14). During that time, water began to flow between May 17 and June 8, with a median date of May 30. The annual peak discharge occurred between May 19 and June 9, with a median date of June 5. In 9 out of 17 years the peak stage occurred earlier and was higher than the stage at the time of the peak discharge. The largest difference was 1.82 feet in 2005. The time from the beginning of flow to the peak discharge varied between 1 and 7 days, with a median time of 3 days. The annual peak discharge varied from 55 to 3,200 cfs, with a median of 1,700 cfs. Freeze-up data were collected in 7 of the 17 years. During that time, freeze-up occurred between September 26 and October 21, with a median date of October 8.

The Ublutuoch (Tiŋmiaqsiuġvik) River has a relatively low gradient and highly sinuous channel. In the vicinity of RM 13.7 the channel is incised within relatively steep upper banks that are vegetated with dense brush (URS Corporation 2003). The lower portion of the channel consists of a relatively flat bench located approximately 10 to 15 feet below the top of the upper banks (URS Corporation 2003). A 2- to 3-foot-deep × 15- to 20-foot-wide low-water channel is located in the bottom of the otherwise vegetated channel (URS Corporation 2003). The riverbed is composed of sand and gravel, with a median diameter of 7.0 mm (URS Corporation 2003).

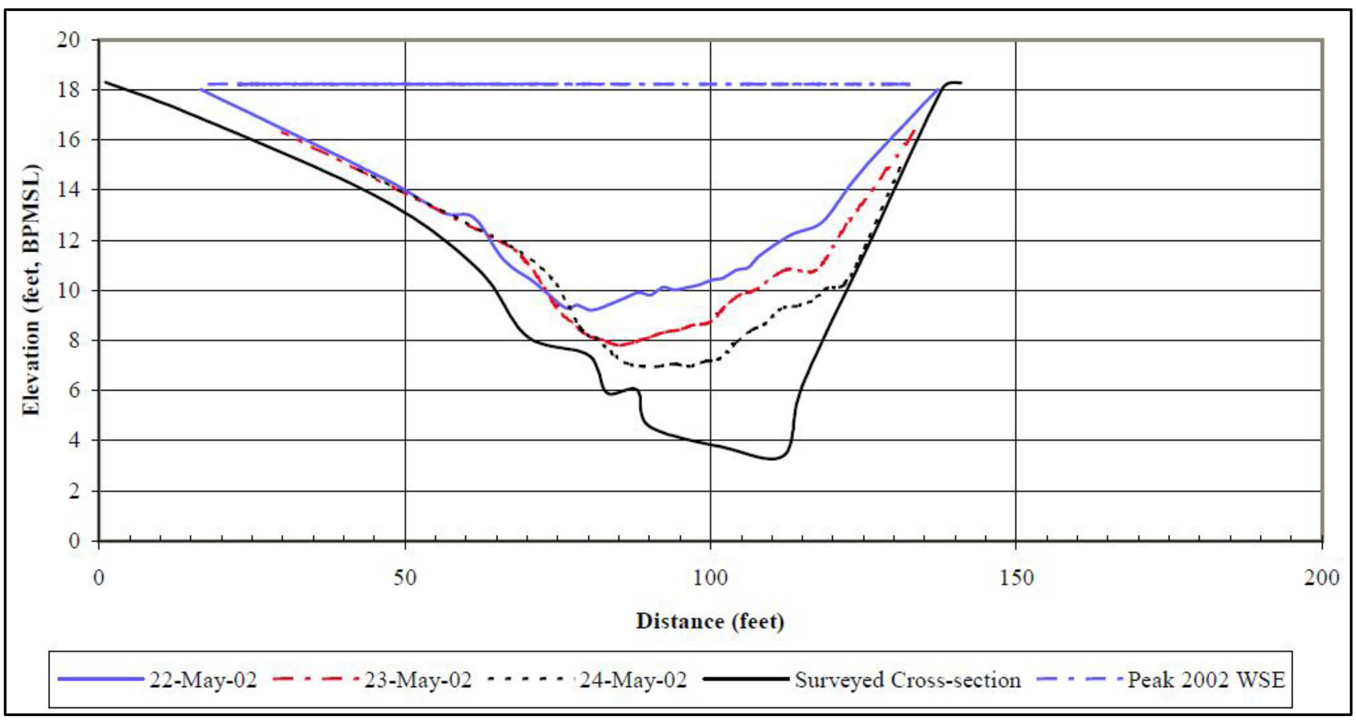
At the time of the 2001 and 2002 spring peak WSE and discharge, the water was flowing on snow within the channel. A comparison of riverbed elevation on various dates during the 2002 breakup at RM 13.7 is shown in Figure E.8.10, and 2001 and 2002 riverbed elevations at the time of the peak discharge are presented in Figure E.8.11.

Table E.8.14. Summary of Annual Peak Stage and Discharge for the Ublutuoch (Tiŋmiaqsiuġvik) River at River Mile 13.7

Year	Date Flow Begins (m/d)	Date of Freeze-Up (m/d)	Annual Peak Stage Date (m/d)	Annual Peak Stage (ft)	Annual Peak Stage Discharge (cfs)	Annual Peak Discharge Date (m/d)	Annual Peak Discharge Stage (ft)	Annual Peak Discharge (cfs)	Zero Flow to Peak Q (days)
2001	6/8	N/A	6/9	18.09	N/A	6/9	18.09	2,200	1
2002	5/19 e	N/A	5/22	18.22	N/A	5/22	18.22	2,000	3
2003	6/5	N/A	6/6	19.30	N/A	6/7	18.34	1,600	2
2004	6/1	N/A	6/5	19.55	N/A	6/5	19.55	2,400	4
2005	6/5	N/A	6/6	19.23	N/A	6/9	17.41	1,520	4
2006	6/1 e	N/A	6/4	16.67	N/A	6/6	15.04	1,250	5
2007	6/3	N/A	6/5	17.35	N/A	6/5	16.84	1,520	2
2008	5/27	N/A	5/29	17.42	N/A	5/29	16.85	955	2
2009	5/25	10/8	5/28	18.90	N/A	5/28	18.34	1,700	3
2010	6/5	9/27	6/7	19.68	N/A	6/7	19.68	3,200	2
2011	5/30	N/A	6/1	19.17	N/A	6/3	17.91	1,960	4
2012	5/30	10/11	6/5	18.33	N/A	6/5	18.33	2,130	6
2013	6/2	10/4	6/5	19.29	N/A	6/9	18.47	2,440	7
2014	5/17	10/11	5/19	18.61	N/A	5/19	18.61	1,270	2
2015	5/20	9/26	5/22	19.91	N/A	5/23	19.26	2,440	3
2016	5/22	10/21	5/24	17.76	N/A	5/24	17.76	1,150	2
2017	5/28	N/A	5/31	16.69	N/A	5/31	16.69	1,380	3

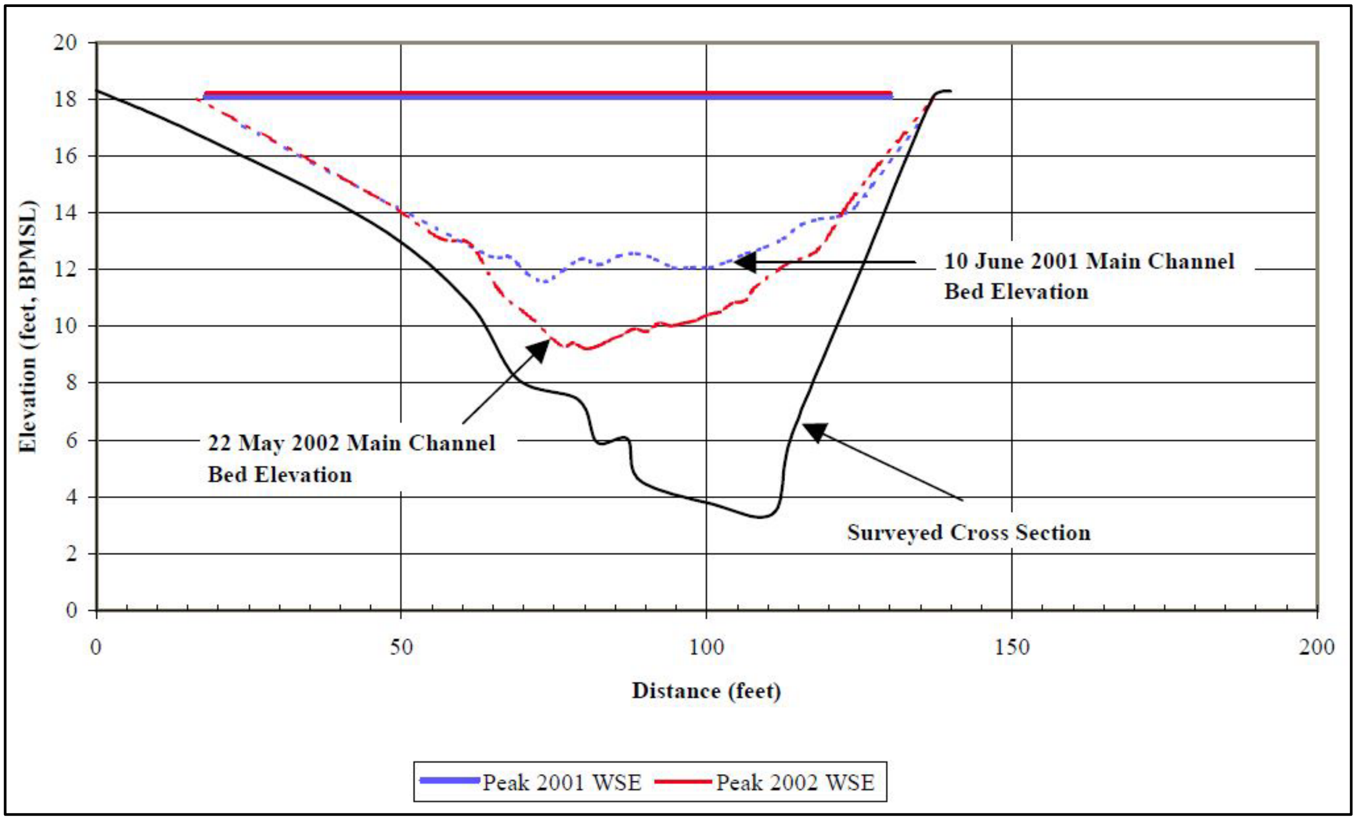
Source: J. Aldrich (Arctic Hydrologic Consultants), personal communication to Richard Kemnitz (BLM). September 11, 2018

Note: cfs (cubic feet per second); d (day); e (estimate); ft (feet); m (month); N/A (not available); Q (discharge); RM (river mile). The coordinates of the site (NAD83): 70.24316, -151.29693.



Source: URS Corporation 2003

Figure E.8.10. Effect of Snow and Ice in 2002 on Channel Cross-Section at River Mile 13.7



Source: URS Corporation 2003

Figure E.8.11. Comparison of 2001 and 2002 Cross-Sections at Peak Discharge at River Mile 13.7

Discharge and water surface slope measurements, along with surveyed cross-sections and a water surface profile model, were used to estimate hydraulic roughness in the channel on a particular day during the 2002 spring breakup. At RM 8 and RM 13.7, the channel hydraulic roughness on the day of the measurements, when ice and snow were impacting the hydraulic conditions, was 0.012 and 0.021, respectively (URS Corporation 2003). Computations of hydraulic roughness based on measured discharge and water surface slope and normal depth computations at RM 13.7 on each of 3 days in 2001 and 2002 during ice- and snow-impacted conditions varied from 0.019 to 0.025, with a median of 0.023 (URS Corporation 2001, 2003).

Seventeen years of summer flow data is available for the Ublutuoch (Tiŋmiaqsiuġvik) River at RM 13.7 (J. Aldrich [Arctic Hydrologic Consultants], personal communication to Richard Kemnitz [BLM]. September 11, 2018) . A summary of the available mean monthly discharge data is provided in Table E.8.15.

Table E.8.15. Mean Monthly Discharge (cubic feet per second) in the Ublutuoch (Tiŋmiaqsiuġvik) River at River Mile 13.7

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	0	0	0	0	0	435	47	45	38	27	16	5
2002	0	0	0	0	377	133	80	24	24	17	10	3
2003	0	0	0	0	0	389	112	57	52	6	0.5	0
2004	0	0	0	0	0	827	69	21	32	6	0.3	0
2005	0	0	0	0	0	467	78	13	7	2	0	0
2006	0	0	0	0	0	434	36	25	16	9	1	0
2007	0	0	0	0	0	283	18	2	0.5	0	0	0
2008	0	0	0	0	101	223	15	7	3	0.6	0	0
2009	0	0	0	0	241	456	27	12	31	15	4	0.6
2010	0	0	0	0	0	596	54	54	25	7	0.5	0
2011	0	0	0	0	11	628	33	10	12	7	0.8	0
2012	0	0	0	0	0.2	535	37	10	12	9	5	0.3
2013	0	0	0	0	0	857	72	26	30	8	2	0.1
2014	0	0	0	0	359	441	84	25	38	38	6	0.6
2015	0	0	0	0	438	208	18	14	16	2	0.2	0
2016	0	0	0	0	184	181	24	22	91	87	10	3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	0	0	0	0	92	367	18	78	200	150	23	0.1

Source: J. Aldrich (Arctic Hydrologic Consultants), personal communication to Richard Kemnitz (BLM). September 11, 2018

At RM 14.5 (MBI Monitoring Site UB14.5) and RM 15.5 (MBI Monitoring Site UB15.5), the spring breakup stage and the extent of flooding was monitored in 2018 and 2019 (Michael Baker International 2020a; Michael Baker Jr. Inc. 2018). RM 14.5 is just downstream of the mouth of Bill's Creek, and RM 15.5 is just upstream. MBI (2018) also monitored the stage and extent of flooding on Bill's Creek, at Monitoring Site BC1. All of these sites are within the gravel mine site analysis area.

At UB14.5, the channel is incised and deep and fills with wind-blown snow during winter (Michael Baker Jr. Inc. 2018). During the 2018 spring breakup, the peak stage was 20.20 feet (adjusted for NAVD88 in 2020) and occurred on June 9. Pictures of the monitoring site on the day of the peak stage suggest that the peak stage was affected by snow and ice. During the 2019 spring breakup, the peak stage was 19.23 feet NAVD88 and occurred on May 29 (Michael Baker International 2020a).

At UB15.5, the channel is incised and deep and fills with wind-blown snow during the winter (Michael Baker Jr. Inc. 2018). During the 2018 spring breakup, the peak stage was 23.49 feet (adjusted for NAVD88 in 2020) and occurred on June 8. Pictures of the monitoring site on the day of the peak stage suggest that the peak stage was affected by snow and ice. During the 2019 spring breakup, the peak stage was 22.46 feet NAVD88 and occurred on May 26 (Michael Baker International 2020a).

Bill's Creek is a beaded channel consisting of large beads connected by deeply incised, narrow grass-lined channels with its headwaters in an area of small lakes (Michael Baker Jr. Inc. 2018). Wind-blown snow fills much of the drainage during the winter (Michael Baker Jr. Inc. 2018). During the 2018 spring breakup, the peak stage at BC1 was 41.85 feet (adjusted to NAVD88) and occurred on June 11. Based on the description of the conditions at the time of the peak stage (Michael Baker Jr. Inc. 2018), the peak stage was affected by snow and ice in the channel. The summer stage fluctuated with precipitation events but remained below the peak breakup stage (Michael Baker Jr. Inc. 2018). The stage increased at the end of the summer monitoring period as a result of late summer precipitation (Michael Baker Jr. Inc. 2018). The maximum and minimum summer stages were 88.67 feet and 87.01 feet (arbitrary datum), respectively (Michael Baker Jr. Inc. 2018).

During the 2019 spring breakup, the peak stage at BC1 was 39.78 feet NAVD88 and occurred on May 23. The peak stage was affected by snow and ice in the channel (Michael Baker International 2020a).

Spring breakup observations have also been made at the following sites:

- RM 6.8 in 2003, 2004, 2005, 2006, 2009, 2010, 2011, and 2013 (CPAI 2018a)
- RM 8.0 in 2002 (URS Corporation 2003)
- RM 13.5 in 2001 (URS Corporation 2001) and 2002 (URS Corporation 2003)

Hydraulic designs on the Ublutuoch (Tiŋmiaqsiuġvik) River should consider the flood-peak data that have been collected at RM 13.7, the impact of snow and ice at the time of the annual peak discharge, the impact of snow and ice on the annual peak WSE, and the hydraulic roughness likely to be present at the time of the design discharge. In developing flood-peak magnitude and frequency estimates on streams in the Ublutuoch (Tiŋmiaqsiuġvik) River basin, the 17 years of data collected at RM 13.7 should be considered. A single-station flood-peak magnitude and frequency analyses could be conducted with these data to estimate the flood-peak magnitude and frequencies at RM 13.7. A best estimate of the flood-peak magnitude and frequency at RM 13.7 could then be developed from a weighted average, based on the uncertainty associated with estimates from each of two methods: the single-station frequency analysis and the Shell regression equations[3] (Arctic Hydrological Consultants and ERM 2015). The weighted average estimate would then be extrapolated to other locations within the basin as a proportion of the Shell regression equation estimate.

Since the hydraulic roughness is changing throughout spring breakup, when designing structures on this river it would be prudent to consider a range of hydraulic roughness values. Higher hydraulic roughness values will provide estimates with higher WSEs and lower velocities. Lower hydraulic roughness values will provide estimates with lower WSEs and higher velocities. Both conditions are important when designing structures within

[3] The Shell regression equations are suggested rather than the 2003 USGS regression equations because considerably more North Slope river data was used to prepare the Shell regression equations than the USGS regression equations.

the channel and the floodplain. Additionally, snow blockage at the time of the peak discharge seems to be an annual occurrence and should be considered when estimating design WSEs.

1.2.3 Kalikpik River

The Kalikpik River originates in a complex network of lakes, approximately 15 miles south of Teshekpuk Lake, and flows into Harrison Bay northwest of Fish (Iqalliqpik) Creek (Michael Baker Jr. Inc. 2018). The river has a relatively low gradient, a highly sinuous channel, and the channel bed and banks consist predominantly of silt and sand (Michael Baker Jr. Inc. 2018). The most downstream end of the proposed infrastructure comes close to the Kalikpik River, about 17.5 RMs upstream from the coast (RM 17.5).

In 2018 and 2019, the stage was monitored during spring breakup at Kal 1 (Michael Baker Jr. Inc. 2018), about 21.8 RMs upstream from the coast. In 2018, the channel was full of windblown snow prior to the start of breakup (Michael Baker Jr. Inc. 2018). The peak stage occurred on June 11 at an elevation of 50.30 feet NAVD88 and was affected by snow and ice conditions (Michael Baker Jr. Inc. 2018). Snow remained along the banks and large ice floes were present in the channel for a couple of days following the peak stage (Michael Baker Jr. Inc. 2018). A second, smaller rise in the stage was observed on June 16 and may have been coincident with the peak discharge (Michael Baker Jr. Inc. 2018). A discharge of 320 cfs was measured at a stage of 48.18 feet NAVD88 on June 16 at 4:00 p.m. The stage was just below bankfull (Michael Baker Jr. Inc. 2018). No ice or snow was observed in the channel, but saturated snow remained along the south bank just above the water surface (Michael Baker Jr. Inc. 2018).

In 2019, the peak stage of 49.44 feet NAVD88 occurred on May 26, and was likely elevated by large quantities of saturated snow and bottom-fast channel ice (Michael Baker International 2020a). A discharge of 245 cfs was measured at a stage of 48.94 feet NAVD88 on May 30 (Michael Baker International 2020a).

For 2018 and 2019, MBI continued to monitor the stage during summers. The stage fluctuated throughout summer as a result of precipitation events but remained below the spring breakup peak stage (Michael Baker Jr. Inc. 2018). For both summers, later summer precipitation events led to increased stage levels that were slightly higher than the stage during the discharge measurement near the end of the summer monitoring period (Michael Baker International 2020a; Michael Baker Jr. Inc. 2018). The highest summer stage levels were 47.10 feet in 2018 and 47.91 feet in 2019 (Michael Baker International 2020a; Michael Baker Jr. Inc. 2018).

At Kal 1, the bankfull width is approximately 140 feet, the average bankfull depth is approximately 3 feet, and the thalweg depth is approximately 8 feet (CPAI 2018b).

1.3 Environmental Consequences

1.3.1 In-Water Structures

1.3.1.1 Bridge Crossings

The potential impacts to streams crossed by bridges during the life of the structure include the following:

- Increased backwater on the upstream side of the bridge
- Increased riverbed erosion within the bridge opening
- Increased riverbed and bank erosion downstream from the bridge
- Increased sediment deposition downstream from the bridge
- Increased sediment transport within and downstream from the bridge
- A change in channel morphology downstream from the bridge

The impact of a bridge on the stream being crossed is directly related to the criteria used to design the bridge and the extent to which the bridge is constructed according to the design. Some of the most important factors related to the hydraulic design of bridges on the North Slope include 1) the frequency of the design event in relation to the anticipated life of the structure; 2) the reliability of the computed magnitude and frequency of the design event; 3) the impact of snow and ice (including ice floes) at the time of the design event and during events with a smaller discharge than the design event; and 4) the reliability of the hydraulic computations used to estimate WSE and velocity, riverbed scour, and bank erosion. With regard to the frequency of the design event, the probability that the design event will not be exceeded during the life of the structure should be considered.

All bridges would be designed to maintain bottom chord clearance of 4 feet above the 100-year base flood elevation and at least 3 feet above the highest documented flood elevation. Table E.8.16 presents the relationship between the average return period of the design event and the probability that the design event will not be exceeded during various lengths of time. Note that the probability that the design event will not be exceeded decreases as the life of the structure increases. Based on the life of past structures on the North Slope, it seems very likely that the life of the structures could be greater than 40 or 50 years. A culvert or bridge based on a 100-year flood design that is likely to be in place for 50 years before removal or replacement would have a 61% chance that the design flood would not be exceeded one or more times during the life of the structure (i.e., 39% chance that design flood would be exceeded). As shown, although it is more likely that the design life will not be exceeded during the life of the Project, there is still a 39% chance it could be. This section describes the potential effects of bridges.

Table E.8.16. Theoretical Probability That the Design Event Will Not Be Exceeded in a Specified Number of Years

Design Event (average return period in years)	10 years	20 years	30 years	40 year	50 years	60 years	70 years
25	66%	44%	29%	20%	13%	8%	6%
50	82%	67%	55%	45%	36%	30%	24%
100	**90%**	**82%**	**74%**	**67%**	**61%**	**55%**	**49%**
200	95%	90%	86%	82%	78%	74%	70%
500	98%	96%	94%	92%	90%	89%	87%

Note: **Bold** denotes the design life of bridges for the Project. The difference between the theoretical probability and the actual probability is the accuracy of the design events' predicted probability of occurrence. For instance, if the design discharge is supposed to be a 100-year event but actually has an average return period of 90 years, the theoretical probability that the design event will not be exceeded will be higher than what is experienced.

During floods in which the cross-sectional area of the flow is restricted by the bridge, water would back up behind the bridge. The difference between the unrestricted WSE and the restricted WSE on the upstream side of the bridge is called backwater. The magnitude of the backwater would depend upon the amount of constriction presented by bridge or road embankments and would usually become larger with larger flood events. The maximum increase in WSE generally occurs at a location upstream from the bridge, about equal in distance to about one-half the total length of the embankment obstructing the flow of water. The upstream extent of the backwater is a function of both the magnitude of the constriction and the slope of the stream. The duration of the backwater would be somewhat less than the duration of the flood. Backwater is generally a concern if it causes a structure (such as an upstream pipeline) or another resource to be damaged by the inundation created as a result of the backwater.

The more a bridge restricts the flow (i.e., the greater the backwater), the higher the velocity through the bridge. At a particular discharge, if the velocity through the bridge exceeds the velocity that would have occurred prior to construction of the bridge, and the bed material is mobile at that velocity, it is likely that the depth of the scour would be greater than would have occurred prior to bridge construction. Similarly, if the velocity downstream from the bridge is greater than the velocity that would have occurred prior to bridge construction, it is possible that bank erosion would be more severe than would have occurred. With increased erosion comes increased sediment transport and increased sediment deposition. An increase in erosion and deposition can lead to a change in channel morphology. If the bridge abutments or pier piles are undermined by scour, the bridge may collapse. Scour is historically one of the most common causes of bridge failure in North America (Cook 2014). However, scour is not a problem if it is correctly addressed during the design of the bridge.

1.3.1.2 Culverts

The potential impacts to streams crossed by culverts during the life of the structure include the following:

- Increased backwater on the upstream side of the culvert
- Increased riverbed and bank erosion downstream from the culvert
- Increased sediment deposition downstream from the culvert
- Increased sediment transport downstream from the culvert
- A change in channel morphology downstream from the culvert

The impact of the culvert on the stream being crossed is directly related to the criteria used to design the culvert and the extent to which the culvert is constructed according to the design. The size, layout, and quantity of Project culverts would be based on site-specific conditions in order to pass the 50-year flood event with a headwater elevation not exceeding the top of the culvert (headwater to diameter ratio of 1 or less). Some of the most important factors related to the hydraulic design of culverts on the North Slope include 1) the frequency of the design event in relation to the anticipated life of the structure; 2) the reliability of the computed magnitude and frequency of the design event; 3) the impact of snow and ice (including ice floes) at the time of the design event and during events with a smaller discharge than the design event; 4) the reliability of the hydraulic computations used to estimate WSE and velocity, riverbed scour, and bank erosion; and 5) the reliability of the topographic and flow information used to located the culvert. With regard to the frequency of the design event, see the discussion in Section 2.5.3.2.1, *Bridges*. A culvert based on a 50-year flood design that is likely to be in place for 50 years before removal or replacement would have a 36% chance that the design flood would not be exceeded one or more times during the life of the structure (i.e., 64% chance that design flood would be exceeded).

During floods in which the cross-sectional area of the flow is restricted by the culvert, water would back up behind the culvert. The magnitude of the backwater would depend upon the amount of constriction presented by the culvert. See discussion in Section 2.5.3.2.1 for additional information.

The more the culvert restricts streamflow (i.e., the greater the backwater), the higher the velocity through the culvert. The higher the velocity through the culvert, the more likely it is that riverbed erosion (scour) and bank erosion would occur at the culvert outlet and downstream from the culvert. With increased erosion comes increased sediment transport and increased sediment deposition. An increase in erosion and deposition can lead to a change in channel morphology.

1.3.2 Pipelines

All of the pipeline waterbody crossings would be aboveground on vertical support members (VSMs) except for the Colville River crossing, which would be installed 70 feet below the river channel using horizontal directional drilling (HDD).

1.3.2.1 Aboveground Crossings

As water passes around VSMs, at an aboveground crossing there is the potential for an increase in velocity and scour. This may result in erosion at the VSM and sediment deposition downstream from the VSM. If ice floes or debris build up on a VSM, the scour at the VSM could be greater than anticipated and could compromise the integrity of the VSM and thus the pipeline.

If water, floating ice, or debris comes in contact with the aboveground pipeline, the pipeline could be ruptured. It is unknown to what flood event or ice condition the pipeline crossings would be designed.

Where an aboveground pipeline crossing is immediately upstream from a road crossing (either a bridge or a culvert), backwater from the road during the pipeline design event should be considered when setting the bottom of the pipe elevation. Additionally, if the road is designed for a smaller flood than the pipeline, the changes in hydraulic conditions at the pipeline as a result of the road wash-out should be considered (i.e., changes in location of the concentrated flow and the impact on erosion at the VSM).

Where an aboveground pipeline crossing is immediately downstream from a road crossing (either a bridge or a culvert), the impact of the road on where water will be flowing and the velocity of the water at the pipeline VSM should be considered. Additionally, if the road is designed for a smaller flood than the pipeline, the changes in hydraulic conditions at the pipeline as a result of the road wash-out should be considered (i.e., changes in the location of the concentrated flow and the impact on erosion at the VSM).

1.3.2.2 Belowground Crossings

Design of the HDD crossing should consider the likely scour depth during all floods up to and including the design flood and the likely channel migration over the life of the crossing. It is unknown to what flood event the HDD crossing would be designed.

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Willow Master Development Plan

Appendix E.8B
Ocean Point Technical Memorandum

August 2020

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HYDRAULIC MAPPING AND MODELING
Kenneth F. Karle, P.E.
1091 West Chena Hills Drive, Fairbanks, AK 99709

May 26, 2020

Ocean Point Technical Memorandum

To: E. Leyla Arsan, DOWL

From: Kenneth Karle, P.E.

Subject: Ocean Point Monthly Mean Discharge

An EPA SDEIS reviewer recommended that, as there are no flow data available for the Colville River at Ocean Point, a representative 'synthetic dataset' could be developed for the Ocean Point crossing, using discharge data from the Umiat gaging station. This memo describes the methodology for conducting such an analysis, and includes a table listing average monthly discharge estimates for the Ocean Point crossing.

The drainage-area ratio method suggested by EPA to develop an Ocean Point discharge dataset is indeed commonly used to estimate both flood frequency magnitudes, and individual streamflow discharges, for sites where no streamflow data are available using data from one or more nearby gaging stations (Emerson et al., 2005). The method is intuitive and straightforward to implement and is in widespread use by analysts and managers of surface-water resources. It's often used for locations where no supporting discharge data are available to confirm the validity or develop some type of bias correction to account for differences in watershed characteristics.

A simple ratio of watershed areas upstream of the point of interest is used to estimate flood magnitudes of ungaged sites on gaged streams. The drainage area ratio equation is:

$$Q_u = \frac{Q_g \times A_u}{A_g}$$

Where

Q_u = ungaged area flow statistic
Q_g = gaged area flow statistic
A_u = ungaged area
A_g = gaged area

In a memo dated November 16, 2018, Jim Aldrich (Arctic Hydrologic Consultants) compiled a table of Colville River Mean Monthly Flow at Umiat, AK, using data from the USGS gaging station 15875000. I updated the table in February 2020; see Table 1.

Note that in every year from 2002 to 2009, there was at least one month from February to April with an average discharge of 0 cfs. Starting in 2010, there were no more ‘0 cfs’ months, and average winter monthly discharge values increased significantly for the period from 2010 to 2019. There are several possible explanations for this. Ongoing climate change on the Alaskan North Slope, with drastically increased temperatures, is well documented. Warmer winters will result in increased winter discharge. Matt Schellekens, the chief hydrologist of the USGS Fairbanks office, noted that prior to the mid-1990s, winter flow was never observed in the Sagavanirktok River. Now, flow is almost always observed and often it is quite a bit (M. Schellekens, personal communication, January 31, 2020).

A second explanation is that slight differences in procedures were used for two different periods. From 2003 to 2009, the site was operated from the USGS Anchorage field office. During that time, there were not many late winter visits, and flow was assumed to go to zero. Since 2010 the gage has been operated from the USGS Fairbanks field office. The Fairbanks hydrographers “usually spent a lot of time in late March or April hunting around the river reach near the gage and almost always found/find at least one or two very small open leads of water seeping out of the downstream end of a gravel bar or two” (M. Schellekens, personal communication, January 31, 2020).

The EPA reviewer noted the increase in winter flows and recommended that only the last 10 years of the Umiat discharge data should be used for the area-ratio analysis, as using mean discharges from the entire period of record “will likely underestimate the discharge at Ocean Point…”

The drainage area for USGS Umiat gaging station 15875000 is 13,860 mi^2. The drainage area upstream of the proposed Ocean Point ice bridge crossing is estimated at 20,580 mi^2. The drainage area ratio (Ocean Point/Umiat) is 1.48.

As a check on the validity of using the drainage area ratio method, I compared a discharge measurement made at Ocean Point to gaged flow at Umiat. CPAI measured a discharge flow rate of 29,000 cfs at Ocean Point on 9/5/2019 at 250 pm. The average flow velocity was 3 ft/sec. Accounting for travel time downstream, the related upstream discharge at Umiat on 9/4/2019 at 1050 am was 23,000 cfs. The Ocean Point flow was approximately 1.3 times greater than the Umiat flow. One data-pair point set is not statistically significant. However, it does imply some reassurance for using the drainage-are method for flow estimates.

Table 1 includes the mean value of the mean monthly discharge values at Umiat for two periods: 2003-2019, and 2010-2019.

I conducted an area ratio analysis to estimate flows at Ocean Point using the mean value of the mean monthly flows for the period 2010-2019, and a drainage area ratio (ungaged/gage) of 1.48. See Table 2.

Table 1. Colville River mean monthly discharge (cfs) at Umiat.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002									21,030	7,221	844.3	100.1
2003	3.55	0	0	0	690	65,690	24,030	31,800	12,760	10,490	560	72.6
2004	6.87	2.17	0.161	0	40,890	24,940	15,310	24,870	12,060	556.5	142.3	56.6
2005	20.8	4.23	0.016	0	12,830	72,480	13,920	4,143	6,014	1,169	200	104.5
2006	18.4	0.107	0	0	22,010	37,120	21,940	33,560	6,229	2,667	324.7	80
2007	27.9	11.7	0.887	0	4,179	50,530	12,140	17,820	7,511	873.5	177	72.6
2008	21.1	0.724	0	0	17,260	46,530	12,900	10,770	1,867	560	207	72.9
2009	15	0	0	3.03	36,940	45,050	13,890	13,440	13,750	1,775	418	95.2
2010	36.5	13.9	1.65	0.5	17,280	48,760	10,370	15,720	6,213	1,248	454	132.2
2011	35.5	9.66	1.07	0.37	37,790	31,190	13,170	11,330	11,940	1,958	375	93.5
2012	29.2	11	1.92	0.5	16,680	41,910	16,970	14,860	27,440	3,678	145.3	45.9
2013	16.4	3.93	2	1.02	6,434	83,970	10,530	10,290	11,750	1,475	509.3	130.7
2014	25.9	9.25	6	6	33,290	72,180	29,820	10,130	16,140	1,215	216.7	89.9
2015	45.2	29	16.8	12	62,410	17,010	8,243	22,250	11,550	1,504	275.7	65.5
2016	24.4	10.1	5.71	2.75	47,460	32,660	14,540	27,290	15,310	4,868	404.7	64.4
2017	16	3.79	1.16	1	12,070	26,220	13,110	36,370	25,900	6,403	447.9	86.5
2018	24.9	11.9	7.14	6.00	12,220	47,610	26,970	30,330	23,280	3,122	342.9	67.1
2019	40.9	30.2	22.6	20.0	36,180	18,370	12,380	38,990	15,500			
Mean of Monthly Discharge- Sept 2002-Sept 2019	24.0	8.9	3.9	3.1	24,500	44,800	15,900	20,800	13,700	2,990	356.0	84.0
Mean of Monthly Discharge- Jan 2010- Sept 2019	29.5	13.3	6.6	5.0	28,181	41,988	15,610	21,756	16,502	2,830	352.4	86.2

Table 2. Estimated Colville River mean monthly discharge (cfs) at Ocean Point, based on mean monthly discharge at Umiat 2010-2019.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Estimated Mean Monthly Discharge	43.7	19.7	9.8	7.4	41,710	62,140	23,100	32,200	24,420	4190	521.6	127.6

Numerous factors will affect the relationship between discharge and drainage area. For example, if the watershed characteristics of the upper watershed, such as the ratio of mountainous area to lowlands, were significantly different than those of the additional downstream drainage area, then the flow relationship may not be linear. Such a relationship could potentially be improved by investigating regional statistics, regression, and rainfall-runoff modeling (bias correction). That type of additional analysis generally leads to the development of an exponent for the drainage area ratio. But that type of data is obviously scarce and probably not worth pursuing.

Another consideration is that this analysis does not account for other conditions that may affect flow rates at Ocean Point. For example, surface flow passing Umiat may be forced downstream into a gravel bed flow condition due to a blocked channel. Surface flow may also end up in storage as ice until warming temperatures occur. Conversely, groundwater seeps between Umiat and Ocean Point may lead to larger flows downstream than predicted by the drainage area ratio. The consensus of opinion from Jim Aldrich, Matt Schellekens (USGS), and Richard Kemnitz (BLM retired) is that there is probably surface flow in the Colville River downstream of Umiat in every month of the year.

As noted elsewhere, the best course of action to characterize winter flows at Ocean Point will be to conduct field observations and measurements during the winter months at the Ocean Point crossing for the next several years. However, until such field measurements are made, the flow statistics in Table 2 can be used, with caution, to provide an estimate of the magnitude of winter flows for the Ocean Point crossing.

Please let me know if you have additional questions or need more information.

Ken

References

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Willow Master Development Plan

Appendix E.9
Vegetation and Wetlands Technical Appendix

August 2020

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Table of Contents

List of Tables

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.

Palustrine – Produced or originating from or within a marsh.

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

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1.0 VEGETATION AND WETLANDS

1.1 Affected Environment

Table E.9.1 details the wetland types in the Willow Master Development Plan 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 of Wetland Type in Analysis Area[b]	Acres of Wetland Type in Field-Verified Portion of Analysis Area[c]
Estuarine Subtidal **Unconsolidated** Bottom	E1UBL	64,514.9	0
Estuarine Intertidal **Emergent** Persistent/Unconsolidated Shore Irregularly Flooded	E2EM1/USP	14,258.7	0
Estuarine Intertidal Emergent Persistent Regularly Flooded	E2EM1N	9.3	0
Estuarine Intertidal Emergent Persistent Irregularly Flooded	E2EM1P	16,112.1	0
Estuarine Intertidal Emergent Nonpersistent/Unconsolidated Shore Irregularly Flooded	E2EM2/USP	5,162.3	0
Estuarine Intertidal Unconsolidated Shore/Emergent Persistent Irregularly Flooded	E2US/EM1P	11,406.3	0
Estuarine Intertidal Unconsolidated Shore/Emergent Nonpersistent Irregularly Flooded	E2US/EM2P	60.9	0
Estuarine Intertidal Unconsolidated Shore Regularly Flooded	E2USN	136.3	0
Emergent Intertidal Unconsolidated Shore Irregularly Flooded	E2USP	30,802.5	0
Lacustrine Limnetic Unconsolidated Bottom Permanently Flooded	L1UBH	580,142.9	190.7
Lacustrine Limnetic Unconsolidated Bottom Permanently Flooded Diked/Impounded	L1UBHh	2,682.2	0
Lacustrine Littoral Aquatic Bed Aquatic Moss Permanently Flooded	L2AB2H	3.9	0
Lacustrine Littoral Emergent Nonpersistent/Unconsolidated Bottom Semi-Permanently Flooded	L2EM2/UBF	153.4	0
Lacustrine Littoral Emergent Nonpersistent/Unconsolidated Bottom Permanently Flooded	L2EM2/UBH	3,500.9	0
Lacustrine Littoral Emergent Nonpersistent Semi-Permanently Flooded	L2EM2F	1,512.4	0
Lacustrine Littoral Emergent Nonpersistent Permanently Flooded	L2EM2H	5,831.0	2.0
Lacustrine Littoral Unconsolidated Bottom/Emergent Nonpersistent Permanently Flooded	L2UB/EM2H	1,229.1	0.1
Lacustrine Littoral Unconsolidated Bottom Semi-Permanently Flooded	L2UBF	34.9	0
Lacustrine Littoral Unconsolidated Bottom Permanently Flooded	L2UBH	1,362.4	0
Lacustrine Littoral Unconsolidated Shore Temporarily Flooded	L2USA	4,168.4	0
Lacustrine Littoral Unconsolidated Shore Seasonally Flooded	L2USC	5,158.8	0
Marine Subtidal Unconsolidated Bottom[c]	M1UBL	35,718.1	0
Marine Intertidal Unconsolidated Shore Regularly Flooded	M2USN	4.6	0
Marine Intertidal Unconsolidated Shore Irregularly Flooded	M2USP	275.0	0
Palustrine Emergent Persistent/Nonpersistent Semi-Permanently Flooded	PEM1/2F	4,476.4	0
Palustrine Emergent Persistent/Moss-Lichen Moss Seasonally Saturated	PEM1/ML1B	300.7	0

Wetland Type	Cowardin Code[a]	Acres of Wetland Type in Analysis Area[b]	Acres of Wetland Type in Field-Verified Portion of Analysis Area[c]
Palustrine Emergent Persistent/Scrub-Shrub Broad-Leaved Deciduous Temporarily Flooded	PEM1/SS1A	68.1	0
Palustrine Emergent Persistent/Scrub-Shrub Broad-Leaved Deciduous Seasonally Saturated	PEM1/SS1B	907,739.0	3,018.0
Palustrine Emergent Persistent/Scrub-Shrub Broad-Leaved Deciduous Continuously Saturated[d]	PEM1/SS1D	2,607.8	2,607.8
Palustrine Emergent Persistent/Scrub-Shrub Broad-Leaved Deciduous Continuously Seasonally Flooded/Saturated	PEM1/SS1E	421,058.3	57.2
Palustrine Emergent Persistent/Scrub-Shrub Broad-Leaved Deciduous Semi-Permanently Flooded	PEM1/SS1F	38,561.6	840.8
Palustrine Emergent Persistent/Unconsolidated Bottom Semi-Permanently Flooded	PEM1/UBF	41,103.0	0
Palustrine Emergent Persistent/Unconsolidated Bottom Semi-Permanently Flooded Diked/Impounded	PEM1/UBFh	5.3	0
Palustrine Emergent Persistent/Unconsolidated Shore Temporarily Flooded	PEM1/USA	1,273.2	0
Palustrine Emergent Persistent/Unconsolidated Shore Seasonally Flooded	PEM1/USC	677.9	0
Palustrine Emergent Persistent/Unconsolidated Shore Seasonally Flooded/Saturated	PEM1/USE	2,927.2	0
Palustrine Emergent Persistent Seasonally Saturated	PEM1B	23,878.0	0
Palustrine Emergent Persistent Seasonally Flooded	PEM1C	567.1	0
Palustrine Emergent Persistent Seasonally Flooded/Saturated	PEM1E	287,089.2	0
Palustrine Emergent Persistent Semi-Permanently Flooded	PEM1F	166,688.6	2,176.0
Palustrine Emergent Persistent Semi-Permanently Flooded Diked/Impounded	PEM1Fh	12.8	0
Palustrine Emergent Persistent Permanently Flooded[d]	PEM1H	247.5	247.5
Palustrine Emergent Nonpersistent/Persistent Semi-Permanently Flooded	PEM2/1F	5,043.5	0
Palustrine Emergent Nonpersistent/Unconsolidated Bottom Semi-Permanently Flooded	PEM2/UBF	64.2	0
Palustrine Emergent Nonpersistent/Unconsolidated Bottom Permanently Flooded	PEM2/UBH	781.0	0
Palustrine Emergent Nonpersistent Semi-Permanently Flooded	PEM2F	178.7	0
Palustrine Emergent Nonpersistent Permanently Flooded	PEM2H	2,406.9	20.0
Palustrine Scrub-Shrub/Emergent Persistent Temporarily Flooded	PSS/EM1A	489.0	0
Palustrine Scrub-Shrub/Emergent Persistent Seasonally Saturated	PSS/EM1B	15,971.8	0
Palustrine Scrub-Shrub/Emergent Persistent Seasonally Flooded/Saturated	PSS/EM1E	27,603.9	0
Palustrine Scrub-Shrub/Emergent Persistent Semi-Permanently Flooded	PSS/EM1F	51.0	0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Emergent Persistent Temporarily Flooded	PSS1/EM1A	1,348.8	0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Emergent Persistent Seasonally Saturated	PSS1/EM1B	9,770.4	0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Emergent Persistent Seasonally Flooded	PSS1/EM1C	167.5	0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Emergent Persistent Seasonally Flooded/Saturated	PSS1/EM1E	11,792.6	0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Emergent Persistent Semi-Permanently Flooded	PSS1/EM1F	751.6	0
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Unconsolidated Shore Temporarily Flooded	PSS1/USA	747.6	0

Wetland Type	Cowardin Code[a]	Acres of Wetland Type in Analysis Area[b]	Acres of Wetland Type in Field-Verified Portion of Analysis Area[c]
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Unconsolidated Shore Seasonally Saturated[d]	PSS1/USB	12.5	12.5
Palustrine Scrub-Shrub Broad-Leaved Deciduous/Unconsolidated Shore Seasonally Flooded	PSS1/USC	13.9	0
Palustrine Scrub-Shrub Broad-Leaved Deciduous Temporarily Flooded	PSS1A	4,449.8	0
Palustrine Scrub-Shrub Broad-Leaved Deciduous Seasonally Saturated	PSS1B	2,641.0	317.9
Palustrine Scrub-Shrub Broad-Leaved Deciduous Seasonally Flooded	PSS1C	91.7	64.9
Palustrine Shrub-Scrub Broad-Leaved Deciduous Continuously Saturated[d]	PSS1D	117.1	117.1
Palustrine Shrub-Scrub Broad-Leaved Deciduous Seasonally Flooded/Saturated	PSS1E	117.6	0
Palustrine Scrub-Shrub Broad-Leaved Evergreen Seasonally Saturated[d]	PSS3B	109.8	109.8
Palustrine Unconsolidated Bottom/Emergent Persistent Semi-Permanently Flooded	PUB/EM1F	9,137.7	0
Palustrine Unconsolidated Bottom/Emergent Nonpersistent Semi-Permanently Flooded	PUB/EM2F	45.0	0
Palustrine Unconsolidated Bottom/Emergent Nonpersistent Permanently Flooded	PUB/EM2H	734.0	0
Palustrine Unconsolidated Bottom Semi-Permanently Flooded	PUBF	155.8	0
Palustrine Unconsolidated Bottom Semi-Permanently Flooded Diked/Impounded	PUBFh	5.9	0
Palustrine Unconsolidated Bottom Semi-Permanently Flooded Excavated	PUBFx	2.5	0
Palustrine Unconsolidated Bottom Permanently Flooded	PUBH	61,263.0	227.6
Palustrine Unconsolidated Bottom Permanently Flooded Diked/Impounded	PUBHh	42.9	0
Palustrine Unconsolidated Bottom Permanently Flooded Excavated	PUBHx	25.6	0
Palustrine Unconsolidated Shore/Emergent Persistent Temporarily Flooded	PUS/EM1A	483.1	0
Palustrine Unconsolidated Shore/Emergent Persistent Seasonally Flooded	PUS/EM1C	69.3	0
Palustrine Unconsolidated Shore/Emergent Persistent Seasonally Flooded/Saturated	PUS/EM1E	309.1	0
Palustrine Unconsolidated Shore/Scrub-Shrub Broad-Leaved Deciduous Temporarily Flooded	PUS/SS1A	53.5	0
Palustrine Unconsolidated Shore Temporarily Flooded	PUSA	265.6	0
Palustrine Unconsolidated Shore Seasonally Flooded	PUSC	165.4	0
Riverine Tidal Unconsolidated Bottom Permanently Flooded[d]	R1UBV	45.7	19.5
Riverine Tidal Unconsolidated Shore Permanently Flooded	R1USQ	16.2	15.0
Riverine Low Perennial Emergent Nonpersistent/Unconsolidated Bottom Permanently Flooded	R2EM2/UBH	580.8	0
Riverine Low Perennial Emergent Nonpersistent Semi-Permanently Flooded	R2EM2F	4.5	0
Riverine Low Perennial Unconsolidated Bottom/Emergent Nonpersistent Permanently Flooded	R2UB/EM2H	435.5	0
Riverine Low Perennial Unconsolidated Bottom Semi-Permanently Flooded	R2UBF	5,808.8	0
Riverine Low Perennial Unconsolidated Bottom Permanently Flooded	R2UBH	19,635.3	19.3
Riverine Low Perennial Unconsolidated Shore Temporarily Flooded	R2USA	1,717.6	0

Wetland Type	Cowardin Code[a]	Acres of Wetland Type in Analysis Area[b]	Acres of Wetland Type in Field-Verified Portion of Analysis Area[c]
Riverine Low Perennial Unconsolidated Shore Seasonally Flooded	R2USC	14,631.4	11.5
Riverine Upper Perennial Unconsolidated Bottom Permanently Flooded	R3UBH	6,343.9	0
Riverine Upper Perennial Unconsolidated Shore Temporarily Flooded	R3USA	186.9	0
Riverine Upper Perennial Unconsolidated Shore Seasonally Flooded	R3USC	512.4	0
Riverine Intermittent Streambed Temporarily Flooded	R4SBA	22.1	0
Riverine Intermittent Streambed Seasonally Flooded	R4SBC	10.7	0
Riverine Unknown Perennial Unconsolidated Bed Permanently Flooded	R5UBH	70.1	0
Upland	U[e]	122.7	122.7
Upland	Upland[e]	12,345.0	0
Upland (fill)	Us[e]	42.9	42.9
NA	**Total**	**2,903,535.8**	**10,240.8**

Note: NA (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	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
L1UBH	1.5	1.7	1.5	0	0	0
PEM1/SS1B	277.2	258.0	262.8	0	0	2.5
PEM1/SS1D	176.0	205.6	164.1	0	0	0
PEM1/SS1E	1.1	1.1	0.9	0	0	2.1
PEM1/SS1F	26.3	40.3	24.9	0	0	0
PEM1/UBF	0	0	0	0	0	< 0.1
PEM1E	0	0	0	0	0	0.3
PEM1F	93.7	118.8	95.4	0	0	< 0.1
PEM1H	5	13.3	9.8	0	0	0
PEM2H	0.6	1.1	0	0	0	0
PSS1/EM1B	0.1	0	0	0	0	0
PSS1/EM1E	0.1	0.1	0.1	0	0	0
PSS1/USB	0.9	0.7	0.7	0	0	0
PSS1B	11.5	12.7	18.4	0	0	0
PSS1C	1.8	1.5	1.7	0	0	0
PSS1D	2.5	2.2	8.7	0	0	0
PSS3B	10.2	8.5	10.3.0	0	0	0
PUBH	2.5	3.7	5.5	0	0	0
R2UBF	0.3	0	0	0	0	0
R2UBH	0.5	0.3	0.5	0	0	0
R2USC	0.4	0.1	0.3	0	0	0
U	7.9	3.6	4.9	0	0	0
Us	0.3	0.3	0.3	0	0	0
Total	**620.4**	**673.6**	**610.8**	**0**	**0**	**4.9**
Total in Wetlands[a]	**607.0**	**663.9**	**597.8**	**0**	**0**	**4.9**
Total in Freshwater WOUS	**5.2**	**5.8**	**7.8**	**0**	**0**	**0**
Total in Uplands	**8.2**	**3.9**	**5.2**	**0**	**0**	**0**

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 Type and Action Alternative or Module Delivery Option

Cowardin Code	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
PEM1/SS1B	1.2	5.0	8.6	15.6	16.2	0
PEM1/SS1D	8.8	12.2	10.5	0	0	0
PEM1/SS1F	19.5	11.4	2.9	0	0	0
PEM1F	0.5	0.5	1.0	13.5	13.1	0
PSS1B	0	0.9	7.0	0	0	0
PUBH	< 0.1	0	0	0.9	0.7	0
Total	**30.0**	**30.0**	**30.0**	**30.0**	**30.0**	**0**

Note: < (less than). 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)
Colville River Delta-Frontal Harrison Bay (303,614.3)	2.2	< 0.1	2.2	< 0.1	3.5	< 0.1
Kalikpik River (233,090.1)	28.0	< 0.1	29.1	< 0.1	28.0	< 0.1
Outlet Fish Creek (137,576.9)	61.0	< 0.1	112.5	<0.1	66.1	< 0.1
Outlet Judy Creek (246,274.6)	365.0	0.1	370.1	0.1	355.5	0.1
Ublutuoch River (150,954.4)	155.2	< 0.1	5.5	< 0.1	1.8	< 0.1
Ugnuravik River (77,253.8)	0.9	< 0.1	0.9	< 0.1	0.9	< 0.1
Total	**612.3**	**NA**	**520.3**	**NA**	**455.8**	**NA**

Note: < (less than); NA (not applicable). The total acres for each watershed were assumed to be equal to the total wetland acres since uplands compose less than 1% of the analysis area. 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	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	118.9	195.2	83.4
Multi-season ice pads	30.0	30.0	30.0	30.0	30.0	0.0
Freshwater ice roads	3,590.7	4,411.6	5,893.4	710.7	1,530.9	583.2
Total	**4,557.3**	**5,608.0**	**7,164.8**	**859.6**	**1,756.1**	**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	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
L1UBH	18.6	21.3	17.9	0	0	0.8
L2EM2H	0.1	0.1	0.1	0	0	0
PEM1/SS1B	1,094.5	1,104.90	821.9	0	0	16.7
PEM1/SS1D	907.4	969.6	700.2	0	0	0
PEM1/SS1E	22.6	24.6	19.6	0	0	9.5
PEM1/SS1F	257.4	290.6	167.8	0	0	0
PEM1/USE	0	0	0	0	0	0.3
PEM1E	0	0	0	0	0	0.9
PEM1F	731.3	672.0	560.0	0	0	0.4
PEM1H	62.5	70.9	38.0	0	0	0
PEM2H	4.6	5.3	1.4	0	0	0
PSS1/EM1B	2.0	0	0	0	0	0
PSS1/EM1E	2.9	2.9	2.9	0	0	0
PSS1/USB	10.1	8.3	8.3	0	0	0
PSS1B	112.0	117	108.2	0	0	0
PSS1C	20.8	17.7	20.3	0	0	0
PSS1D	34.9	27.2	44.6	0	0	0
PSS3B	47.5	29.4	49.5	0	0	0
PUBH	54.3	55.0	47.5	0	0	0
R1UBV	0.4	0.4	0.4	0	0	0
R2EM2/UBH	0	0	0	0	0	< 0.1
R2UBF	5.9	0	0	0	0	0
R2UBH	11.5	8.3	10.3	0	0	0
R2USC	4.8	1.8	3.8	0	0	0
U	66.5	41.9	58.1	0	0	0
Us	0.1	0.1	0.1	0	0	0
Total	**3,472.7**	**3,469.3**	**2,680.9**	**0**	**0**	**28.6**
Total in Wetlands[a]	**3,310.5**	**3,340.4**	**2,542.7**	**0**	**0**	**27.8**
Total in Freshwater WOUS	**95.6**	**86.9**	**80.0**	**0**	**0**	**0.8**
Total in Uplands	**66.6**	**42.0**	**58.2**	**0**	**0**	**0**

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)
Colville River Delta-Frontal Harrison Bay (224,452.3)	27.2	< 0.1	27.2	< 0.1	30.6	< 0.1
Kalikpik River (233,088.3)	191.2	< 0.1	191.8	< 0.1	191.2	< 0.1
Outlet Fish Creek (137,576.9)	562.2	< 0.1	760.5	< 0.1	564.9	< 0.1
Outlet Judy Creek (246,274.6)	2,432.0	< 0.1	2,254.2	< 0.1	1,685.8	< 0.1
Ublutuoch (Tiŋmiaqsiuġvik) River (150,954.4)	71.8	< 0.1	71.8	< 0.1	28.7	< 0.1
Ugnuravik River (77,253.8)	1.0	< 0.1	1.0	< 0.1	1.0	< 0.1
Total	**3,285.4**	**NA**	**3,306.5**	**NA**	**2,502.2**	**NA**

Note: < (less than); NA (not applicable). The total acres for each watershed were assumed to be equal to the total wetland acres since uplands compose less than 1% of the analysis area. However, numbers may vary slightly from other resource 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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Willow Master Development Plan

Appendix E.10
Fish Technical Appendix

There is no technical appendix for this resource

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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	Common Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
Waterfowl	Greater white-fronted goose	*Anser albifrons*	Common	Breeder	SAMA, TLHC, DOWIP, SOW, SOWIP, SEMA, DPC, YBWC, OBWC, NPWM, PWM, MSSM, MTT, TLDS	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	Common 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[c]	*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;**
Seabirds	Pomarine jaeger	*Stercorarius pomarinus*	Uncommon	Visitor	NA[d]	Johnson and Herter 1989

Group	Common Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
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**
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

Group	Common Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
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
Raptors	Gyrfalcon	*Falco rusticolus*	Rare	Visitor	NA[d]	Johnson, Parrett et al. 2014

Group	Common Name	Scientific Name	Relative Abundance[a]	Status	Habitats Used[b]	References
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 colonize river deltas on the Arctic Coastal Plain. They spread across a variety of habitats during expansion. Initially found on raised areas, where snow melts early but is not subject to flooding; thus, unvegetated and partially vegetated BAR, TLDS, NPWM, PWM, and DPC.

[d] 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; it uses 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. Parret, 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); it uses 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. Although nest surveys have not been conducted in the Willow area, three spectacled eider nests were found in a wetland about 7 miles east of the Bear Tooth drill site 4 (BT4) in 2001. 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% 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 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, Wildman 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 successful nests were closer than failed nests on average than to a road, drill pad, and airstrip (Johnson, Wildman 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 28 breeding territories encompassing 32 lakes within approximately 3 miles of the Project (Johnson, Parrett et al. 2018b, 2019). Yellow-billed loons maintain territories on the same lakes for several decades (Johnson, Parrett et al. 2019) and are habitat specialists, preferring deep, clear, open lakes and deep lakes with emergent vegetation containing fish (Earnst, Platte et al. 2006; Haynes, Schmutz et al. 2014); 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	1,838.6
Riverine Complex	Mosaic of moist to wet sedge and shrub types, water, and barrens along flooded streams and associated floodplains	Yes	3	1,701.4
River or Stream	Permanently flooded channels large enough to be mapped as separate units	No	4	8,199.3
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	4	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	10,609.2
Barren	Area without vegetation and not normally inundated	Yes	12	10,255.1
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	34,753.6
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	25,351.9
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	7,482.2
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	1,919.0
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	19	134,620.5
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	4,606.2
Open Nearshore Water	Shallow estuaries, lagoons, and embayments along the Beaufort Sea coast	Yes	22	1,786.5
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	9,177.3
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	35,899.6
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	26,802.2

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	37	104,498.2
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	30,076.9
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	68,927.1
Unmapped	Unknown	Unknown	Unknown	642,071.6
Total	**NA**	NA	**NA**	**1,174,832.6**

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).

[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
Unmapped Area	NA	0	0	0
Dune Complex	2	0.9	0.7	0.7
Riverine Complex	3	0.9	0.9	0.8
River or Stream	4	0.6	0.3	0.5
Salt-Killed Tundra	4	0	0	0
Tapped Lake with Low-Water Connection	5	0	0	0
Human Modified	7[b]	0.4	0.4	0.4
Tidal Flat Barrens	7	0	0	0
Brackish Water	10	0	0	0
Tapped Lake with High-Water Connection	10	0	0	0
Shallow Open Water without Islands	11	2.5	2.4	2.7
Barren	12	0.8	0.1	0.5
Deep Open Water without Islands	12	0	0.3	0
Deep Open Water with Islands or Polygonized Margins	14	0	0	0
Shallow Open Water with Islands or Polygonized Margins	14	0.3	1.0	2.5
Grass Marsh	15	0	0.5	0
Moist Tussock Tundra	19	259.1	261.3	245.0
Salt Marsh	21	0	0	0
Young Basin Wetland Complex	21	0.1	0	0.1
Open Nearshore Water	22	0	0	0
Deep Polygon Complex	25	0	0	0
Sedge Marsh	25	3.2	11.5	7.9
Old Basin Wetland Complex	27	26.5	41.1	25.1
Tall, Low, or Dwarf Shrub	27	26.2	20.8	34.9
Moist Sedge-Shrub Meadow	37	52.9	61.1	41.8
Nonpatterned Wet Meadow	39	16.2	30.1	20.1
Patterned Wet Meadow	44	63.8	75.1	61.6
Total high-use acres (> 20 species)	**NA**	**188.9**	**239.7**	**191.5**
Total acres	**NA**	**454.4**	**507.6**	**444.6**

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	Tiŋmiaqsiuġvik Mine Site
Deep Open Water without Islands	12	1.5	0
Moist Tussock Tundra	19	0	94.6
Sedge Marsh	25	0	1.8
Tall, Low, or Dwarf Shrub	27	1.6	0
Moist Sedge-Shrub Meadow	37	4.6	48.3
Nonpatterned Wet Meadow	39	7.0	0
Patterned Wet Meadow	44	1.7	4.9
Total high-use acres (> 20 species)	**NA**	**14.9**	**55.0**
Total acres	**NA**	**16.4**	**149.6**

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.

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
Unmapped Area	NA	0	0	0
Dune Complex	2	11.4	8.3	8.3
Riverine Complex	3	16.6	18.6	13.6
River or Stream	4	13.7	7.3	9.2
Salt-Killed Tundra	4	0	0	0
Tapped Lake with Low-Water Connection	5	0	0	0
Human Modified	7[b]	1.1	1.1	1.1
Tidal Flat Barrens	7	0	0	0
Brackish Water	10	0	0	0
Tapped Lake with High-Water Connection	10	0	0	0
Shallow Open Water without Islands	11	35.4	33.3	23.5
Barren	12	10.3	2.5	6.8
Deep Open Water without Islands	12	11.0	17.0	10.7
Deep Open Water with Islands or Polygonized Margins	14	7.2	4.4	7.2
Shallow Open Water with Islands or Polygonized Margins	14	17.5	16.9	19.0
Grass Marsh	15	0.1	0.8	0.1
Moist Tussock Tundra	19	1,503.0	1,622.7	1,166.9
Salt Marsh	21	0	0	0
Young Basin Wetland Complex	21	1.3	1.8	1.3
Open Nearshore Water	22	0	0	0
Deep Polygon Complex	25	0	0	0
Sedge Marsh	25	62.5	70.7	37.8
Old Basin Wetland Complex	27	262.8	298.9	173.6
Tall, Low, or Dwarf Shrub	27	276.4	227.7	274.4
Moist Sedge-Shrub Meadow	37	390.4	345.2	247.4
Nonpatterned Wet Meadow	39	164.9	169.5	155.2
Patterned Wet Meadow	44	566.4	501.9	404.2
Total high-use acres (> 20 species)	**NA**	**1,724.5**	**1,615.7**	**1,293.9**
Total acres	**NA**	**3,352.0**	**3,348.6**	**2,560.3**

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.
[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
Unmapped Area	NA	0	0	0
Dune Complex	2	15.8	11.8	11.8
Riverine Complex	3	55.8	62.3	43.6
River or Stream	4	167.0	161.3	163.0
Salt-Killed Tundra	4	0.9	0.9	0.9
Tapped Lake with Low-Water Connection	5	1.2	1.2	1.2
Human Modified	7[b]	178.4	178.4	183.4
Tidal Flat Barrens	7	0	0	0
Brackish Water	10	0	0	0
Tapped Lake with High-Water Connection	10	32.6	32.6	32.6
Shallow Open Water without Islands	11	326.2	330.6	325.5
Barren	12	181.1	172.4	173.4
Deep Open Water without Islands	12	352.7	376.3	371.7
Deep Open Water with Islands or Polygonized Margins	14	158.4	151.4	169.1
Shallow Open Water with Islands or Polygonized Margins	14	141.7	144.5	154.4
Grass Marsh	15	39.5	40.3	37.0
Moist Tussock Tundra	19	6,269.3	6,716.4	6,095.3
Salt Marsh	21	44.4	44.4	44.4
Young Basin Wetland Complex	21	144.5	145.0	142.9
Open Nearshore Water	22	129.6	129.6	129.6
Deep Polygon Complex	25	79.5	79.5	79.5
Sedge Marsh	25	391.1	400.0	324.9
Old Basin Wetland Complex	27	1,480.2	1,568.6	1,409.5
Tall, Low, or Dwarf Shrub	27	1,012.1	949.0	951.0
Moist Sedge-Shrub Meadow	37	3,452.2	3,403.0	3,052.8
Nonpatterned Wet Meadow	39	1,181.6	1,200.8	1,190.1
Patterned Wet Meadow	44	2,923.7	2,944.8	2,785.7
Total high-use acres (by >20 species)	**NA**	**10,838.9**	**10,864.7**	**10,110.4**
Total acres	**NA**	**18,759.5**	**19,245.1**	**17,873.3**

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	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	859.6	1,756.1	666.6
Multi-season ice pads (acres)[a]	30.0	30.0	30.0	30.0	30.0	0
Freshwater use (millions of gallons)	1,662.4	1,914.3	2,286.3	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 Focal Bird 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	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
Spectacled eider	1.1	1.1	1.1	NA	NA	< 0.1
Yellow-billed loon	6.1	6.3	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	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 gravel infrastructure	11	10	11	ND	ND	ND
Number of lakes with nests within 1 mile of gravel infrastructure	7	6	7	ND	ND	ND
Number of breeding lakes (with nests or broods) within 1,640 feet (500 m) of gravel infrastructure	6	6	4	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 1,640 feet from a breeding lake are stipulated as no development areas in Best Management Practice 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	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
Direct habitat loss	109.4	150.5	112.0	12.8	13.0	1.2
Direct habitat alteration (excavation)	15.2	15.2	15.2	0	0	0
Indirect habitat alteration (dust shadow)	1,066.7	1,044.4	794.9	0	0	4.8[a]
Disturbance zone[b]	7,035.5	7,189.4	6,873.0	188.5	188.4	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

August 2020

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List of Acronyms

ACP	Arctic Coastal Plain
BMP	best management practice
CAH	Central Artic Herd
CRD	Colville River Delta
km^2	square kilometers
LS	lease stipulations
m	meters
NPR-A	National Petroleum Reserve in Alaska
Project	Willow Master Development Plan Project
TCH	Teshekpuk Caribou Herd

Glossary Terms

Subnivean – Occurring beneath a layer of snow.

Ungulate – A hoofed mammal.

1.0 TERRESTRRIAL MAMMALS

1.1 Species

At least 19 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*.

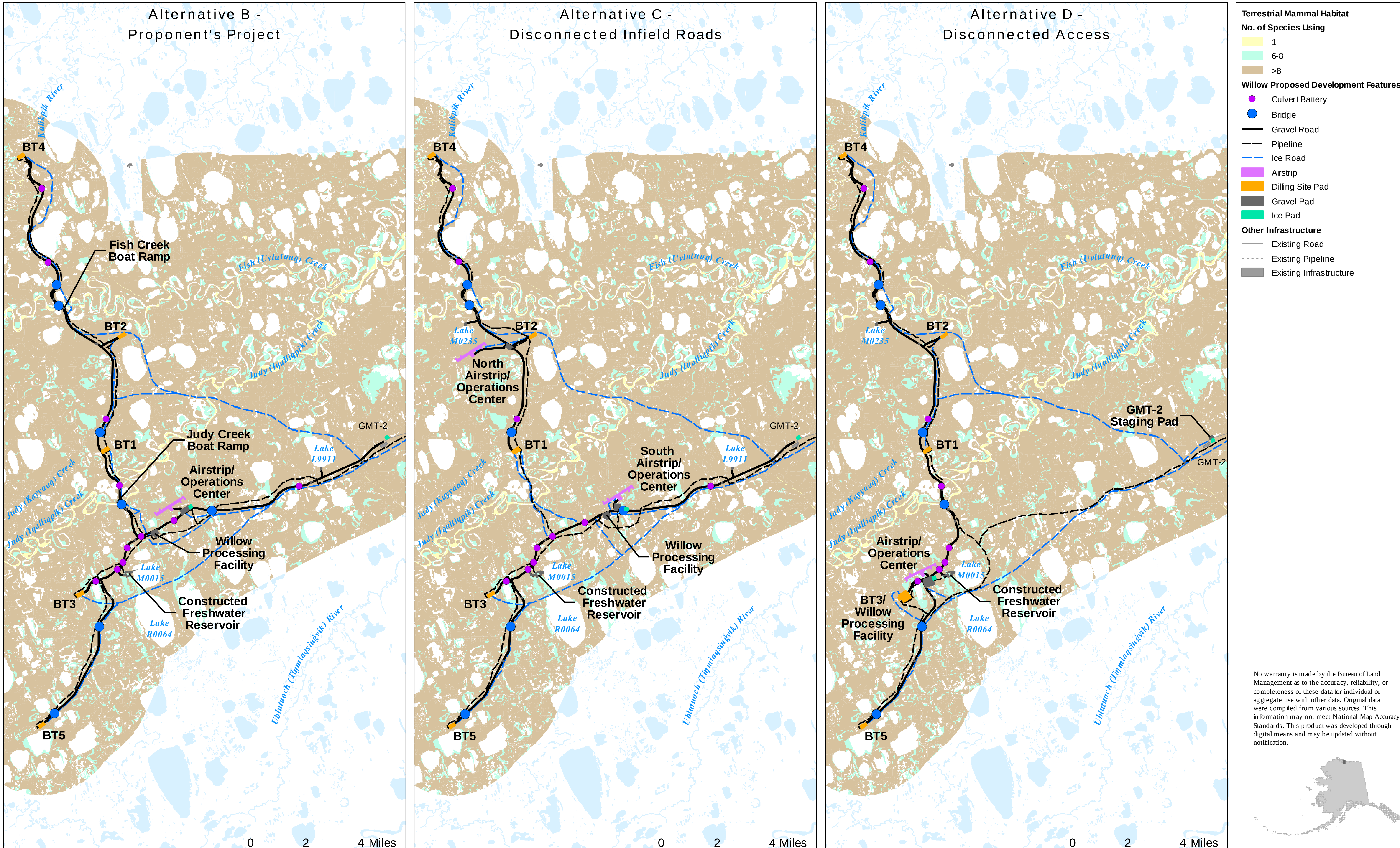
Alternative B - Proponent's Project
Alternative C - Disconnected Infield Roads
Alternative D - Disconnected Access
Kalikpik River
Fish (Uvlutuuq) Creek
Judy (Iqalliqpik) Creek
Judy (Kayyaaq) Creek
Ublutuoch (Tiŋmiaqsiuġvik) River
BT4
BT2
BT1
BT3
BT5
GMT-2
Fish Creek Boat Ramp
Judy Creek Boat Ramp
Airstrip/ Operations Center
Willow Processing Facility
Constructed Freshwater Reservoir
North Airstrip/ Operations Center
South Airstrip/ Operations Center
GMT-2 Staging Pad
BT3/ Willow Processing Facility
Lake M0235
Lake L9911
Lake M0015
Lake R0064
0 2 4 Miles
Terrestrial Mammal Habitat
No. of Species Using
1
6-8
>8
Willow Proposed Development Features
Culvert Battery
Bridge
Gravel Road
Pipeline
Ice Road
Airstrip
Dilling Site Pad
Gravel Pad
Ice Pad
Other Infrastructure
Existing Road
Existing Pipeline
Existing Infrastructure
No warranty is made by the Bureau of Land Management as to the accuracy, reliability, or completeness of these data for individual or aggregate use with other data. Original data were compiled from various sources. This information may not meet National Map Accuracy Standards. This product was developed through digital means and may be updated without notification.

Figure E.12.1

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
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, no groups currently using the area	Arthur and Del Vecchio 2009, 2013b; Danks and Klein 2002; Gustine, Barboza et al. 2011; Wilson and Klein 1991; Lenart 2015c
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
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

Common Name	Scientific Name	Habitat Use	Relative Abundance in Analysis Area	References
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.

1.1.1 Foxes

Arctic foxes and red foxes occur in the analysis area year-round, although arctic foxes are more abundant (Johnson, Burgess et al. 2003). Both species use similar denning habitats, which include well-drained soils such as riverbanks, lake basins, and pingos. Red foxes are aggressive toward arctic foxes and will displace them from feeding areas and den sites (Johnson, Burgess et al. 2005; Stickney, Obritschkewitsch et al. 2014). In the Prudhoe Bay oil fields, red foxes have increased in abundance at a faster pace than arctic foxes, possibly due to warmer winters or higher tolerance of human presence (Stickney, Obritschkewitsch et al. 2014). Foxes in the oilfields are highly tolerant of humans and are often attracted to areas of human activities (Burgess 2000).

Arctic foxes range from the Brooks Range to the Beaufort Sea coast, but the highest abundance is on the ACP. Red foxes range throughout most of Alaska (MacDonald and Cook 2009). Arctic and red foxes prey on small mammals, such as lemmings, ground squirrels, and voles. Fluctuations in lemming abundance are often followed by fluctuations in the arctic fox population (Angerbjorn, Arvidson et al. 1991). Red foxes are omnivorous and opportunistic, eating a variety of items, including insects, small mammals, berries, and carrion. Both species will also scavenge eggs from ground-nesting birds (Hull 1994).

1.1.2 Grizzly Bears

Grizzly bears occur throughout the ACP in low densities (0.5–2.0 bears per 1,000 square kilometers [km^2]) compared to the mountains and foothills of the Brooks Range (10–30 bears per 1,000 km^2) (Carroll 1998). The lower density on the ACP is likely due to marginal habitat because of severe climate, a short growing season, and limited food resources. Grizzly bears of all ages and both sexes den during winter in pingos, river and lake banks, sand dunes, and steep gullies in uplands (Shideler and Hechtel 2000) that accumulate large snowdrifts for insulation. The Willow area contains some of these features and generally has more topography than areas further east on the central ACP. As a result, the area likely has suitable denning habitat for grizzly bears. Grizzly bears are opportunistic omnivores that rely on food sources that vary with the season. Small mammals, such as ground squirrels, are a common prey source in the NPR-A as are eggs of ground-nesting birds. In June, caribou calves are an important seasonal food source. Since 2001, incidental observations of grizzly bears and their dens have been recorded during aerial surveys for caribou and other wildlife throughout the analysis area (Johnson, Burgess et al. 2005; Lawhead, Prichard, and Welch 2014; Prichard, Welch et al. 2018). Moderate numbers of grizzly bears have used the North Slope oilfields in the last few decades (Shideler and Hechtel 2000), and can be attracted to areas of human activity, or garbage storage.

1.1.3 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 (Uvlutuuq and Iqalliqpik) Creek and Judy (Kayyaak and Iqalliqpik) Creek in the Willow area (Lawhead, Prichard et al. 2009; Lawhead, Prichard, Macander et al. 2014).

1.1.4 Muskoxen

Muskoxen historically occurred throughout northern Alaska, but over-harvesting led to their extirpation in the late 1800s or early 1900s (Hone 2013 [1934]; Smith 1989). Their population in northeastern Alaska was reestablished by translocation to Barter Island and the Kavik River in 1969 and 1970. As their numbers on the ACP increased, their range expanded westward to the Colville River and eastward to Babbage River in the Yukon (Lenart 2007; Reynolds 1998).

Although small numbers of muskoxen have occasionally been observed west of the Colville River, they are not considered common in the NPR-A (BLM 2012). Between 2001 and 2012, muskoxen herds as large as 25 individuals were occasionally recorded incidentally in the NPR-A near the Beaufort Sea coast along Harrison

Bay. A group of six was recorded near Greater Mooses Tooth 2 in June 2001 (Lawhead and Prichard 2002). Nuiqsut residents report muskox using the Fish (Uvlutuuq and Iqalliqpik) Creek drainage (Jonah Nukapigak, Nuiqsut resident, personal communication to CPAI. June 6, 2018). Although their current population is reportedly stable or in slight decline (Arthur and Del Vecchio 2013a), the population on the central North Slope could potentially expand into the analysis area. Suitable habitat, which generally consists of riparian, upland shrub, and moist sedge shrub meadows, exists throughout the NPR-A (Danks 2000; Johnson, Burgess et al. 1996).

1.1.5 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.

1.2 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

Habitat[a]	Description	Species Use[b]
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.	12

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	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	–	–	12
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 Existing and Proposed Lease Stipulations and Best Management Practices

All the existing lease stipulations (LS) and best management practices (BMPs) for caribou in Table 3.12.1 (in the Willow MDP Environmental Impact Statement [EIS], Section 3.12, *Terrestrial Mammals*) would also apply to other terrestrial mammals. Table E.12.4 summarizes other existing LS and BMPs that would apply to Project actions on BLM-managed lands and are intended to mitigate impacts to terrestrial mammals from development activity (BLM 2013). The LS and BMPs would reduce impacts to terrestrial mammal habitat, subsistence hunting areas, and the environment that are associated with the construction, drilling, and operation of oil and gas facilities. The BLM is currently revising the NPR-A IAP (BLM 2013), including potential changes to required BMPs (described as Required Operating Procedures [ROPs] in BLM [2020]). Updated ROPs adopted in the new NPR-A IAP will replace existing LSs or BMPs (BLM 2013a). The Willow MDP ROD will detail which of the measures described below will be implemented for the Project. Table E.12.4 also summarizes new ROPs or proposed substantial changes to existing NPR-A IAP LSs and BMPs that would help mitigate impacts to terrestrial wildlife. Although many of the LSs and BMPs have proposed minor language revisions, Table E.12.4 includes only changes that would be apparent in the paraphrased table text. Full text of the changes to LSs and BMPs is provided in BLM (2020).

Table E.12.4. Summary of Existing and Proposed Lease Stipulations and Best Management Practices Intended to Mitigate Impacts to Terrestrial Mammals

LS or BMP	Description or Objective	2013 Requirement	Proposed Changes per 2020 IAP Revisions
BMP A-1	Protect the health and safety of oil and gas field workers and the general public by disposing of solid waste and garbage in accordance with applicable federal, state, and local law and regulations.	Areas of operation shall be left clean of all debris.	Changes do not affect text as described.
BMP A-2	Minimize impacts on the environment from non-hazardous and hazardous waste generation. Encourage continuous environmental improvement. Protect the health and safety of oil field workers and the general public. Avoid human-caused changes in predator populations.	Prepare and implement a comprehensive waste management plan for all phases of exploration and development, including seismic activities.	Changes do not affect text as described.
BMP A-8	Minimize conflicts resulting from interaction between humans and bears during oil and gas activities.	Prepare and implement bear-interaction plans to minimize conflicts between bears and humans.	Added text: – Feeding wildlife is prohibited. – Prevent the emission of odors by installing kitchen hood exhaust filtration systems such as cleaners, filters, purifiers, and scrubbers.
BMP C-1	Protect grizzly bear, polar bear, and marine mammal denning and/or birthing locations.	Cross-country use of heavy equipment is prohibited within one-half mile of known occupied grizzly bear dens.	Changes do not affect text as described.
BMP E-8	Minimize the impact of mineral materials mining activities on air, land, water, fish, and wildlife resources.	Gravel mine site design and reclamation will be in accordance with a plan approved by the authorized officer and in consultation with appropriate federal, state, and North Slope Borough regulatory and resource agencies.	Added text: The plan shall consider locations outside the active floodplain or designing gravel mine sites within active floodplains to serve as water reservoirs if environmentally beneficial. Removal of greater than 100 cubic yards of bedrock outcrops, sand, and/or gravel from cliffs is prohibited. Any extraction of sand or gravel from an active river or stream channel shall be prohibited unless preceded by a hydrological study that indicates no potential impact on streamflow, fish, turbidity, and the integrity of the river bluffs, if present.

LS or BMP	Description or Objective	2013 Requirement	Proposed Changes per 2020 IAP Revisions
BMP E-9	Avoidance of human-caused increases in populations of predators of ground-nesting birds.	Utilize best available technology to prevent facilities from providing nesting, denning, or shelter sites for ravens, raptors, and foxes. Feeding of wildlife is prohibited.	Requirements combined with ROP A-8 (Wildlife Interaction Plan).
BMP M-4	Minimize loss of individuals of, and habitat for, mammalian species designated as Sensitive by the BLM in Alaska.	If development is proposed in an area that provides potential habitat for the Alaska tiny shrew, the proponent would conduct surveys at appropriate times of the year and in appropriate habitats in an effort to detect the presence of the shrew.	Changes do not affect text as described.

Source: BLM 2013, 2020.
Note: BLM (Bureau of Land Management); BMP (best management practice); IAP (Integrated Activity Plan); LS (lease stipulation); ROP (required operating procedure).

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 616.1 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 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 3,401.3 acres of terrestrial mammal habitats within 328 feet (100 meters [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 best management practice (BMP) C-1 for the NPR-A stipulate that occupied grizzly bear dens must be avoided by a distance of 0.5 mile. Grizzly bears may abandon dens because of disturbance (Clough, Patton et al. 1987; Swenson, Sandegren et al. 1997). Although the analysis area likely provides suitable denning habitat, the number of bears denning near Project facilities in a single year would be low, thus reducing the risk of disturbance; however, females denning with cubs would be of most concern. Because bank habitats along Fish (Uvlutuuq and Iqalliqpik) Creek and Judy (Kayyaak and Iqalliqpik) Creek are suitable for bear dens in the analysis area. 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 2019 ranged from one to five collisions per year. Collisions were mostly with foxes and one wolverine. In general, however, the scheduling of the heaviest construction-related traffic during the winter would help to reduce the potential for vehicles to strike terrestrial mammals.

Small terrestrial mammals with limited mobility and small home ranges could be directly killed within the footprints of ice road construction, gravel excavation, and gravel placement. In addition, individual lemmings, voles, and shrews may experience indirect mortality due to habitat disruption and fragmentation from the compaction of **subnivean** spaces by ice road construction and from construction of gravel roads and pads, which would pose barriers to small-mammal movement.

1.3.5 Attraction to Human Activities and Facilities

Foxes and grizzly bears are attracted to areas of human activity, where they feed on garbage and handouts (Eberhardt, Hanson et al. 1982; Follmann 1989; Follmann and Hechtel 1990; LGL Ecological Research Associates 1993; Shideler and Hechtel 2000). Their presence near human activity increases the potential for animals to be struck by vehicles, ingest toxic substances, or be killed by humans in defense of life or property. Foxes and, to a lesser extent, grizzly bears, may use human structures, such as gravel embankments and empty pipes, for denning (Burgess, Rose et al. 1993; Shideler and Hechtel 2000).

Increased predator populations around oil field developments may increase predation on prey populations (Day 1998; Martin 1997). This impact is inferred from the higher number of foxes, increased density of fox dens (Burgess 2000; Burgess, Rose et al. 1993; Eberhardt, Hanson et al. 1982), and higher numbers of bears (Shideler and Hechtel 2000) in the North Slope oil fields. Foxes prey on birds and small terrestrial mammals, and bears prey on caribou, muskoxen, ground squirrels, and bird nests. Red fox may displace arctic fox and kill pups. Increases in mortality of **ungulate** calves by fox or bear may affect populations locally, although there is little information to suggest population-level effects occur with any regularity. Grizzly bear predation of muskoxen is difficult to quantify. It is unlikely that bear predation depresses the caribou population substantially, although the muskox population appears to be more affected.

Human-animal interactions would occur during all seasons and all phases of the Project but would be likely to occur most frequently during construction when human activity would be most intensive and widespread. Lower levels of human activity during drilling and operations would result in correspondingly lower rates of human-animal interactions.

Control of food waste and other garbage would help minimize predators and scavengers being attracted to facilities. Existing BMPs and company policies against feeding animals would be strictly enforced. Proper containment and removal of garbage and hazardous waste at camps and drill sites would minimize the attraction of predators and the risks to animals. A Wildlife Avoidance and Interaction Plan and environmental awareness program for all Project employees would be required to address waste-handling practices and bear interactions. Even with effective enforcement of these policies, attraction of predators and scavengers would be likely.

1.4 Alternatives Comparison Tables: All Species

Habitat loss and alteration is summarized by land-based alternative in Tables E.12.5 and E.12.6. Table E.12.7 summarizes 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	Option 3: Colville River Crossing
Unmapped Area	NA	620,107.1	0	0	0	0
Barren	1	9,714.8	0.8	0.1	0.5	0
Grass Marsh	1	1,786.0	0	0.5	0	0
Rivers and Streams	1	7,473.7	0.6	0.3	0.5	0
Tidal Flat Barrens	1	362.8	0	0	0	0
Salt-Killed Tundra	1	131.3	0	0	0	0
Human Modified	3[b]	4,035.8	0.4	0.4	0.4	1.0
Nonpatterned Wet Meadow	6	26,645.2	23.2	37.1	27.1	0.4
Sedge Marsh	6	8,854.6	5.0	13.3	9.8	0
Dune Complex	7	1,770.8	0.9	0.7	0.7	0
Riverine Complex	8	1,694.8	0.9	0.9	0.8	0
Young Basin Wetland Complex	9	2,849.6	0.1	0	0.1	0
Moist Tussock Tundra	10	119,195.6	353.7	356.0	339.6	0.8
Old Basin Wetland Complex	10	31,392.3	26.5	41.1	25.1	0.4
Patterned Wet Meadow	10	65,690.6	70.5	81.7	68.2	0.5
Salt Marsh	10	1,132.0	0	0	0	0
Tall, Low, or Dwarf Shrub	11	22,035.5	27.8	22.5	36.5	0
Moist Sedge-Shrub Meadow	12	94,270.3	105.7	113.9	94.6	1.9
Total high-use habitat acres	**NA**	**333,716.3**	**584.2**	**615.2**	**564.0**	**3.6**
Total acres	**NA**	**1,019,142.8**	**616.1**	**668.5**	**603.9**	**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	Option 3: Colville River Crossing
Unmapped Area	NA	0	0	0	2.2
Barren	1	10.3	2.5	6.8	0
Grass Marsh	1	0.1	0.8	0.1	0
Rivers and Streams	1	13.9	7.5	9.5	0
Tidal Flat Barrens	1	0	0	0	0
Salt-Killed Tundra	1	0	0	0	0
Human Modified	3[b]	1.1	1.1	1.1	0
Nonpatterned Wet Meadow	6	164.9	169.5	155.2	1.0
Sedge Marsh	6	62.5	70.9	38.0	0
Dune Complex	7	11.4	8.3	8.3	0
Riverine Complex	8	16.6	18.6	13.6	0.1
Young Basin Wetland Complex	9	1.3	1.8	1.3	0
Moist Tussock Tundra	10	1,599.9	1,719.6	1,263.7	6.4
Old Basin Wetland Complex	10	262.8	298.9	173.6	0.7
Patterned Wet Meadow	10	568.1	503.7	406.0	3.0
Salt Marsh	10	0	0	0	< 0.1
Tall, Low, or Dwarf Shrub	11	277.6	228.9	275.5	0.4
Moist Sedge-Shrub Meadow	12	410.8	365.6	267.8	13.6

Habitat	Habitat Value (1 to 13)[a]	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Road	Alternative D: Disconnected Access	Option 3: Colville River Crossing
Total high-use habitat acres	**NA**	**3,120.5**	**3,118.5**	**2,387.9**	**24.1**
Total acres	**NA**	**3,401.3**	**3,397.7**	**2,620.5**	**25.2**

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	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	1.02	< 0.01	0.01	0.00	6.78
Calving	0.84	0.87	0.77	0.01	0.08	0.00	12.29
Calving (maternal females only)	0.67	0.69	0.63	0.01	0.06	0.00	14.32
Post-calving	0.57	0.59	0.53	0.01	0.36	0.00	15.81
Mosquito season	0.30	0.31	0.29	0.01	0.75	0.00	18.59
Oestrid fly season	0.67	0.69	0.62	0.01	0.20	0.00	11.05
Late summer	1.39	1.44	1.28	0.01	0.01	0.00	7.90
Fall migration	1.64	1.70	1.47	0.01	< 0.01	0.00	8.33
Winter	1.10	1.14	0.98	< 0.01	0.01	0.00	5.71

Source: ABR Inc. 2019

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

August 2020

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Table of Contents

List of Tables

List of Acronyms

CRD	Colville River Delta
dB	decibels
dBA	A-weighted decibels
dB re 1 μPa	decibels referenced to 1 micropascal
DPS	distinct population segment
EIS	Environmental Impact Statement
Hz	hertz
IWC	International Whaling Commission
kHz	kilohertz
m	meter
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
SPL	sound pressure level
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 BLM (2019b, 2020) and BOEM (2018).

1.1.1 Baleen Whales

1.1.1.1 Blue Whale

There are two stocks of blue whale (*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 (IWC), 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. Bowhead whales could be encountered along the barge transit route in fall as they migrate west across the Beaufort and Chukchi seas. They migrate to the east in spring, generally prior to when barges would be transiting the analysis area. 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. They are not expected to be near Oliktok Dock due to the area’s shallow waters.

There is no critical habitat designated for bowhead whales.

1.1.1.3 Fin Whale

Fin whales (*Balaenoptera physalus*) of the Alaska stock can be found in the Chukchi Sea, in the Sea of Okhotsk, around the Aleutian Islands, and in the Gulf of Alaska (BOEM 2015). Surveys conducted along the Bering Sea shelf indicated that fin whales were the most common large whale sighted, with the 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 stocks of humpback whale (*Megaptera novaeangliae*) occur in Alaska: the Western North Pacific distinct population segment (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. 2018) (Figure 11). 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.

There is no critical habitat designated for humpback whales.

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. 2018). The majority of NPRW sightings have occurred from about 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. 2018). 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 Western North Pacific Gray Whale
Western North Pacific gray whales (*Eschrichtius robustus*) feed during the summer and fall in the Okhotsk Sea off northeastern Sakhalin Island, Russia; and southeastern Kamchatka in the Bering Sea (Allen and Angliss 2015). 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 (Allen and Angliss 2015). 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. Sperm whales are widely distributed in the North Pacific, with the northernmost boundary extending from Cape Navarin to the Pribilof Islands. 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

Bearded seals (*Erignathus barbatus*) 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 2 to 3 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).

There is no critical habitat designated for bearded seals.

1.1.3.2 Ringed Seal

Ringed seals (*Pusa hispida*) 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, National Marine Fisheries Service (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); however, the rule has yet to be finalized. Proposed critical habitat includes all U.S. coastal waters, from the Arctic Canadian border along the coastline to Cape Avinof. Primary constituent elements include sea ice habitat and prey resources such as Arctic cod, saffron cod, shrimp, 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. 2018). 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 (Muto, Helker et al. 2018). 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 kilometers [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.

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 is 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, > 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 < 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). Dens are often located at the edge of stable sea ice on the shoreward side of barrier islands. Between Utqiaġvik (Barrow) and the Kavik River (east of Prudhoe Bay), 95% of dens occupied by radio-collared bears were located within 5 miles of the coast (Durner, Douglas et al. 2009); historical reports of dens found by other methods demonstrate that some females den farther inland (Durner, Fischbach et al. 2010; Seaman 1981).

Polar bear critical habitat was designated by 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 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 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) along the Beaufort Sea coast, as shown in Figures 3.13.1 and 3.13.2.

The analysis area is populated by the SBS and Chukchi/Bering Sea (CBS) stocks of polar bears, which are classified as depleted under the MMPA and listed as threatened under the ESA (USFWS 2008). 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 (Muto, Helker et al. 2017).

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 (USFWS 2010). 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. 2018). 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 BS stock migrating in spring (April and May) and ECS stock migrating in summer (June and July; Suydam , Lowry et al. 2001). The BS 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 ECS 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 BS 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 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 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. 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 (Muto, Helker et al. 2018). 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 Bering Sea Transient stock (that can occur in the Chukchi and Beaufort seas). 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 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 the 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 (Muto, Helker et al. 2019). 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 184,967 seals. 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

Spotted seals (*Phoca largha pallas*) 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. 2018). 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 Marine Mammal Protection Act (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	N/A
Mid-frequency cetaceans	*230 dB L_{pk}* 185 dB SEL	198 dB SEL	160 dB rms	120 dB rms	N/A
High-frequency cetaceans	202 dB L_{pk} 155 dB SEL	173 dB SEL	160 dB rms	120 dB rms	N/A
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	N/A

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. N/A (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 MDP FEIS, 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 SPLs 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 Avoid and Minimize Effects to Marine Mammals

The following measures were identified during ESA consultation with NMFS to avoid or minimize the effects of the Project on species and habitats protected by the ESA.

1.4.1.1 General Measures

1. The applicant will notify NMFS 7 days prior to the start of in-water activity.
    a. If there is a delay in activity, the applicant will notify NMFS as soon as possible.

1.4.1.2 Measures for Transiting Vessels

1. Crew members on barges and support vessels will be trained on basic marine mammal identification and vessel disturbance guidelines.

2. When weather conditions require, such as when visibility drops, vessel operators must reduce speed and change direction, as necessary (and as operationally practicable), to avoid the likelihood of injuring marine mammals.
3. The transit of vessels is not authorized before July 1. This operating condition is intended to allow marine mammals the opportunity to disperse from the confines of spring leads in sea ice and minimize interactions with subsistence hunters. The return transit is dependent on completion of project work and presence of near shore ice that precludes safe operations. The typical timeframe for returning vessels is mid-to late October or early November, depending on ice conditions. Transit will be prior to formation of shore or landfast ice.
4. The marine vessel route will avoid North Pacific right whale (NPRW)designated critical habitat. Should crew members identify NPRW outside of critical habitat, a sighting report will be reported to NMFS within 24 hours with the following information:
    a. Date, time, and geographic coordinates of the sighting(s);
    b. Species observed, number of animals observed per sighting event; and number of adults/juveniles/calves per sighting event (if determinable); and
    c. Because sightings of NPRWs are uncommon, and photographs that allow for identification of individual whales from markings are extremely valuable, photographs will betaken if feasible, but in a way that does not involve disturbing the animal (e.g., if vessel speed and course changes are not otherwise warranted, they will not take place for the purpose of positioning a photographer to take better photographs). Photographs taken of NPRWs will be submitted to NMFS.

5. Vessels may not be operated in such a way as to separate members of a group of marine mammals from other members of the group.
6. Operators should take reasonable steps to alert other vessel operators in the vicinity of marine mammals.
7. Vessels will not allow tow lines to remain in the water, and no trash or other debris will be thrown overboard, thereby reducing the potential for marine mammal entanglement. All personnel will be responsible for cutting all unused packing straps, plastic rings, and other synthetic loops that have the potential to become entangled around fish or wildlife.
8. Vessels will implement measures to minimize risk of spilling hazardous substances. These measures will include avoiding operation of watercraft in the presence of sea ice to the extent practicable and using fully operational vessel navigation systems composed of radar, chart plotter, sonar, marine communication systems, and satellite navigation receivers, as well as the Automatic Identification System (AIS) for vessel tracking.
9. Vessel operators will avoid groups of 3 or more whales. A group is defined as being 3 or more whales observed within a 500 m (1,645 ft) area and displaying behaviors of directed or coordinated activity (e.g., group feeding).
10. All nonessential boat and barge traffic will be scheduled to avoid periods when bowhead whales are migrating through the area to where they may be affected by sound from the project. Any non-essential boat, barge, or aircraft will be scheduled to avoid approaching the harvest area around Cross Island during the bowhead whale subsistence hunting season consistent with the Conflict Avoidance Agreement.
11. If a vessel approaches within1.6 km (1 mi) of observed whales, except when providing emergency assistance to whalers or in other emergency situations, the operator will take reasonable precautions to avoid potential interaction with the whales by taking one or more of the following actions, as appropriate:
    a. Reducing vessel speed to less than 5 knots (5.8 miles per hour [mph]) within 274m (900 ft) of the whale.
    b. Steering around the whale, if possible.
    c. Operating the vessel to avoid causing a whale to make multiple changes indirection.

   d. Checking the waters around the vessel to ensure that no whales will be injured when the propellers are engaged.
   e. Vessels will not exceed speeds of 10 knots (11.5 mph) in order to reduce potential whale strikes.
   f. If a whale approaches the vessel and if maritime conditions safely allow, the engine will be put in neutral and the whale will be allowed to pass beyond the vessel. If the vessel is taken out of gear, vessel crew will ensure that no whales are within 50 m (164 ft) of the vessel when propellers are re-engaged, thus minimizing risk of marine mammal injury.
   g. Vessels will stay at least 300 m (984 ft) away from cow-calf pairs, feeding aggregations, or whales that are engaged in breeding behavior.

12. Consistent with NMFS marine mammal viewing guidelines(https://alaskafisheries.noaa.gov/pr/mm-viewing-guide), vessel operators will, at all times, avoid approaching within 91 m (300 ft) of marine mammals. Operators will observe direction of travel and attempt to maintain a distance of 91 m (300 ft) or greater between the animal and the vessel by working to alter course or slowing the vessel.
13. If a listed marine mammal is struck by a vessel, it must be reported to NMFS within 24hours. The following will be included when reporting vessel collisions with marine mammals:
    a. Information that will otherwise be listed in the PSO Observation Record.
    b. Number and species of marine mammals involved in the collision.
    c. The date, time, and location of the collision.
    d. The cause of the take (e.g., vessel strike).
    e. The time the animal(s) was first observed and last seen.
    f. Mitigation measures implemented prior to and after the animal was taken.
    g. Contact information for PSO on duty at the time of the collision, vessel's pilot at the time of the collision, or ship's captain.

14. Vessel transit through Steller sea lion critical habitat or near major rookeries and haulouts:
    a. The vessel operator will not purposely approach within 3 nmi (5.5 km) of major Steller sea lion rookeries or haulouts where vessel safety requirements allow and/or where practicable. Vessels will remain 3 nmi (5.5 km) from all Steller sealion rookery sites listed at 50 CFR 224.103(d)(1)(iii).

1.4.1.3 Measures for screeding at Oliktok Dock

1. During screeding, a trained PSO will be stationed on the tug or barge.
2. Screeding will stop if a marine mammal is observed within a 215 m (707 ft) radius of the screeding equipment. Screeding will recommence when the marine mammal has moved outside of that radius or has not been observed for 15 minutes (for seals) or 30 minutes (for cetaceans).
3. PSOs will record observations on data forms or electronic data sheets to be submitted to NMFS in a digital spreadsheet in monthly, annual, and final reports. PSOs will record the following:
   a. Date and time that in-water activity and observation efforts begin and end;
   b. Weather parameters (e.g., percent cloud cover, percent glare, visibility) and sea state where the Beaufort Wind Force Scale will be used to determine sea-state(https://www.weather.gov/mfl/beaufort);
   c. Species, numbers, and, if possible, sex and age class (or color) of observed marine mammals, along with the date, time, and location of the observation;
   d. The predominant sound-producing activities occurring during each marine mammal sighting;

e. Description of any marine mammal behavior patterns during observation, including direction of travel and estimated time spent within the shutdown zone while screeding was active. Behavioral reactions of marine mammals observed just prior to, and during, screeding;
f. Location of marine mammals (geographic coordinates), distance from observer to the marine mammal, and distance from the predominant sound-producing activity or activities to marine mammals;
g. Whether the presence of marine mammals necessitated the implementation of mitigation measures to avoid acoustic impact, and the duration of time that operations were affected by the presence of marine mammals.

1.4.1.4 Reporting

1. Operators should report any dead or injured listed marine mammals to NMFS.
2. Monthly reports will be submitted to NMFS for all months with project activities by the15th of each month following the monthly reporting period. The monthly report will contain and summarize the following information:
    a. Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort state and wind force), and a list of all in-water sound-producing activities occurring concurrent with marine mammal observations.
    b. Species, number, location, distance from the vessel, and behavior of all observed marine mammals, as well as associated project activity (e.g., number of power-downs and shutdowns), observed throughout all monitoring activities.
    c. Observation data will be provided in digital spreadsheet format that can be queried.
    d. An estimate of the number of animals (by species) exposed to sound at received levels greater than or equal to Level B harassment thresholds, with a discussion of any specific behaviors those individuals exhibited.
    e. The report will confirm the implementation of each mitigation measure, and describe their effectiveness for minimizing the adverse effects of the action on ESA-listed marine mammals.

3. Within 90 calendar days of the cessation of in-water work each year, a comprehensive annual report will be submitted to NMFS for review. The report will synthesize all sighting data and effort during each activity for each year. NMFS will provide comments within 30 days after receiving annual reports, and the action agency or its non-federal designee will address the comments and submit revisions within 30 days after receiving NMFS comments. If no comments are received from the NMFS within 30 days, the annual report is considered completed. The report will include the following information:
    a. Summaries of monitoring effort including total hours, observation rate by species and marine mammal distribution through the study period, accounting for sea state and other factors affecting visibility and detectability of marine mammals.
    b. Analyses of the effects of various factors that may have influenced detectability of marine mammals (e.g., sea state, number of observers,fog/glare, and other factors as determined by the PSOs).
    c. Species composition, occurrence, and distribution of marine mammal sightings, including date, water depth, numbers, age/size/gender categories (if determinable), group sizes, and ice cover.
    d. Marine mammal observation data with a digital record of observation data provided in digital spreadsheet format that can be queried.
    e. Summary of implemented mitigation measures (i.e., shutdowns and delays).
    f. Number of marine mammals during periods with and without project activities(and other variables that could affect detectability), such as: (i) initial sighting distances

versus project activity at the time of sighting; (ii) closest point of approach versus project activity; (iii) observed behaviors and types of movements versus project activity; (iv) numbers of sightings/individuals seen versus project activity; (v) distribution around the source vessels versus project activity; and (vi) numbers of animals detected in the Shutdown Zone.

g. Analyses of the effects of project activities on listed marine mammals

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Willow Master Development Plan

Appendix E.14
Land Ownership and Uses Technical Appendix

There is no technical appendix for this resource

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Willow Master Development Plan

Appendix E.15
Economics Technical Appendix

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Memorandum

Date: January 17, 2020

To: Kristen Hansen, DOWL

From: Patrick Burden and Leah Cuyno

Re: Updated Economic Analysis of Proposed Alternatives for the Willow Master Development Plan EIS

DOWL requested Northern Economics to quantify the potential economic impacts of the proposed alternatives being considered for the Willow Master Development Plan (MDP) EIS. This analysis considers the recent changes proposed by CPAI to the construction and operations activities. These changes include the addition of a potential future option to pipe unprocessed oil from GMT2 to the WCF for processing, a new freshwater source, a third option for module delivery, and other refinements to the schedule and project components as presented in Chapter 2 of the Supplemental Draft EIS. The results of this economic impact analysis will be used to inform the environmental consequences section of the Supplemental Draft EIS (SDEIS).

This memorandum transmits the results of the updated economic impact analysis and describes the approach, assumptions, and data used in the analysis.

Scope of Analysis

Project Alternatives

For the purpose of this quantitative analysis, only the action alternatives are analyzed-- Alternatives B, C, and D. Note that Alternative A, is the No Project alternative; no development will occur under this alternative and the existing or baseline economic conditions will continue.

Alternative B is the *Proponent's Project* alternative. The alternative provides the shortest road access from the GMT Unit to the proposed Willow facilities.

Alternative C is described as the '*disconnected infield roads*' alternative.

Alternative D is described as the '*disconnected access*' alternative.

The proposed development scenarios for all three action alternatives include 5 drill sites, and construction of processing facilities at the Willow Central Processing Facility (WCF), a Willow Operations Center (WOC), access roads, pipelines, an airstrip, and a gravel mine. However, certain features, particularly with respect to location and access vary depending on the alternative. For example, Alternative C would not include a gravel road connection between the WCF and the three northern drillsites, BT1, BT2, and BT4. There would be no road bridge across Judy Creek. Instead, an annually- constructed ice road would provide seasonal ground access to these drillsites. Alternative C would require two WOCs and airstrips: a South WOC and airstrip near the WCF, and a North WOC and airstrip, near BT2.

Alternative D, on the other hand, considers a development in which the Plan Area does not have year-round gravel road access to GMTU and Alpine. Instead, the Plan Area would be accessible only by air, ice road, and limited low ground-pressure vehicle. Alternative D includes construction of an annual ice road from GMTU to the Plan Area. Alternative D retains gravel roads between Plan Area facilities for safety and spill response. Alternative D would require a new diesel pipeline to the WOC from the Kuparuk CPF2 and approximately 25 acres of additional gravel pad footprint at the WCF. The lack of flexibility to use existing North Slope infrastructure and associated constraints on construction and logistics would extend the construction phase, delay the first oil date, and affect operational efficiency and emergency response for the life of the development.

In addition to the facilities described above, a total of 9 sealift barges are anticipated for the Project to deliver large, prefabricated modules as well as other materials to the North Slope. Bulk materials and smaller modules would be delivered to Oliktok Dock and transported to the Plan Area on the Alpine Resupply Ice Road. Three options for delivery of the heavy prefabricated WCF and drillsite modules are being considered, with the first two options using a nearshore staging area (NSA) west of the Colville River and construction of ice roads to reach the Willow Development, and a third option would make use of the existing Oliktok Dock and gravel roads, as well as construction of land-based ice roads from the dock to the Willow Development.

More details on the different alternatives are presented in Chapter 2 of the SDEIS document.

Economic Indicators

This analysis quantifies the potential economic effects or consequences of the Project alternatives with respect to the following economic indicators:

1. **Potential Revenues.** This analysis provides estimates of the following potential government revenue streams--
    - State of Alaska: Royalty Revenue, Property Tax, Production Tax, Oil Surcharge, Corporate Income Tax.
    - Federal Government: Royalty Revenue, Corporate Income Tax, Gravel sales
    - North Slope Borough: Property Tax
2. **Potential Employment.** This analysis provides estimates of the direct, indirect, and induced employment effects associated with the construction phase and operations phase of the proposed Project alternatives. Employment effects reflect the total number of average part-time and full-time jobs resulting from the proposed construction and production (operations) activities.
3. **Potential Labor Income.** This analysis provides estimates of the potential labor income effects associated with the construction phase and operations phase of the proposed Project alternatives.

Approach, Assumptions, and Data

Estimating Potential Revenues

To quantify the potential streams of government revenues, the cash-flow model originally developed by the Alaska Department of Natural Resources (DNR) for evaluation of oil and gas projects in the Alaska North Slope was adapted and modified to reflect the Willow MDP EIS project alternatives. The DNR model is based on the current fiscal regime and contains input cells that are fixed due to statutes or regulations; the major fiscal model parameters are shown in the table below.

Table 1. Alaska Fiscal Model Parameters

Category	Definition (Alaska Statute)	Value
Conservation Surcharges ($/barrel)	*43.55.201, 43.55.300*	$0.05
North Slope Oil Tax		
Production Tax Rate on PTV	*43.55.011 (e)*	35%
$/BOE QCE exclusion ($/barrel)	*43.55.165 (e)(18)*	$0.30
Overhead allowance for lease expenditures	*43.55.165 (a)(2), 15 AAC 55.271*	4.5%
Minimum tax		
Minimum Gross Tax (applied on GVPP)	*43.55.011 (f)*	4.0%
Oil and Gas Property Tax		
Property Tax Rate	*43.56.010*	2.0%
Gross Value Reduction on "New Oil"		
GVR %	43.55.160 (f)	20.0%
Additional GVR % (New field, ROY>12.5%)	43.55.160 (f &g)	30.0%
GVR Year Limit	*43.55.160 (f)*	7
GVR Oil Price limit: 3 years with ANS price above	*43.55.160 (f)*	$70.00
State and Federal Income Tax		
State Income Tax		9.40%
Federal Income Tax		21.00%

The major inputs and assumptions used in the model to reflect the proposed project include:

1. Capital Expenditures (CAPEX)

Over the last 10 years Northern Economics, Inc. (NEI) has been working on various development projects in the North Slope, to estimate the effects of oil and gas development on local communities, the regional entities, and the State of Alaska. As part of these projects, NEI has obtained cost information from company specific projects as well as from surveys of operating companies and those providing support to the operating companies on shore and offshore activities.

The facility CAPEX estimates presented in this memorandum are based on data from five proprietary project CAPEX estimates that had central processing facilities. The CAPEX estimates were adjusted to fit the specification required by the DNR cash-flow model, and a linear regression equation for CAPEX was developed based on total volume of oil and natural gas liquids (NGLs) produced over the life of the field, and whether the project had seasonal access. The regression equation has the form of Seasonal Access (1 if seasonal access, 0 if year-round access) * 810.215935 + million barrels of oil and NGLs produced (MMBO) * 0.630787 + 4137.326. The equation has a coefficient of determination (r^2) of 0.60.

Drilling CAPEX was estimated using the same variables as the facility CAPEX. The drilling regression equation has the form of Seasonal Access (0,1) * 27.9 + MMBO * 1.230835 + 2781.832. The equation has a coefficient of determination (r^2) of 0.72.

The estimated drilling and facilities capital expenditures are shown in the table below.

Table 2. Estimated Capital Expenditures by Alternative, in millions of 2019 $

Capital Expenditure Item:	Alternatives B	Alternative C	Alternative D
Drilling	$3,651	$3,863	$ 3,918
Facilities	$4,583	$5,393	$ 5,474
Total:	**$8,234**	**$9,256**	**$9,392**

Source: Northern Economics estimates.

2. Operating Expenditures (OPEX)

The OPEX regression equation has the form of MMBO * 0.039739755 + 4542.095296. Alternatives C and D have higher operating costs than Alternative B due to the additional costs of providing seasonal access and operating additional facilities.

The estimated total cumulative operating expenditures amount to $4.6 billion for Alternative B, $4.8 billion for Alternative C, and $4.9 billion for Alternative D.

3. Crude Oil Price Forecasts

Two oil price projections were used in this analysis to provide a range of estimates for the potential revenue effects— 1) the latest U.S. Energy Information Administration (EIA) oil price projections published in the *Annual Energy Outlook 2019* on January 24, 2019, and 2) the latest Alaska Department of Revenue (ADOR) oil price projections published in the *Fall 2019 Revenue Sources* in December 6, 2019.

The ADOR oil price forecast (for ANS West Coast) reflects a more conservative price forecast (at $58.34 per barrel in real 2019$, average over 2019 to 2029 period) while the EIA price forecast reflects a higher oil price scenario (at $97.04 per barrel in real 2019$, average over 2019 to 2050). The ADOR forecast is a 10-year forecast through 2029 and the EIA forecast is through year 2050. Prices beyond the timeframe published were extrapolated using the cumulative annual growth rate provided in the 10-year forecast.

4. Netback Costs: Tariffs/Transportation Costs

For royalty calculations, oil is valued at the wellhead, hence, netback costs which include marine transportation cost, quality adjustment, TAPS tariff, and pipeline and feeder line tariffs, are deducted from the projected market price. Estimates of netback costs used in this analysis are from the Alaska Department of Revenue's *Fall 2019 Revenue Sources Book*; except for the feeder line tariff data which was obtained from the Alaska Department of Natural Resources, Division of Oil and Gas.

5. Projected Annual Production Volumes

The table below shows the total projected oil production for both Willow and GMT2 under each alternative. All Alternatives have a 25-year production life. Oil production for Alternatives B and C begin in year 2026, while first oil production for Alternative D starts in year 2027.

Table 3. Annual Production Volumes in millions of barrels of oil (MMBO)

Year	Alternative B	Alternative C	Alternative D
2026	70.98	70.98	
2027	70.66	70.66	70.98
2028	70.56	70.56	70.66
2029	58.72	58.72	70.56
2030	48.62	48.62	58.72
2031	43.79	43.79	48.62
2032	40.85	40.85	43.79
2033	36.01	36.01	40.85
2034	30.87	30.87	36.01
2035	26.82	26.82	30.87
2036	24.19	24.19	26.82
2037	21.19	21.19	24.19
2038	19.63	19.63	21.19
2039	17.93	17.93	19.63
2040	16.50	16.50	17.93
2041	15.09	15.09	16.50
2042	13.82	13.82	15.09
2043	12.74	12.74	13.82
2044	11.82	11.82	12.74
2045	10.74	10.74	11.82
2046	10.28	10.28	10.74
2047	9.59	9.59	10.28
2048	8.91	8.91	9.59
2049	8.28	8.28	8.91
2050	7.71	7.71	8.28
2051			7.71

Source: CPAI, 2020.

Note: The volumes presented in the table include oil from GMT2. However, for the purpose of estimating royalties and taxes, only the production volumes from the Willow field were used. Willow only production volumes were provided by CPAI.

Estimating Employment and Income Effects

Direct manpower requirements for the Willow MDP were estimated by CPAI and presented in this memorandum. The potential indirect and induced employment and income effects for this analysis were estimated using the IMPLAN model of the Alaska economy. The IMPLAN model is an input-output model that is commonly used in economic impact studies to measure the multiplier effects/stimulus effects of an economic development project.

The estimates of industry spending on capital expenditures (CAPEX; construction costs) and on operating expenditures (OPEX) for each of the project alternatives, as described above, were used as inputs for the model. The IMPLAN model provides estimates of the number of part-time and full-time indirect and induced jobs required to meet the increase in demand for goods, materials, and services during the construction and the operations phases of the proposed project. These indirect and induced jobs (and associated income) are considered the multiplier effects or stimulus effects that result from the increase in demand in various industries/sectors in the Alaska economy, particularly those that support the construction sector, and the oil and gas extraction/production sector (indirect effects), as well as all the other sectors that provide goods and services to the industry workers (induced effects).

The IMPLAN model provides estimates of indirect and induced labor income based on information on average Alaska wages and salaries in the various sectors of the economy.

Results

Projected Government Revenues

The Willow MDP is projected to generate revenues to the federal government, the State of Alaska, and the North Slope Borough from royalties, taxes, and other fees. The projected revenues by revenue stream and by Alternative are presented in the table below. The values shown in the table reflect the estimated total cumulative revenues through the end of the production life of the field.

Table 4. Estimated Potential Revenues of the Willow MDP EIS Alternatives

Revenue Category	Alternative B		Alternative C		Alternative D	
	DOR Price	**EIA Price**	**DOR Price**	**EIA Price**	**DOR Price**	**EIA Price**
State of Alaska						
Royalty Revenue	$2,642.0	$4,292.1	$2,642.0	$4,292.1	$2,644.1	$4,362.1
Property Tax	$100.0	$100.0	$116.6	$116.6	$120.1	$120.1
Production Tax	$886.0	$6,345.7	$679.1	$5,915.9	$645.3	$5,986.9
Oil Surcharge	$24.4	$24.4	$24.4	$24.4	$24.4	$24.4
Corporate Income Tax	$1,126.6	$2,164.1	$1,007.5	$2,066.0	$989.2	$2,101.6
Total:	**$4,779.0**	**$12,926.2**	**$4,469.7**	**$12,414.9**	**$4,423.1**	**$12,595.1**
Federal Government						
Royalty Revenue	$2,642.0	$4,292.1	$2,642.0	$4,292.1	$2,644.1	$4,362.1
Corporate Income Tax	$2,317.9	$4,417.8	$2,077.0	$4,219.3	$2,037.3	$4,288.8
Gravel sales	$9.9	$9.9	$9.9	$9.9	$10.7	$10.7
Total:	**$4,969.7**	**$8,719.7**	**$4,728.8**	**$8,521.2**	**$4,692.1**	**$8,661.6**
North Slope Borough						
Property Tax	$1,233.6	$1,233.6	$1,438.4	$1,438.4	$1,481.3	$1,481.3

Source: Northern Economics estimates.

At the State level, there are several potential sources of revenues that would be generated from the proposed development. Production from the Willow development would result in royalties paid to the federal government, and State of Alaska would receive 50 percent of those royalties. The federal royalty rate is 16.67 percent of the wellhead value. Total estimated cumulative state royalties range from $2.6 billion to $4.4 billion.

The state would receive property tax payments on onsite facilities and these revenues would start accruing during the construction phase. Total State property tax revenues are projected to range between $100 million and $120 million, depending on the Alternative.

Oil produced and sold from lands within Alaska are subject to a severance tax as the resources leave the land. This severance tax is commonly referred to as the "production tax." The production tax applies to oil produced from any area within the boundaries of the state, including lands that are owned by the state, the federal government (like NPR-A), or private parties, such as Native corporations. Severance tax or production tax payments are based on the current tax rate of 35 percent of the production value, which is the value at the point of production, less all qualified lease expenditures (net value). Qualified lease expenditures include certain qualified capital and operating expenditures. Total production taxes are estimated to range from $645 million to over $6 billion, depending on the oil price assumption and the Alternative.

An oil and gas corporation's Alaska income tax liability depends on the relative size of its Alaska and worldwide activities and the corporation's total worldwide net earnings. State corporate income tax is calculated as 9.4 percent of the Alaska share of worldwide income for each corporation. The ADNR model, however, does not take into consideration corporate worldwide income (which is unknown at this time) but simply evaluates all the costs and revenues and the resulting state income tax given the 9.4 percent income tax rate. Total estimated state corporate income tax payments could range between $989 million and $2.16 billion, depending on the Alternative and oil price assumption. In addition, the state would also receive oil surcharge revenues estimated to amount to about $24 million. Conservation surcharges apply to all oil production in Alaska and are in addition to oil and gas production taxes. Revenues derived from these surcharges are intended to be used for oil and hazardous substance release prevention and response

At the Federal level, projected federal royalty revenue, corporate income taxes, and gravel royalties could amount to between $4.7 billion and $8.7 billion (total through the entire economic life of the field).

At the regional level, the NSB government is anticipated to benefit from property tax revenues. The property tax would be based on the assessed valuation of the facilities developed onsite. The annual levy is based on the full and true value of property taxable under AS 43.56. For production property, the full and true value is based on the replacement cost of a new facility, less depreciation. The depreciation rate is based on the economic life of proven reserves. Pipeline property is treated differently; it is valued on the economic value of the property over the life of the proven reserves. The State property tax rate is 20 mills. A local tax is levied on the state's assessed valued for oil and gas property within a city or borough and is subject to local property tax limitations. The current tax rate for the NSB is 18.5 mills (hence, the state portion of the property tax is 1.5 mills). Property tax payments would start to accrue during the construction phase. Total cumulative NSB property tax revenues are estimated to amount to between $1.2 billion and $1.5 billion, depending on the Alternative.

The City of Nuiqsut could also potentially benefit from higher bed tax revenues from higher hotel occupancy during the initial construction years while mobilization of construction equipment is occurring and even during operations. The City of Nuiqsut currently has a 12 percent bed tax. The change in the level of hotel occupancy however is difficult to quantify at this point because the timing and level of activities are uncertain and may vary. The City also has a tobacco tax that could generate additional revenues for the City. Furthermore, the City of Nuiqsut would be eligible to receive funds through the NPR-A Impact Mitigation Grant Program, which is funded by royalty and other revenues from leases in the NPR-A. As noted above, production from the Willow development is anticipated to generate royalties that would significantly increase funds for the NPR-A Impact Mitigation Grant Program.

Projected Employment and Income Effects

Table 5 presents the direct manpower requirements during the construction phase of the proposed development. These estimates are specific to the Proponent's Project (Alternative B) and were estimated by CPAI. Peak construction employment is anticipated to occur in 2023 with about 1,650 jobs (seasonal peak) or 1,073 annual average jobs. The jobs created during the construction phase would be temporary, with some activities only occurring over several months (i.e. ice road construction).

In addition to these construction jobs, drilling activities are estimated to require 390 workers based in the North Slope and 10 workers based in Anchorage, per year from 2024 to 2029, and the last year of drilling activities (year 2030), employment requirements are estimated to decline to 99 North Slope based workers and 10 Anchorage-based workers.

Direct construction and drilling activities would also support on average about 2,800 indirect and induced part-time and full-time jobs per year in other sectors of the state's economy over the construction phase (under Alternatives B). Alternatives C and D would result in slightly higher indirect and induced jobs (about 3,200), mainly due to the higher estimated construction spending on additional facilities and logistics.

Table 5. Estimated Number of Direct Construction Jobs: Proponent's Project Alternative

Year	Seasonal Peak	Annual Average
2020	40	26
2021	200	130
2022	750	488
2023	1,650	1,073
2024	1,500	975
2025	950	618
2026	350	228
2027	100	65
2028	100	65
2029	100	65

Source: CPAI, 2020.

During the operations phase, annual operations and maintenance activities are estimated to generate 350 direct jobs; these will include direct North Slope positions as well as direct CPAI positions based in Anchorage (CPAI, 2019). These operations and maintenance jobs would mostly be year-round but there will be some jobs associated with production activities that will also be seasonal in nature.

Table 6. Estimated Number of Direct O&M Jobs: Proponent's Project Alternative

Year	Slope Based	Anchorage Based
2025	100	25
2026	275	25
2027	400	25
2028-2050 (end of field life)	425	25

Source: CPAI, 2020.

In addition to the direct jobs, annual operations and maintenance activities are estimated to create an additional 360 to 400 indirect and induced jobs per year.

These estimated jobs are available for workers residing in the North Slope, other areas of Alaska, and outside Alaska. It is unknown at this time how many workers from North Slope communities and other Alaska communities would participate in the direct oil and gas activities. According to the Alaska Department of Labor and Workforce Development, over the past decade, the share of oil industry workers who are not Alaska residents has grown, ranging from 28 percent nonresident in 2009 to 37 percent in 2016. This percentage of non-resident workers could change in the future, depending on availability of training programs and labor supply.

Oil field development projects in the North Slope typically require specialty tradesmen and construction workers with the skills and experience in ice roads, pipeline construction, facilities construction, and drilling; and these jobs are typically held by non-local workers. However, opportunities do exist for North Slope residents that live near existing oil developments. Local residents have participated in oil and gas jobs such as ice road monitors, camp security and facilities operators, and subsistence representatives. The Alaska Department of Labor and Workforce Development and the oil and gas industry have training programs geared towards developing special skills required in oilfield services. This is expected to create more employment opportunities for local residents.

Table 7 shows the prevailing average yearly earnings of workers in various industries in Alaska that are associated with the direct construction and operations jobs described above. The table shows that direct oil and gas industry jobs currently pay about $150,000 per year; and the oil and gas extraction sector paying even more at approximately $225,000 per year.

Note that a direct oil and gas industry worker either works for an oil producer or an oilfield service company. Thousands of other jobs that directly serve the oil and gas industry but are not categorized under this sector are generally included in the Support Activities for Mining sector; some of these jobs are in security, catering, accommodations, transportation, and logistics services.

Indirect and induced jobs, on the other hand, would be jobs in a variety of other sectors of the Alaska economy that provide goods and services to the oil and gas industry and its direct workers. The projected annual average earnings associated with these indirect and induced jobs are estimated to be about $57,000.

Table 7. Prevailing Statewide Average Annual Earnings by Selected Industries associated with the Direct Construction and Operations Jobs

Industry	Average Annual Earnings
Oil and Gas Industry	$147,584
Oil and Gas Extraction	$224,827
Support Activities for Mining	$101,136
Construction (industry-wide average)	$78,872
Construction of Buildings	$72,560
Heavy Construction	$103,616
Specialty Trade Contractors	$68,897

Source: ADOLWD, 2019.

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Willow Master Development Plan

Appendix E.16
Subsistence and Sociocultural Systems
Technical Appendix

August 2020

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List of Acronyms

ATV	all-terrain vehicle
CRD	Colville River Delta
MDP	Master Development Plan
NSB	North Slope Borough
Project	Willow Master Development Plan Project
SRB&A	Stephen R. Braund and Associates

Glossary Terms

Direct effects analysis area – All subsistence use areas within 2.5 miles of Willow Master Development Plan Project infrastructure.

Household – One or more individuals living in one housing unit, whether or not they are related.

Subsistence use areas – The geographic extent of a resident's or community's use of the environment to conduct traditional subsistence activities.

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

1.0 SUBSISTENCE USES AND PRACTICES, NUIQSUT AND UTQIAĠVIK

This appendix provides detailed data tables, figures, and discussion related to Nuiqsut and Utqiaġvik (Barrow) **subsistence** uses. The Willow Master Development Plan (MDP) Final Environmental Impact Statement defines the analysis area for subsistence and sociocultural systems as all areas used for subsistence activities by the communities of Nuiqsut and Utqiaġvik. These study communities were selected because they both have documented use near the Willow MDP Project (Project) and would be most likely to experience direct and indirect effects to subsistence uses. The following sections provide a brief introduction to Iñupiat subsistence harvesting patterns followed by a description of each community's **subsistence use areas**, harvest and use data, timing of subsistence activities, travel methods, and resource importance.

1.1 Introduction

The Iñupiat are an Alaska Native people whose territory extends throughout northwest and northern Alaska. Archaeological research indicates that humans have occupied northern Alaska for roughly 14,000 years (Kunz and Reanier 1996). At the time of European contact, the North Slope was inhabited by two indigenous Iñupiat populations: the Tagiugmiut and the Nunamiut. The Tagiugmiut ("people of the sea") inhabited coastal areas of the Arctic Coastal Plain and relied primarily on harvests of marine mammals, terrestrial mammals (mainly caribou), and fish. The Nunamiut ("people of the land") inhabited the interior, including the Brooks Range and Arctic foothills areas, and relied mostly on terrestrial mammals and fish, with caribou comprising the majority of their subsistence harvests. Being located on or near the coast, the study communities of Nuiqsut and Utqiaġvik were traditionally inhabited by the Tagiugmiut. The Iñupiat remain the primary occupants of the North Slope today and continue the traditions of their ancestors, including hunting, harvesting, and sharing wild resources. Subsistence activities tend to occur near communities, along rivers and coastlines, or at particularly productive sites where resources are known to occur seasonally. Residents often conduct subsistence activities from camps located in areas that provide access to multiple resources throughout the year. Harvesters apply traditional knowledge, which is passed down through generations and learned through experience on the land, to determine the locations, timing, and methods for their subsistence activities. Relevant traditional knowledge includes knowledge about the distribution, migration, and seasonal variation of animal populations and other environmental factors such as tides, currents, ice, and snow conditions.

Prior to the 1950s, when mandatory school attendance and economic factors such as a decline in fur prices compelled families to permanently settle in centralized communities, the Iñupiat were seminomadic and ranged over large geographic areas for trapping, fishing, gathering, and hunting activities. Contemporary subsistence use areas include many of these traditional use areas. Certain harvest locations are used infrequently or by a small number of harvesters; however, these places may still be important to a community if they are particularly productive areas or if they have cultural, historical, or familial significance to the user. As an example, while the Prudhoe Bay development area is no longer part of the contemporary use area of the Nuiqsut people, residents continue to identify with the area as part of their traditional territory due to its historical use by their ancestors. Like other communities on the North Slope, Nuiqsut and Utqiaġvik have a "mixed, subsistence-market" economy (Walker and Wolfe 1987), where families invest money into small-scale, efficient technologies to harvest wild foods. In recent years, the advent of snow machines and all-terrain vehicles (ATVs), including four-wheelers, has reduced the time required to travel to traditional hunting and harvesting areas but has also increased the need for cash employment to purchase, maintain, and procure supplies for the new equipment, a hallmark of the mixed cash economy (Ahtuangaruak 1997; Impact Assessment Inc. 1990a, 1990b; SRB&A and ISER 1993; Worl and Smythe 1986).

While the use of camps and cabins continues, residents of the North Slope today more commonly use their communities as a base from which they conduct same-day subsistence activities (Impact Assessment Inc. 1990a; SRB&A 2010b, 2017).

1.2 Subsistence Overview

1.2.1 Nuiqsut

Nuiqsut is located on the Nigliq Channel of the Colville River, in an area that provides abundant opportunities for the subsistence harvesting of terrestrial mammals, marine mammals, fish, and waterfowl. Although the location is less advantageous for marine mammal harvests than some other North Slope communities that are located directly on the coast, the Beaufort Sea is easily accessible via the Nigliq Channel. The Colville River is the largest river system on the North Slope and supports the largest overwintering areas for whitefish, which local residents harvest in substantial quantities (Craig 1987; Seigle, Gutierrez et al. 2016).

The Nuiqsut area was traditionally a gathering place where Iñupiat and Athabascan people gathered to trade and fish, maintaining connections between the Nunamiut and the Tagiugmiut (Brown 1979). After the 1971 passage of the Alaska Native Claims Settlement Act, 27 Iñupiat families from Barrow (since renamed Utqiaġvik) resettled at Nuiqsut to live a more traditional lifestyle and to reclaim their ancestral ties to the area (Impact Assessment Inc. 1990b). The site was selected primarily for its easy access to the main channel of the Colville River for fishing and hunting and for the ease of movement between upriver hunting sites and downriver whaling and sealing sites (Brown 1979).

Today, according to the North Slope Borough's (NSB's) most recent census, Nuiqsut has a population of 449 residents living in 138 **households** (NSB 2016). Primary sources of employment in the community include the village corporation (Kuukpik Corporation), the NSB, and the NSB school district (NSB 2018). Nuiqsut is one of 11 Alaska Eskimo bowhead whaling communities. It is the closest community to the major oil-producing fields of the North Slope, which have resulted in impacts to subsistence and sociocultural systems (SRB&A 2009, 2017, 2018) but also provide jobs, corporate dividends, and local revenue. During winter, Nuiqsut residents have seasonal access to the Dalton Highway via Alpine, Kuparuk, and Prudhoe Bay development roads. This access allows residents to travel to Fairbanks and Anchorage to purchase subsistence equipment and supplies, including boats, snow machines, firearms, and ammunition at reduced cost.

1.2.1.1 Subsistence Use Areas

Figure E.16.1 depicts Nuiqsut subsistence use areas for all resources over multiple historic and contemporary time periods (BLM 2004; Brown, Braem et al. 2016; Pedersen 1979, 1986; SRB&A 2010b). Use areas from all these studies overlap with portions of the Project area. Lifetime (pre-1979) use areas show Nuiqsut residents using a large area centered on the community to harvest subsistence resources; reported use areas extended offshore approximately 15 miles, as far east as Camden Bay, south along the Itkillik River, and west as far as Teshekpuk Lake. Subsequent use area data show Nuiqsut residents traveling across a progressively larger area to harvest subsistence resources. Use areas for the 1995–2006 time period document Nuiqsut residents traveling beyond Atqasuk in the west, offshore more than 50 miles northeast of Cross Island, overland to Cape Halkett and Utqiaġvik in the north, to Camden Bay in the east, and beyond the Colville River in the south. The majority of these use areas are concentrated around the Colville River, in areas to the southwest of the community, offshore areas north of the Colville River Delta (CRD), and northeast of Cross Island. Use areas for other time periods (1973–1986; 2014) are generally within the extent of the Pedersen (1979) and Stephen R. Braund and Associates (SRB&A) (2010b) use areas described above. SRB&A (2010b) notes that for the 1995–2006 time period, wolf and wolverine use areas continued farther south toward Anaktuvuk Pass but were not documented due to the extent of the map used during interviews.

Nuiqsut subsistence use areas for individual resources are shown on Figures E.16.2 through E.16.9 for the time periods listed above, in addition to the 2008–2016 time period (SRB&A 2018) for caribou only. Nuiqsut subsistence use areas for large land mammals are shown on Figures E.16.2 through E.16.4. Nuiqsut caribou use areas are shown on Figure E.16.2. As indicated on the figure, areas consistently used by Nuiqsut residents for caribou hunting are in an overland area between the Ikpikpuk and Kuparuk rivers, north to the coast, and south along the Colville River. The maximum extent of the use areas documented among all the studies extends from Atqasuk in the west toward Point Thomson in the east and south along the Colville and Anaktuvuk rivers to Anaktuvuk Pass. SRB&A's (2010b) overlapping use areas show that the greatest number of caribou use areas are concentrated along the Colville River and CRD, along the Itkillik River, and overland to the west and south of the community; these areas generally correspond to the caribou hunting areas reported during the 2008–2016 study years (SRB&A 2018).

Nuiqsut moose use areas (Figure E.16.3) show residents' consistent use of areas adjacent to the Colville River for moose harvests. While lifetime (pre-1979) use areas were completely confined to the Colville River, more recent moose use areas have expanded to include other tributaries such as the Chandler and Anaktuvuk rivers and Fish (Uvlutuuq) Creek. Moose use areas for the 1995–2006 time period show the highest amount of overlapping use along the Colville River south of Nuiqsut as far as Umiat. Figure E.16.4 depicts Nuiqsut grizzly bear use areas for the lifetime and 1973–1986 time periods, including areas along the Colville River watershed from Fish (Iqalliqpik) Creek to Umiat.

Nuiqsut furbearer and small land mammal use areas are shown on Figure E.16.5. Lifetime (pre-1979) use areas show residents using overland areas near the community, as well as the more southern Colville, Chandler, Anaktuvuk, Itkillik, and Kuparuk rivers, to harvest small land mammals. Subsequent studies, including those for the 1973–1986 and 1995–2006 time periods, depict an expansion from previously recorded use areas. SRB&A's (2010b) wolf and wolverine use areas for the 1995–2006 time period extend to the Meade River in the west and beyond the Dalton Highway in the east, including a single-use area that extends east to just south of Kaktovik. Small land mammal use areas for the most recent available use area study show less use to the east and west of the community and more use south into the Brooks Range.

Nuiqsut fishing areas from multiple time periods (Figure E.16.6) indicate consistent use of the Colville River and smaller tributaries, including the Itkillik, Chandler, and Anaktuvuk rivers as well as Fish and Judy (Kayyaaq) creeks. Contemporary use areas extend somewhat father along the Colville and Itkillik rivers as well as along Fish Creek.

Nuiqsut use areas for birds (Figure E.16.7) are mostly concentrated along the Colville River and nearby overland areas for various time periods, although they also include offshore eider hunting areas extending from Cape Halkett to Camden Bay. Lifetime (pre-1979) wildfowl use areas are generally located near the Colville River and in nearshore locations extending east to Prudhoe Bay. More recent goose and eider use areas (1994–2003 and 1995–2006 time periods) occur in a somewhat larger area and include areas offshore and east of Prudhoe Bay to Camden Bay. The most recent documentation of bird use areas for the 2014 time period shows them to be north of the community and offshore into Harrison Bay.

Figure E.16.8 displays Nuiqsut use areas for vegetation for several time periods and shows use of the Colville River as far south as Umiat and areas near Fish (Uvlutuuq) Creek for harvests of vegetation and berries. In addition, berry gathering areas were documented along the Itkillik, Chandler, and Anaktuvuk rivers during a study for the 1994–2003 time period.

Nuiqsut marine mammal use areas (Figure E.16.9) show use of the Beaufort Sea and CRD at varying extents, depending on the time period. Lifetime Nuiqsut use areas for marine mammals included offshore areas from Atigaru Point to Kaktovik at distances of less than 20 miles; subsequent studies documented use areas extending to Cape Halkett in the west and varying distances to the east. SRB&A's (2010b) use areas showed Nuiqsut residents harvesting marine mammals up to 40 miles offshore to the north of the community and even farther offshore (approximately 60 miles) in an area near Cross Island, a sandy barrier island used traditionally and currently as a base of operations for Nuiqsut whaling crews. Nuiqsut 2001–2016 bowhead whale hunting global positioning system tracks extend as far east as Flaxman Island and over 30 miles offshore from Cross Island.

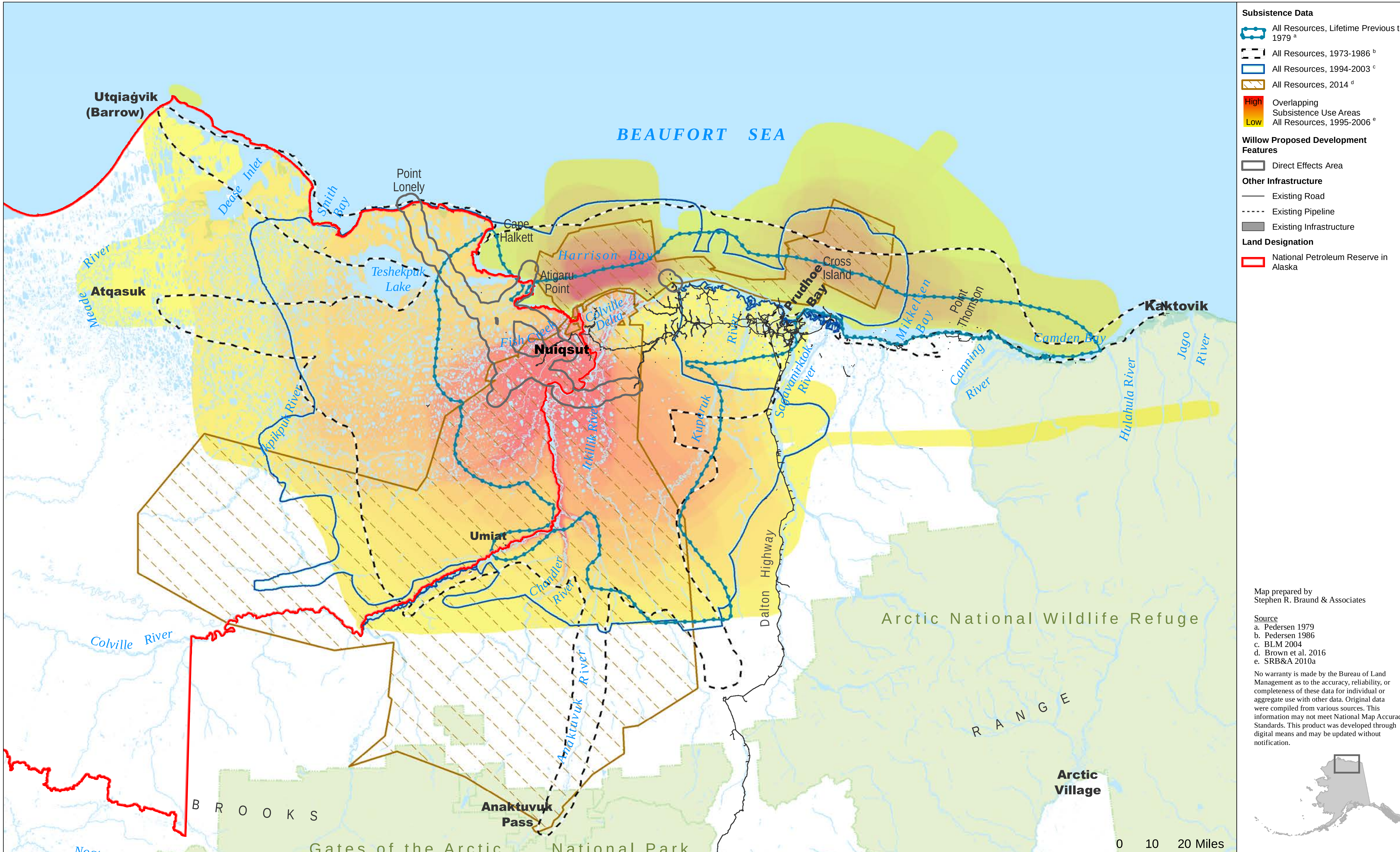
BEAUFORT SEA
Utqiaġvik (Barrow)
Atqasuk
Dease Inlet
Smith Bay
Point Lonely
Teshekpuk Lake
Cape Halkett
Harrison Bay
Atigaru Point
Colville Delta
Fish Creek
Nuiqsut
Cross Island
Prudhoe Bay
Mikkelsen Bay
Point Thomson
Camden Bay
Kaktovik
Meade River
Ikpikpuk River
Itkillik River
Kuparuk River
Sagavanirktok River
Canning River
Hulahula River
Jago River
Umiat
Chandler River
Colville River
Anaktuvuk River
Anaktuvuk Pass
Dalton Highway
Arctic National Wildlife Refuge
B R O O K S
R A N G E
Gates of the Arctic National Park
Arctic Village
Noatak River
0 10 20 Miles
Subsistence Data
All Resources, Lifetime Previous to 1979 a
All Resources, 1973-1986 b
All Resources, 1994-2003 c
All Resources, 2014 d
High
Low
Overlapping Subsistence Use Areas All Resources, 1995-2006 e
Willow Proposed Development Features
Direct Effects Area
Other Infrastructure
Existing Road
Existing Pipeline
Existing Infrastructure
Land Designation
National Petroleum Reserve in Alaska
Map prepared by
Stephen R. Braund & Associates
Source
a. Pedersen 1979
b. Pedersen 1986
c. BLM 2004
d. Brown et al. 2016
e. SRB&A 2010a
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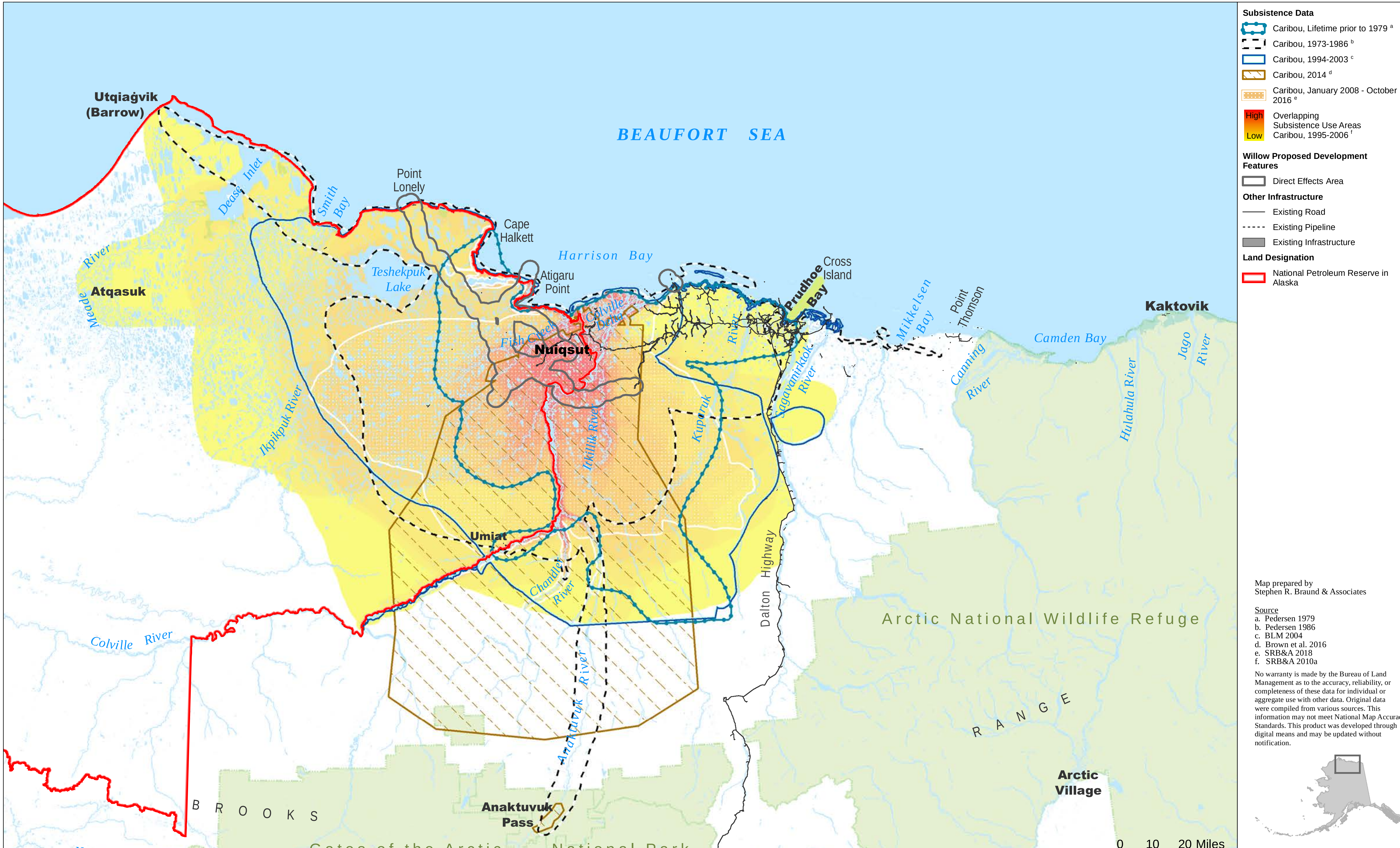
Figure E.16.1


BEAUFORT SEA
Utqiaġvik (Barrow)
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Cape Halkett
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Cross Island
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Teshekpuk Lake
Dease Inlet
Smith Bay
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Colville Delta
Nuiqsut
Itkillik River
Kuparuk River
Sagavanirktok River
Mikkelsen Bay
Point Thomson
Canning River
Camden Bay
Hulahula River
Jago River
Kaktovik
Umiat
Chandler River
Anaktuvuk River
Colville River
Dalton Highway
Arctic National Wildlife Refuge
B R O O K S
R A N G E
Gates of the Arctic National Park
Anaktuvuk Pass
Arctic Village
Noatak River
0 10 20 Miles
Subsistence Data
Caribou, Lifetime prior to 1979 a
Caribou, 1973-1986 b
Caribou, 1994-2003 c
Caribou, 2014 d
Caribou, January 2008 - October 2016 e
High
Low
Overlapping Subsistence Use Areas Caribou, 1995-2006 f
Willow Proposed Development Features
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Figure E.16.2

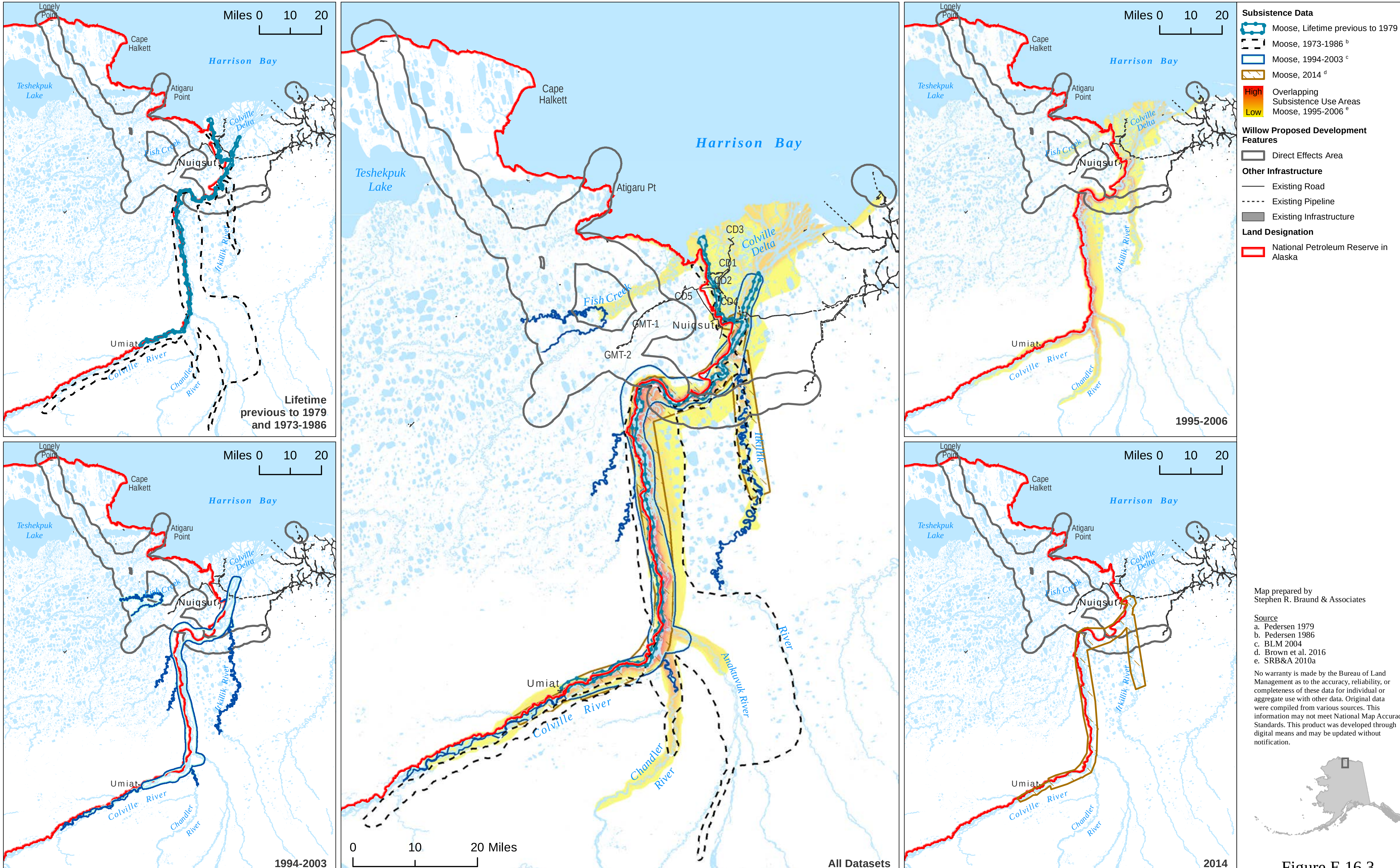
Lifetime previous to 1979 and 1973-1986
1994-2003
All Datasets
1995-2006
2014
Miles 0 10 20
0 10 20 Miles
Lonely Point
Cape Halkett
Harrison Bay
Teshekpuk Lake
Atigaru Point
Atigaru Pt
Colville Delta
Fish Creek
Nuiqsut
Umiat
Colville River
Chandler River
Itkillik River
Anaktuvuk River
CD1
CD2
CD3
CD4
CD5
GMT-1
GMT-2
Subsistence Data
Moose, Lifetime previous to 1979 a
Moose, 1973-1986 b
Moose, 1994-2003 c
Moose, 2014 d
High
Low
Overlapping Subsistence Use Areas Moose, 1995-2006 e
Willow Proposed Development Features
Direct Effects Area
Other Infrastructure
Existing Road
Existing Pipeline
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Figure E.16.3


Subsistence Data
Grizzly Bear, Lifetime previous to 1979 a
Grizzly Bear, 1973-1986 b
Willow Proposed Development Features
Direct Effects Area
Other Infrastructure
Existing Road
Existing Pipeline
Existing Infrastructure
Land Designation
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BEAUFORT SEA
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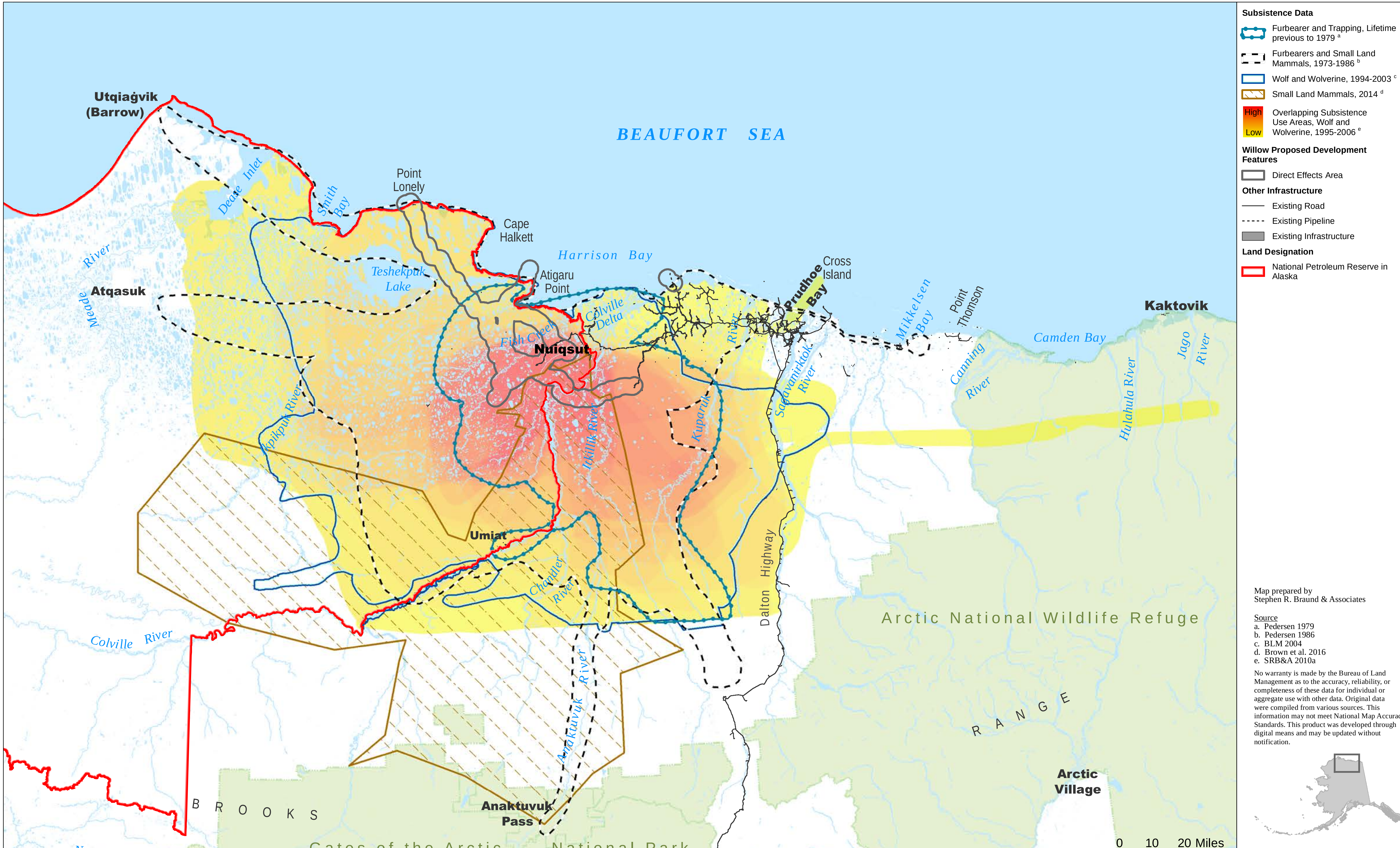
Figure E.16.4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Jago River
Chandler River
Anaktuvuk River
Colville River
Noatak River
Dalton Highway
Anaktuvuk Pass
Arctic Village
Arctic National Wildlife Refuge
Gates of the Arctic National Park
B R O O K S
R A N G E
0 10 20 Miles
Subsistence Data
Furbearer and Trapping, Lifetime previous to 1979 [a]
Furbearers and Small Land Mammals, 1973-1986 [b]
Wolf and Wolverine, 1994-2003 [c]
Small Land Mammals, 2014 [d]
High
Low
Overlapping Subsistence Use Areas, Wolf and Wolverine, 1995-2006 [e]
Willow Proposed Development Features
Direct Effects Area
Other Infrastructure
Existing Road
Existing Pipeline
Existing Infrastructure
Land Designation
National Petroleum Reserve in Alaska
Map prepared by Stephen R. Braund & Associates
Source
a. Pedersen 1979
b. Pedersen 1986
c. BLM 2004
d. Brown et al. 2016
e. SRB&A 2010a
No warranty is made by the Bureau of Land Management as to the accuracy, reliability, or completeness of these data for individual or aggregate use with other data. Original data were compiled from various sources. This information may not meet National Map Accuracy Standards. This product was developed through digital means and may be updated without notification.

Figure E.16.5

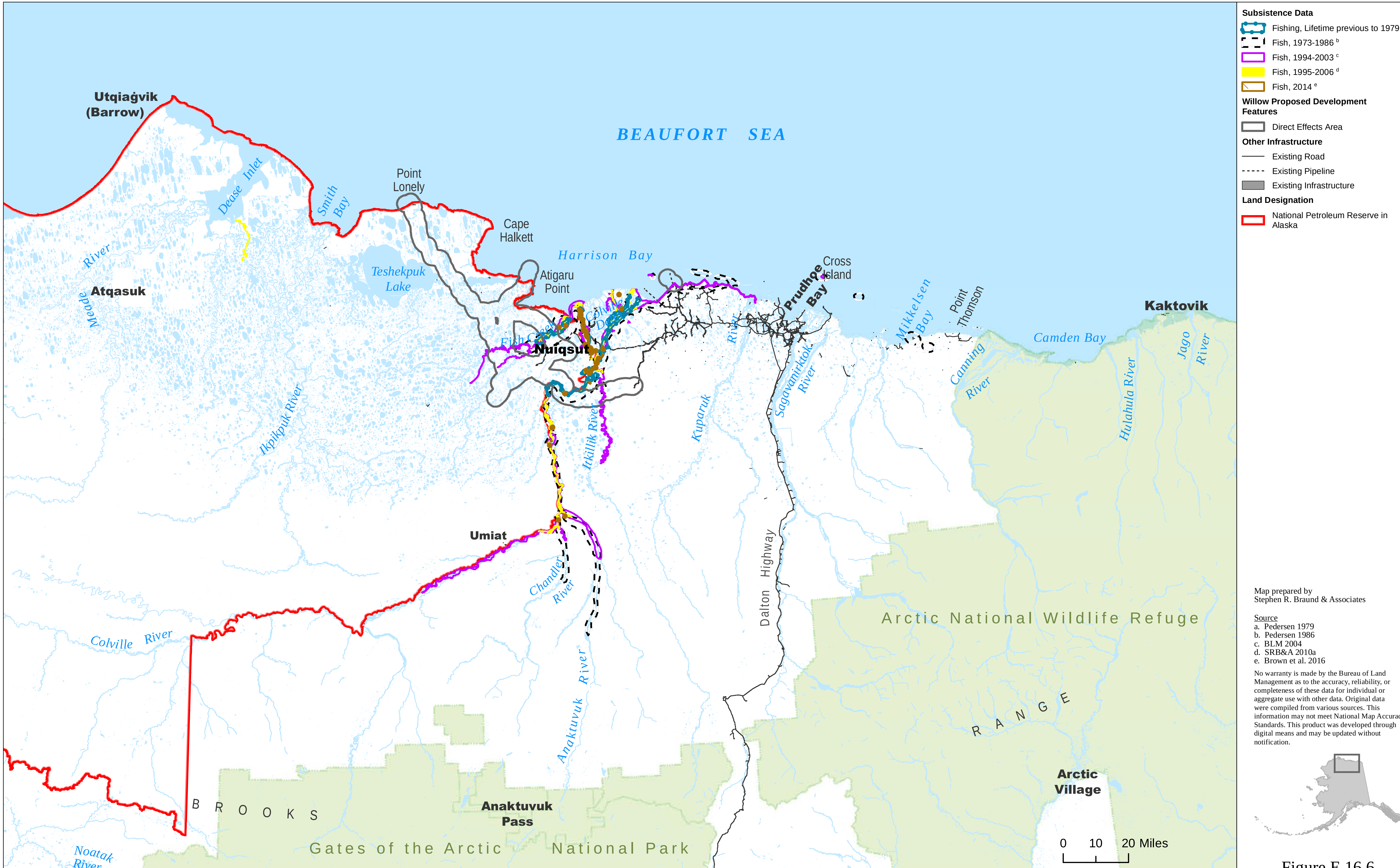
BEAUFORT SEA
Utqiaġvik (Barrow)
Atqasuk
Point Lonely
Cape Halkett
Atigaru Point
Harrison Bay
Teshekpuk Lake
Dease Inlet
Smith Bay
Meade River
Ikpikpuk River
Fish Creek
Nuiqsut
Colville Delta
Cross Island
Prudhoe Bay
Mikkelsen Bay
Point Thomson
Camden Bay
Kaktovik
Jago River
Hulahula River
Canning River
Sagavanirktok River
Kuparuk River
Itkillik River
Dalton Highway
Umiat
Chandler River
Anaktuvuk River
Colville River
Noatak River
B R O O K S
R A N G E
Anaktuvuk Pass
Gates of the Arctic National Park
Arctic National Wildlife Refuge
Arctic Village
0 10 20 Miles
Subsistence Data
Fishing, Lifetime previous to 1979 a
Fish, 1973-1986 b
Fish, 1994-2003 c
Fish, 1995-2006 d
Fish, 2014 e
Willow Proposed Development Features
Direct Effects Area
Other Infrastructure
Existing Road
Existing Pipeline
Existing Infrastructure
Land Designation
National Petroleum Reserve in Alaska
Map prepared by Stephen R. Braund & Associates
Source
a. Pedersen 1979
b. Pedersen 1986
c. BLM 2004
d. SRB&A 2010a
e. Brown et al. 2016
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Figure E.16.6

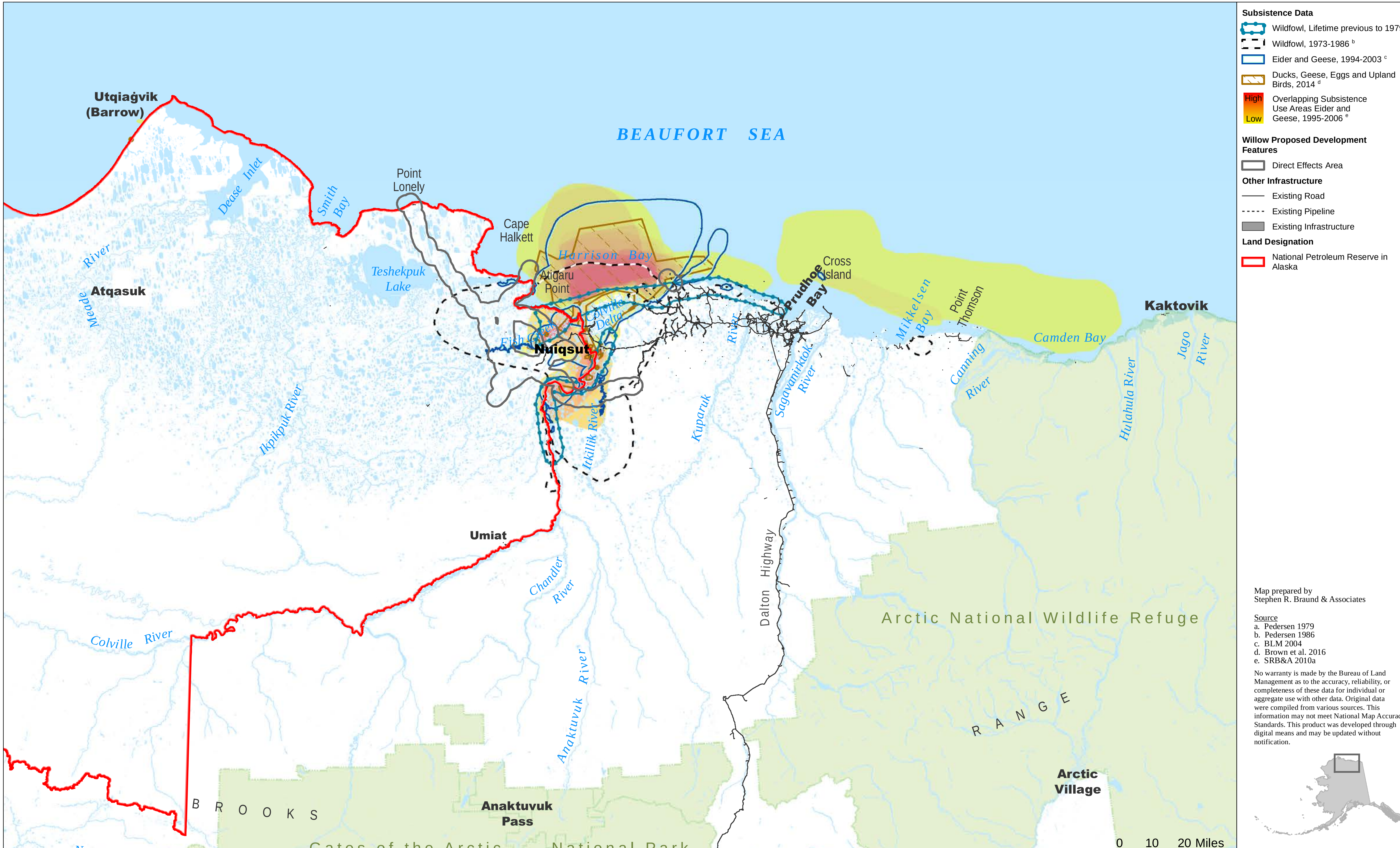
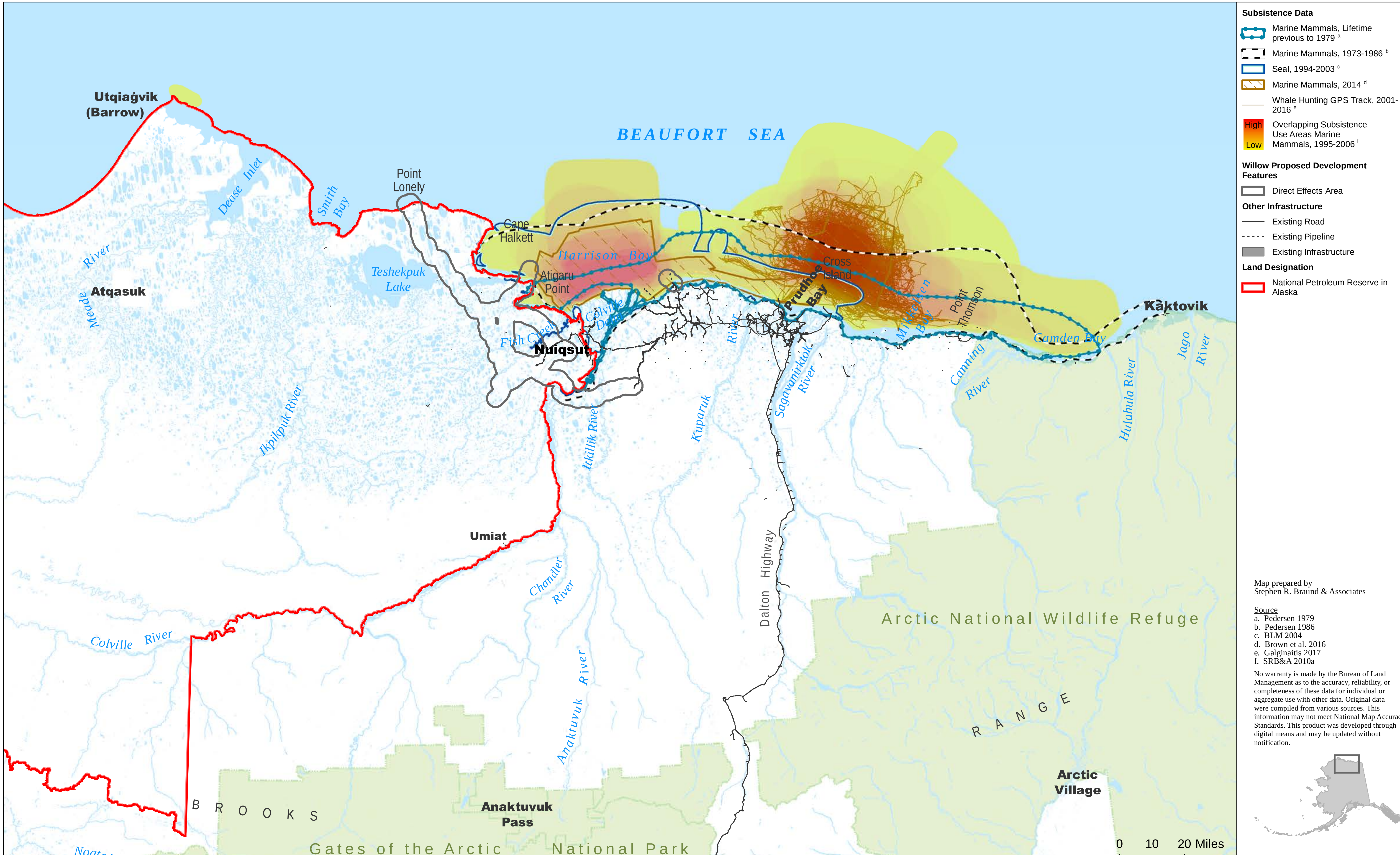

Subsistence Data
Wildfowl, Lifetime previous to 1979 [a]
Wildfowl, 1973-1986 [b]
Eider and Geese, 1994-2003 [c]
Ducks, Geese, Eggs and Upland Birds, 2014 [d]
High
Low
Overlapping Subsistence Use Areas Eider and Geese, 1995-2006 [e]
Willow Proposed Development Features
Direct Effects Area
Other Infrastructure
Existing Road
Existing Pipeline
Existing Infrastructure
Land Designation
National Petroleum Reserve in Alaska
BEAUFORT SEA
Utqiaġvik (Barrow)
Dease Inlet
Smith Bay
Point Lonely
Cape Halkett
Harrison Bay
Atigaru Point
Teshekpuk Lake
Atqasuk
Meade River
Nuiqsut
Fish Creek
Colville Delta
Cross Island
Prudhoe Bay
Mikkelsen Bay
Point Thomson
Camden Bay
Kaktovik
Jago River
Hulahula River
Canning River
Sagavanirktok River
Kuparuk River
Itkillik River
Ikpikpuk River
Umiat
Chandler River
Colville River
Anaktuvuk River
Dalton Highway
Arctic National Wildlife Refuge
R A N G E
B R O O K S
Anaktuvuk Pass
Arctic Village
Gates of the Arctic National Park
Noatak River
0 10 20 Miles
Map prepared by Stephen R. Braund & Associates
Source
a. Pedersen 1979
b. Pedersen 1986
c. BLM 2004
d. Brown et al. 2016
e. SRB&A 2010a
No warranty is made by the Bureau of Land Management as to the accuracy, reliability, or completeness of these data for individual or aggregate use with other data. Original data were compiled from various sources. This information may not meet National Map Accuracy Standards. This product was developed through digital means and may be updated without notification.

Figure E.16.7


Subsistence Data
Vegetation, 1973-1986 a
Berries, 1994-2003 b
Berries and Plants, 2014 c
Willow Proposed Development Features
Direct Effects Area
Other Infrastructure
Existing Road
Existing Pipeline
Existing Infrastructure
Land Designation
National Petroleum Reserve in Alaska
BEAUFORT SEA
Utqiaġvik (Barrow)
Atqasuk
Nuiqsut
Umiat
Kaktovik
Anaktuvuk Pass
Arctic Village
Point Lonely
Cape Halkett
Atigaru Point
Cross Island
Point Thomson
Prudhoe Bay
Harrison Bay
Camden Bay
Mikkelsen Bay
Smith Bay
Dease Inlet
Teshekpuk Lake
Colville Delta
Fish Creek
Meade River
Ikpikpuk River
Itkillik River
Kuparuk River
Sagavanirktok River
Canning River
Hulahula River
Jago River
Chandler River
Anaktuvuk River
Colville River
Noatak River
Dalton Highway
Arctic National Wildlife Refuge
B R O O K S
R A N G E
Gates of the Arctic National Park
0 10 20 Miles
Map prepared by Stephen R. Braund & Associates
Source
a. Pedersen 1986
b. BLM 2004
c. Brown et al.2016
No warranty is made by the Bureau of Land Management as to the accuracy, reliability, or completeness of these data for individual or aggregate use with other data. Original data were compiled from various sources. This information may not meet National Map Accuracy Standards. This product was developed through digital means and may be updated without notification.

Figure E.16.8


BEAUFORT SEA
Utqiaġvik (Barrow)
Atqasuk
Point Lonely
Cape Halkett
Atigaru Point
Nuiqsut
Umiat
Cross Island
Prudhoe Bay
Point Thomson
Kaktovik
Harrison Bay
Teshekpuk Lake
Dease Inlet
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Camden Bay
Mikkelsen Bay
Arctic National Wildlife Refuge
Gates of the Arctic National Park
B R O O K S R A N G E
Anaktuvuk Pass
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Meade River
Ikpikpuk River
Itkillik River
Fish Creek
Colville Delta
Kuparuk River
Sagavanirktok River
Canning River
Hulahula River
Jago River
Chandler River
Anaktuvuk River
Noatak River
Subsistence Data
Marine Mammals, Lifetime previous to 1979 a
Marine Mammals, 1973-1986 b
Seal, 1994-2003 c
Marine Mammals, 2014 d
Whale Hunting GPS Track, 2001-2016 e
High
Low
Overlapping Subsistence Use Areas Marine Mammals, 1995-2006 f
Willow Proposed Development Features
Direct Effects Area
Other Infrastructure
Existing Road
Existing Pipeline
Existing Infrastructure
Land Designation
National Petroleum Reserve in Alaska
Map prepared by
Stephen R. Braund & Associates
Source
a. Pedersen 1979
b. Pedersen 1986
c. BLM 2004
d. Brown et al. 2016
e. Galginaitis 2017
f. SRB&A 2010a
No warranty is made by the Bureau of Land Management as to the accuracy, reliability, or completeness of these data for individual or aggregate use with other data. Original data were compiled from various sources. This information may not meet National Map Accuracy Standards. This product was developed through digital means and may be updated without notification.
0 10 20 Miles

Figure E.16.9

1.2.1.1.1 Direct Effects Analysis Area

Subsistence use of the **direct effects analysis area**, defined as the area within 2.5 miles of Project infrastructure, is relatively high. Analyses specific to the direct effects analysis area are based primarily on *Subsistence Mapping of Nuiqsut, Kaktovik, and Barrow* for the 1995-2006 time period (SRB&A 2010b) and the Nuiqsut Caribou Subsistence Monitoring Project for the 2008-2016 time period (SRB&A 2010a, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018). For the 1995–2006 time period, use areas overlapping the direct effects analysis area accounted for 40% of all use areas documented for Nuiqsut harvesters (Table E.16.1). Across 9 years of the Nuiqsut Caribou Subsistence Monitoring Project (2008–2016), over half (52%) of the caribou use areas overlapped the direct effects analysis area. Areas located within the direct effects analysis area include overland areas to the west, south, and southeast of the community; coastal boating areas to the west and east of the CRD; and riverine boating areas along the Colville and Itkillik rivers and Fish (Uvlutuuq and Iqalliqpik) Creek.

Table E.16.1. Nuiqsut Use Areas within the Direct Effects Analysis Area

Source	Resource Type	Time Period	Total Number of Use Areas	Number (%) of Use Areas in Direct Effects Analysis Area
SRB&A 2010b	All resources	1995–2006	758	304 (40%)
SRB&A 2010a, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018	Caribou	2008–2016	1,692	884 (52%)

As shown in Figures E.16.1 through E.16.9, Nuiqsut harvesters have reported using the direct effects analysis area to harvest the following resources during one or more study years: caribou, moose, other large land mammals, furbearers and small land mammals, fish, birds, vegetation, and marine mammals. Resources that overlap during most study years include caribou, furbearers and small land mammals, fish, and marine mammals. While some resources overlap with a large proportion of the direct effects analysis area (e.g., caribou, furbearers and small land mammals), others overlap with smaller portions of the area, such as where the direct effects analysis area intersects with fishing or hunting areas along Fish (Iqalliqpik) Creek and the Colville River (e.g., fish, birds) or in offshore waters near Atigaru Point or Oliktok Point (e.g., marine mammals).

1.2.1.2 Harvest and Use Data

Tables E.16.2 and E.16.3 provide Nuiqsut harvest data for various years between 1985 and 2015; data are not available for all years within this time period because harvest studies were not conducted in all years. While certain studies address all resources (all resources study years), others address individual species or resources (single-resource study years). Eleven study years only include data on caribou harvests (Braem, Kaleak et al. 2011; SRB&A 2012, 2013, 2014, 2015, 2016, 2017, 2018) (Table E.16.3). During available study years, Nuiqsut households have harvested between 399 (in 1985, one of two years when the community did not successfully harvest a bowhead whale) and 896 (in 2014) pounds of subsistence resources per capita (Table E.16.2). Land mammals, marine mammals, and fish are all major subsistence resources in Nuiqsut. During 4 study years, marine mammals contributed more total edible pounds than any other resource. Non-salmon fish were the top harvested resource during the remaining 3 study years and accounted for between 173 (in 1985) and 248 (in 1993) edible pounds per capita during years with per capita harvest data. Large land mammals were generally the second- or third-most harvested resource during all study years and provided between 169 (in 1985) and 261 (in 2014) edible pounds per capita. Nuiqsut residents harvest other resources such as migratory birds, upland game birds, salmon, bird eggs, and vegetation in much smaller quantities. Small land mammals are also harvested, but because they are harvested primarily for their fur, they contribute little in the way of edible pounds.

In terms of species, bowhead whales, whitefish (Arctic cisco, or *qaaktaq*, and broad whitefish), and caribou are the primary subsistence species harvested in Nuiqsut. Bowhead whale harvests have accounted for between 28.7% and 60.3% of the total harvest during all study years (except for 1985 and 1994–1995, when Nuiqsut did not successfully harvest a bowhead whale) (Table E.16.3). Arctic cisco harvests have accounted for between 1.9% and 14.9% of the total harvest; broad whitefish have accounted for between 5.3% and 45% of the total harvest; and caribou have accounted for between 21.7% and

37.5% of the total harvest. Other subsistence species with substantial contributions to Nuiqsut subsistence harvests include moose, seals, goose, Arctic grayling, least cisco, and burbot.

Data on subsistence participation and use by Nuiqsut households are available for various study years (Tables E.16.2 and E.16.3). As shown in Table E.16.2, 100% of households report using subsistence resources during study years, and over 90% of households participate in subsistence activities (i.e., attempting to harvest). Across all study years, participation in subsistence activities was highest for non-salmon fish, large land mammals, and migratory birds. Specifically, in 2014, over half of Nuiqsut households participated in harvests of caribou, broad whitefish, white-fronted goose, cloudberries, and Arctic cisco. In 2016, 76% of households participated in caribou hunting activities. Sharing of subsistence resources, a core Iñupiat value, is also high among Nuiqsut households; between 95% and 100% of households report receiving subsistence foods during available study years. In particular, households commonly share marine mammals (between 95% and 100% of households receiving), large land mammals (between 70% and 92% receiving), and non-salmon fish (between 71% and 90% receiving).

Table E.16.2. Nuiqsut Subsistence Harvest Estimates by Resource Category, All Resources Study Years

Study Year	Resource	Percentage of Households Use (%)	Percentage of Households Try to Harvest (%)	Percentage of Households Harvest (%)	Percentage of Households Give (%)	Percentage of Households Receive (%)	Estimated Harvest Number[a]	Estimated Harvest Total Pounds[b]	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds	Percentage of Total Harvest (%)
1985	All resources	100	98	98	95	100	–	160,035	2,106	399	100.0
1985	Salmon	60	43	40	23	23	441	1,366	18	3	0.9
1985	Non-salmon fish	100	93	93	83	75	67,712	69,243	911	173	43.3
1985	Large land mammals	98	90	90	80	70	536	67,621	890	169	42.3
1985	Small land mammals	65	63	58	23	13	688	245	3	1	0.2
1985	Marine mammals	100	48	23	30	100	59	13,355	176	33	8.3
1985	Migratory birds	90	90	85	60	55	1,733	6,626	87	17	4.1
1985	Upland game birds	88	88	88	58	13	1,957	1,370	18	3	0.9
1985	Bird eggs	25	25	23	8	10	262	40	1	< 1	< 0.1
1985	Vegetation	38	50	18	10	20	–	169	2	< 1	0.1
1992[c]	All resources	–	–	–	–	–	–	150,195	–	–	100.0
1992[c]	Salmon	–	–	–	–	–	6	65	–	–	0.0
1992[c]	Non-salmon fish	–	74	–	–	–	36,701	51,890	–	–	34.5
1992[c]	Large land mammals	–	–	–	–	–	299	41,386	–	–	27.6
1992[c]	Small land mammals	–	–	–	–	–	46	1	–	–	0.0
1992[c]	Marine mammals	–	–	–	–	–	49	52,865	–	–	35.2
1992[c]	Migratory birds	–	–	–	–	–	1,105	3,655	–	–	2.4
1992[c]	Upland game birds	–	–	–	–	–	378	265	–	–	0.2
1992[c]	Eggs	–	–	–	–	–	25	4	–	–	< 0.1
1992[c]	Vegetation	–	32	–	–	–	–	66	–	–	< 0.1

Study Year	Resource	Percentage of Households Use (%)	Percentage of Households Try to Harvest (%)	Percentage of Households Harvest (%)	Percentage of Households Give (%)	Percentage of Households Receive (%)	Estimated Harvest Number[a]	Estimated Harvest Total Pounds[b]	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds	Percentage of Total Harvest (%)
1993	All resources	100	94	90	92	98	–	267,818	2,943	742	100.0
1993	Salmon	71	45	36	39	47	272	1,009	11	3	0.4
1993	Non-salmon fish	97	79	79	87	90	71,626	89,481	983	248	33.4
1993	Large land mammals	98	76	74	82	92	691	87,306	959	242	32.6
1993	Small land mammals	53	45	42	27	18	599	84	1	< 1	< 0.1
1993	Marine mammals	97	58	37	79	97	113	85,216	936	236	31.8
1993	Migratory birds	87	74	73	63	65	2,238	3,540	39	10	1.3
1993	Upland game birds	60	45	45	42	26	973	681	7	2	0.3
1993	Eggs	40	21	19	15	23	346	104	1	< 1	< 0.1
1993	Vegetation	79	71	71	27	40	–	396	4	1	0.1
1994–1995[d]	All resources	–	–	–	–	–	–	83,228	–	–	100.0
1994–1995[d]	Salmon	–	–	–	–	–	10	31	–	–	< 0.1
1994–1995[d]	Non-salmon fish	–	–	–	–	–	15,190	46,569	–	–	56.0
1994–1995[d]	Large land mammals	–	–	–	–	–	263	32,686	–	–	39.3
1994–1995[d]	Small land mammals	–	–	–	–	–	42	0	–	–	0.0
1994–1995[d]	Marine mammals	–	–	–	–	–	25	1,504	–	–	1.8
1994–1995[d]	Migratory birds	–	–	–	–	–	569	2,289	–	–	2.8
1994–1995[d]	Upland game birds	–	–	–	–	–	58	58	–	–	0.1
1994–1995[d]	Vegetation	–	–	–	–	–	14	91	–	–	0.1
1995–1996	All resources	–	–	–	–	–	–	183,576	–	–	100.0
1995–1996	Salmon	–	–	–	–	–	42	131	–	–	0.1
1995–1996	Non-salmon fish	–	–	–	–	–	10,612	16,822	–	–	9.2
1995–1996	Large land mammals	–	–	–	–	–	364	43,554	–	–	23.7
1995–1996	Small land mammals	–	–	–	–	–	27	0	–	–	0.0
1995–1996	Marine mammals	–	–	–	–	–	178	120,811	–	–	65.8
1995–1996	Migratory birds	–	–	–	–	–	683	2,166	–	–	1.2
1995–1996	Upland birds	–	–	–	–	–	19	13	–	–	< 0.1
1995–1996	Vegetation	–	–	–	–	–	12	78	–	–	< 0.1
2000–2001	All resources	–	–	–	–	–	–	183,246	–	–	100.0
2000–2001	Salmon	–	–	–	–	–	10	75	–	–	< 0.1
2000–2001	Non-salmon fish	–	–	–	–	–	26,545	27,933	–	–	15.2
2000–2001	Large land mammals	–	–	–	–	–	504	62,171	–	–	33.9
2000–2001	Small land mammals	–	–	–	–	–	108	2	–	–	< 0.1
2000–2001	Marine mammals	–	–	–	–	–	31	87,929	–	–	48.0
2000–2001	Migratory birds	–	–	–	–	–	1,192	5,108	–	–	2.8
2000–2001	Upland birds	–	–	–	–	–	23	16	–	–	< 0.1
2000–2001	Vegetation	–	–	–	–	–	2	13	–	–	< 0.1

Study Year	Resource	Percentage of Households Use (%)	Percentage of Households Try to Harvest (%)	Percentage of Households Harvest (%)	Percentage of Households Give (%)	Percentage of Households Receive (%)	Estimated Harvest Number[a]	Estimated Harvest Total Pounds[b]	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds	Percentage of Total Harvest (%)
2014	All resources	100	95	90	91	97	–	371,992	3,444	896	100.0
2014	Salmon	64	41	40	31	35	–	3,889	36	9	1.0
2014	Non-salmon fish	93	78	71	72	71	–	85,106	788	205	22.9
2014	Large land mammals	91	66	64	67	72	–	108,359	1,003	261	29.1
2014	Small land mammals	17	16	10	2	7	–	0	0	0	0.0
2014	Marine mammals	95	55	40	71	95	–	169,367	1,568	408	45.5
2014	Migratory birds	79	71	66	52	38	–	4,742	44	11	1.3
2014	Upland birds	16	12	12	9	5	–	78	1	< 1	< 0.1
2014	Vegetation	67	55	53	21	38	–	414	4	1	0.1

Source: 1985 (ADF&G 2018); 1992 (Fuller and George 1999); 1993 (Pedersen 1995a); 1994–1995 (Brower and Hepa 1998); 1995–1996, 2000–2001 (Bacon, Hepa et al. 2009); 2014 (Brown, Braem et al. 2016)

Note: "–" (No Data). "All Resources" study years are years where studies addressed all subsistence resources harvested by the community, rather than selected resources or species. The estimated harvest numbers for the 1994–1995, 1995–1996, and 2000–2001 data were derived by summing individual species in each resource category. Also for those study years, total pounds were derived from conversion rates found at ADF&G (2018), and total (usable) pounds for bowhead whales were calculated based on the method presented in SRB&A and ISER (1993). These estimates do not account for whale girth and should be considered approximate; more exact methods for estimating total whale weights are available in George, Philo et al. (n.d.).

[a] Estimated numbers represent individuals in all cases except vegetation, where they represent gallons.

[b] Estimated pounds include only edible pounds and therefore do not include estimates for resources that are not typically eaten by community residents (e.g., furbearers).

[c] The estimated pounds of moose harvested in 1992 is likely too high (Fuller and George 1999).

[d] The 1994–1995 study year underrepresents the harvest of Arctic cisco and humpback whitefish (Brower and Hepa 1998); Nuiqsut did not successfully harvest a bowhead whale in 1994–1995.

Table E.16.3. Nuiqsut Subsistence Harvest Estimates by Selected Species, All Study Years

Study Year	Resource[a]	Percentage of Households Use (%)	Percentage of Households Try to Harvest (%)	Percentage of Households Harvest (%)	Percentage of Households Give (%)	Percentage of Households Receive (%)	Estimated Harvest Number[b]	Estimated Harvest Total Pounds[c]	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds	Percentage of Total Harvest (%)
1985	Caribou	98	90	90	80	60	513	60,021	790	150	37.5
1985	Cisco	98	75	73	65	60	46,478	29,354	386	73	18.3
1985	Broad whitefish	95	80	78	70	40	7,900	26,861	353	67	16.8
1985	Bowhead whale	100	23	5	8	100	0	7,458	98	19	4.7
1985	Moose	40	40	18	20	25	13	6,650	88	17	4.2
1985	White-fronted goose	90	90	85	55	48	1,340	6,028	79	15	3.8
1985	Arctic grayling	78	65	63	48	35	4,055	3,650	48	9	2.3
1985	Humpback whitefish	48	45	38	33	13	4,345	3,476	46	9	2.2
1985	Arctic char	75	63	60	33	35	1,060	2,969	39	7	1.9
1985	Burbot	75	60	60	43	33	669	2,675	35	7	1.7
1985	Bearded seal	48	25	15	15	35	15	2,675	35	7	1.7
1985	Ringed seal	53	25	18	23	40	40	1,676	22	4	1.0
1992	Bowhead whale	–	–	–	–	–	2	48,715	–	–	32.4
1992	Caribou	–	81	–	–	–	278	32,551	–	–	21.7
1992	Arctic cisco	–	–	–	–	–	22,391	22,391	–	–	14.9
1992	Broad whitefish	–	–	–	–	–	6,248	15,621	–	–	10.4
1992	Moose[d]	–	–	–	–	–	18	8,835	–	–	5.9

Study Year	Resource[a]	Percentage of Households Use (%)	Percentage of Households Try to Harvest (%)	Percentage of Households Harvest (%)	Percentage of Households Give (%)	Percentage of Households Receive (%)	Estimated Harvest Number[b]	Estimated Harvest Total Pounds[c]	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds	Percentage of Total Harvest (%)
1992	Humpback whitefish	–	–	–	–	–	1,802	4,504	–	–	3.0
1992	Arctic char	–	–	–	–	–	1,544	4,324	–	–	2.9
1992	Bearded seal	–	–	–	–	–	16	2,760	–	–	1.8
1992	Arctic grayling	–	–	–	–	–	3,114	2,491	–	–	1.7
1992	Canada goose	–	–	–	–	–	319	1,437	–	–	1.0
1993	Caribou	98	74	74	79	79	672	82,169	903	228	30.7
1993	Bowhead whale	97	37	5	76	97	3	76,906	845	213	28.7
1993	Broad whitefish	90	66	66	65	66	12,193	41,455	456	115	15.5
1993	Arctic cisco	89	69	68	81	60	45,237	31,666	348	88	11.8
1993	Ringed seal	65	42	31	40	55	98	7,277	80	20	2.7
1993	Burbot	79	63	57	53	55	1,416	5,949	65	16	2.2
1993	Moose	69	47	10	29	63	9	4,403	48	12	1.6
1993	Arctic grayling	79	69	65	44	27	4,515	4,063	45	11	1.5
1993	Least cisco	63	52	47	36	27	6,553	3,277	36	9	1.2
1994–1995[e]	Broad whitefish	–	–	–	–	–	3,237	37,417	–	–	45.0
1994–1995[e]	Caribou	–	–	–	–	–	258	30,186	–	–	36.3
1994–1995[e]	Arctic cisco	–	–	–	–	–	9,842	6,889	–	–	8.3
1994–1995[e]	Moose	–	–	–	–	–	5	2,500	–	–	3.0
1994–1995[e]	Goose, unidentified	–	–	–	–	–	474	2,133	–	–	2.6
1994–1995[e]	Ringed seal	–	–	–	–	–	24	1,008	–	–	1.2
1995–1996	Bowhead whale	–	–	–	–	–	4	110,715	–	–	60.3
1995–1996	Caribou	–	–	–	–	–	362	42,354	–	–	23.1
1995–1996	Broad whitefish	–	–	–	–	–	2,863	9,735	–	–	5.3
1995–1996	Ringed seal	–	–	–	–	–	155	6,527	–	–	3.6
1995–1996	Arctic cisco	–	–	–	–	–	5,030	3,521	–	–	1.9
1995–1996	Bearded seal	–	–	–	–	–	17	2,974	–	–	1.6
1995–1996	Least cisco	–	–	–	–	–	1,804	1,804	–	–	1.0
1999–2000	Caribou	–	–	–	–	–	413	–	–	112	–
2000–2001	Bowhead whale	–	–	–	–	–	4	86220	–	–	47.1
2000–2001	Caribou	–	–	–	–	–	496	57,985	–	–	31.6
2000–2001	Arctic cisco	–	–	–	–	–	18,222	12,755	–	–	7.0
2000–2001	Broad whitefish	–	–	–	–	–	2,968	10,092	–	–	5.5
2000–2001	White-fronted goose	–	–	–	–	–	787	3,543	–	–	1.9
2000–2001	Moose	–	–	–	–	–	6	3,000	–	–	1.6
2002–2003	Caribou	95	47	45	49	80	397	–	–	118	–
2003–2004	Caribou	97	74	70	81	81	564	–	–	157	–
2004–2005	Caribou	99	62	61	81	96	546	–	–	147	–
2005–2006	Caribou	100	60	59	97	96	363	–	–	102	–
2006–2007	Caribou	97	77	74	66	69	475	–	–	143	–
2010	Caribou	94	86	76	–	–	562	65,754	707	–	–
2011	Caribou	92	70	56	49	58	437	51,129	544	134	–
2012	Caribou	99	68	62	65	79	501	58,617	598	147	–
2013	Caribou	95	79	63	62	75	586	68,534	692	166	–
2014	Bowhead	93	29	21	57	91	5	148,087	1,371	357	39.8
2014	Caribou	90	66	64	67	59	774	105,193	974	253	28.3
2014	Broad whitefish	72	60	59	52	40	11,439	36,605	339	88	9.8
2014	Arctic cisco	83	52	48	59	53	46,277	32,394	300	78	8.7

Study Year	Resource[a]	Percentage of Households Use (%)	Percentage of Households Try to Harvest (%)	Percentage of Households Harvest (%)	Percentage of Households Give (%)	Percentage of Households Receive (%)	Estimated Harvest Number[b]	Estimated Harvest Total Pounds[c]	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds	Percentage of Total Harvest (%)
2014	Bearded seal	67	38	22	40	62	13,846	13,846	128	33	3.7
2014	Least cisco	33	28	28	19	7	13,332	9,333	86	22	2.5
2014	Ringed seal	52	40	35	38	33	108	6,156	57	15	1.7
2015	Caribou	96	84	78	74	72	621	72,631	719	178	–
2016	Caribou	96	76	67	73	73	489	56,277	592	132	–

Source: 1985 (ADF&G 2018); 1992 (Fuller and George 1999); 1993 (Pedersen 1995a); 1994–1995 (Brower and Hepa 1998); 1995–1996, 2000–2001 (Bacon, Hepa et al. 2009); 1999–2000, 2002–2007 (Braem, Kaleak et al. 2011); 2010, 2011, 2012, 2013 (SRB&A 2012, 2013, 2014, 2015); 2014 (Brown, Braem et al. 2016); 2015, 2016 (SRB&A 2017, 2018).

Note: "–" (No Data). For all resources study years (1985, 1992, 1993, 1994–1995, 1995–1996, 2000–2001), species are listed in descending order by percentage of the total harvest and are limited to species accounting for at least 1.0% of the total harvest; for single-resource study years, species are listed in descending order by total estimated pounds (or total number harvested, in the case of salmon study years) and limited to the five top species. Years lacking "percentage of total harvest" data were not comprehensive (i.e., all resources) study years. The estimated harvest numbers for the 1992, 1994–1995, 1995–1996, and 2000–2001 data were derived by summing individual species in each resource category. Also, for those study years, total pounds were derived from conversion rates found at ADF&G (2018) and total (usable) pounds for bowhead whales were calculated based on the method presented in SRB&A and ISER (1993). These estimates do not account for whale girth and should be considered approximate; more exact methods for estimating total whale weights are available in George, Philo et al. (n.d.). For the 2002–2003, 2003–2004, 2004–2005, 2005–2006, 2006–2007, 2010, and 2011 study years, total pounds were derived from conversion rates from (Braem, Kaleak et al. 2011).

[a] This table shows individual species unless they are not available for a given study year.

[b] Estimated numbers represent individuals in all cases except vegetation, where they represent gallons.

[c] Estimated pounds include only edible pounds and therefore do not include estimates for resources that are not typically eaten by community residents (e.g., furbearers).

[d] The estimated pounds of moose harvested in 1992 is likely too high (Fuller and George 1999).

[e] The 1994–1995 study year underrepresents the harvest of Arctic cisco and humpback whitefish (Brower and Hepa 1998); Nuiqsut did not successfully harvest a bowhead whale in 1994–1995.

1.2.1.2.1 Direct Effects Analysis Area

Nuiqsut residents harvest various resources within the direct effects analysis area, including caribou, furbearers (wolf and wolverine), seal, goose, eiders, and fish (broad whitefish and burbot). As shown in Tables E.16.2 and E.16.3, caribou are among the top species harvested, in terms of edible weight, by the community of Nuiqsut, as are broad whitefish. During most years, over half of Nuiqsut households participate in the harvests of these resources. Seals, particularly bearded seals, are another important resource that is harvested within the direct effects analysis area. Although not harvested in the same quantities as resources such as caribou and broad whitefish, seals are hunted by a substantial proportion of households (Table E.16.2). Similarly, while migratory birds generally account for less than 5% of the total annual harvest, a high percentage of households participate in harvests of these resources (between 70% and 90% across available study years; Table E.16.2). Wolf and wolverine hunting is an important, specialized activity that is practiced by a more limited subset of the community but which provides income and supports traditional crafts (e.g., providing skins and furs for sewing, craft making, and clothing).

Harvest amounts specific to the direct effects analysis area are available only for caribou. These data show the percentage of the reported caribou harvest that came from the direct effects analysis area between 2008 and 2016. These data represent only the harvests reported by a sample of active harvesters interviewed during each study year and are not based on the total estimated community harvest; thus, other harvests may have occurred within the direct effects analysis area during the study.

As shown in Table E.16.4, across 9 years of the Nuiqsut Caribou Subsistence Monitoring Project, between 13% and 26% of the annual caribou harvests have occurred within the direct effects analysis area. As noted above, residents often travel to the west of their community to hunt caribou by four-wheeler or snow machine in an area east and south of the direct effects analysis area. Caribou often travel through the analysis area before arriving in hunting areas closer to the community.

Table E.16.4. Nuiqsut Caribou Harvests Within the Direct Effects Analysis Area, 2008–2016

Study Year	Percentage of Caribou Harvests within Direct Effects Analysis Area
Year 1	20
Year 2	17
Year 3	16
Year 4	26
Year 5	22
Year 6	13
Year 7	21
Year 8	14
Year 9	18

Source: SRB&A 2018

Based on data from SRB&A (2010b), which collected subsistence use area data for key resources for the 1995–2006 time period, the direct effects analysis area is used by a majority of wolf/wolverine hunters (100% during the 1995–2006 time period), caribou hunters (94%), moose hunters (94%), goose hunters (70%), and bearded seal hunters (56%) (Table E.16.5). In addition, a substantial percentage of harvesters use the direct effects analysis area for eider hunting (50%), ringed seal hunting (43%), and broad whitefish harvest (19%). For resources as a whole, the vast majority (97%) of Nuiqsut harvesters reported using the direct effects analysis area during the study period. Based on more recent caribou harvesting data for the 2008–2016 time period, on an annual basis, between 79% and 97% of respondents use the direct effects analysis area (Table E.16.6); thus, the area is a key caribou hunting ground for the community.

Table E.16.5. Percent of Nuiqsut Harvesters Using the Direct Effects Analysis Area, 1995–2006

Resource	Total Number of Respondents for Resource	Number of Respondents in Direct Effects Analysis Area	Percentage of Nuiqsut Resource Respondents
Caribou	32	30	94%
Wolverine	24	24	100%
Wolf	23	23	100%
Goose	33	23	70%
Bearded seal	27	15	56%
Ringed seal	23	10	43%
Eiders	28	14	50%
Broad whitefish	26	5	19%
Arctic char	26	4	15%
Moose	31	29	94%
Burbot	30	1	3%
All resources	**33**	**32**	**97%**

Source: SRB&A 2010b

Table E.16.6. Percent of Nuiqsut Caribou Harvesters Using the Direct Effects Analysis Area, 2008–2016

Study Year	Number Using Direct Effects Analysis Area	Percentage Using Direct Effects Analysis Area	Total Respondents
Year 1	35	97%	36
Year 2	49	92%	53
Year 3	52	91%	57
Year 4	56	97%	58
Year 5	52	91%	57
Year 6	46	81%	57
Year 7	56	93%	60
Year 8	49	84%	58
Year 9	50	79%	63

Source: SRB&A 2018

1.2.1.3 Timing of Subsistence Activities

Table E.16.7 provides data on the timing of Nuiqsut subsistence activities based on studies from the 1970s through the 2010s. Overall, Nuiqsut harvesters target the highest numbers of resources, including non-salmon fish, caribou, moose and other large land mammals, seals and bowhead whales, and plants and berries, during August and September.

Table E.16.7. Nuiqsut Annual Cycle of Subsistence Activities

Resource	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Freshwater non-salmon	M	L	M	M	L	L	M	H	H	H	H	L
Marine non-salmon	–	–	–	–	–	–	–	–	H	H	–	–
Salmon	–	–	–	–	–	–	H	M	–	–	–	–
Caribou	L	L	L	L	L	M	H	H	M	M	L	L
Moose	L	–	–	–	–	–	L	H	H	M	L	L
Bear	M	M	M	L	L	L	L	L	H	M	M	M
Muskox	–	–	–	–	–	–	–	H	H	H	–	–
Furbearers	H	H	H	H	M	L	L	L	L	L	M	H
Small land mammals	–	–	–	–	L	L	H	H	L	–	–	–
Marine mammals	–	–	M	H	L	L	M	H	H	L	L	L
Upland birds	M	M	H	H	M	L	–	L	L	M	M	M
Waterfowl	–	–	–	L	H	H	M	M	M	M	L	L
Eggs	–	–	–	–	–	H	–	–	–	–	–	–
Plants and berries	–	–	–	–	L	L	H	H	–	–	–	–
Total number of resource categories by month	**6**	**5**	**6**	**7**	**9**	**10**	**10**	**12**	**11**	**10**	**8**	**8**

Source: 1995–1996, 2000–2001 (Bacon, Hepa et al. 2009); 2002–2007 (Braem, Kaleak et al. 2011); 1994–1995 (Brower and Hepa 1998); Pre-1979 (Brown 1979); 2014 (Brown, Braem et al. 2016); 2004 (EDAW Inc., Adams/Russel Consulting et al. 2008); 1992 (Fuller and George 1999); 2001–2012 (Galginaitis 2014); 1988 (Hoffman, Libbey et al. 1988); 1979 (Libbey, Spearman et al. 1979); 1995–2006 (SRB&A 2010b); 2008–2016 (SRB&A 2018)
Note: "–" (no documented activity and/or harvests); L (limited activity and/or harvests); M (moderate activity and/or harvests); H (high activity and/or harvests).

The month of April marks the beginning of the spring waterfowl hunting season, which peaks in May and June. Some residents also harvest goose eggs after the birds begin nesting in June. Beginning as early as May (depending on the timing of breakup), residents travel by boat along the local river system and into the Beaufort Sea to harvest various resources, including caribou, waterfowl, seals, and fish. Caribou hunting occurs throughout the year, but with the most intensity during July and August. During this time, residents also set nets for broad whitefish in local river systems or harvest fish such as Arctic grayling and Dolly Varden with rods and reels, often while hunting caribou along the Colville River. Throughout the summer months, residents also travel to the ocean to hunt for ringed seals, bearded seals, and king and common eiders, with some coastal caribou hunting occurring as well (SRB&A 2010b). Most berry and plant gathering occurs in July and August.

Beginning in August and continuing throughout September, some residents shift their focus upriver in search of moose, with caribou often a secondary pursuit during these trips. Summer rod-and-reel harvests of non-salmon fish, particularly Arctic grayling, continue into the fall as well. Preparation for the bowhead whale hunt begins in August, with whaling crews generally traveling to Cross Island in September. While at Cross Island, Nuiqsut hunters may harvest polar bears and other marine resources; these harvesting events generally occur when whaling is not active due to weather or travel conditions. The fall Arctic cisco fishery, a major community event, may begin in September but is most productive between October and mid-November when the fish are running upriver; residents harvest them in the CRD with gillnets. Other fish, including humpback whitefish, broad whitefish, and least cisco, are caught incidentally during this time. Caribou are also harvested during October and November, as available, to the west of the community.

Starting in November and December and continuing through April, hunters pursue wolves and wolverines and target caribou and ptarmigan as needed and available. Residents may also fish for burbot through the ice during winter.

1.2.1.3.1 Direct Effects Analysis Area

Nuiqsut harvesters use the direct effects analysis area at varying levels throughout the year (Figure E.16.10). For all resources for the 1995–2006 time period, uses of the direct effects analysis area are somewhat consistent throughout the year but with a peak in summer (July and August) and again in mid- to late winter (January through March). During both the 1995–2006 and 2008–2016 time periods, caribou hunting in the direct effects analysis area peaked from July through September but continued through winter. Data from the more recent time period (2008–2016) show decreasing use of the direct effects analysis area in the winter months, consistent with the increasing use of ATVs instead of snow machines to access areas west of Nuiqsut (SRB&A 2018). Summer hunting activities in the direct effects analysis area occur in overland areas to the west of the community, along the Colville River, and, to a lesser extent, in coastal areas to the west and east of the CRD. Wolf and wolverine hunters use the direct effects analysis area solely during November through April, with goose hunting peaking in April and May and occurring to a lesser extent in June. Seal and eider hunting occur offshore primarily during the open-water months of June through September, although some eider hunting occurs as early as May. Fishing occurs in the direct effects analysis area between June and October, peaking in July and August, with minimal activity in November and December. Fishing occurs primarily along the Colville River and in Fish (Iqalliqpik) Creek.

1.2.1.4 Travel Methods

As shown in Table E.16.8, boat is the primary travel method used for subsistence pursuits of most resources, including various non-salmon fish, caribou, moose, bowhead whale, seals, and eider. Snow machine is the primary method of travel used for the late fall, winter, and early spring pursuits of Arctic cisco, burbot, wolf and wolverine, and goose; recent data shows that while boats remain the primary method of travel to caribou use areas, ATVs and trucks have become much more common in recent years, while snow machines have become less common (SRB&A 2018).

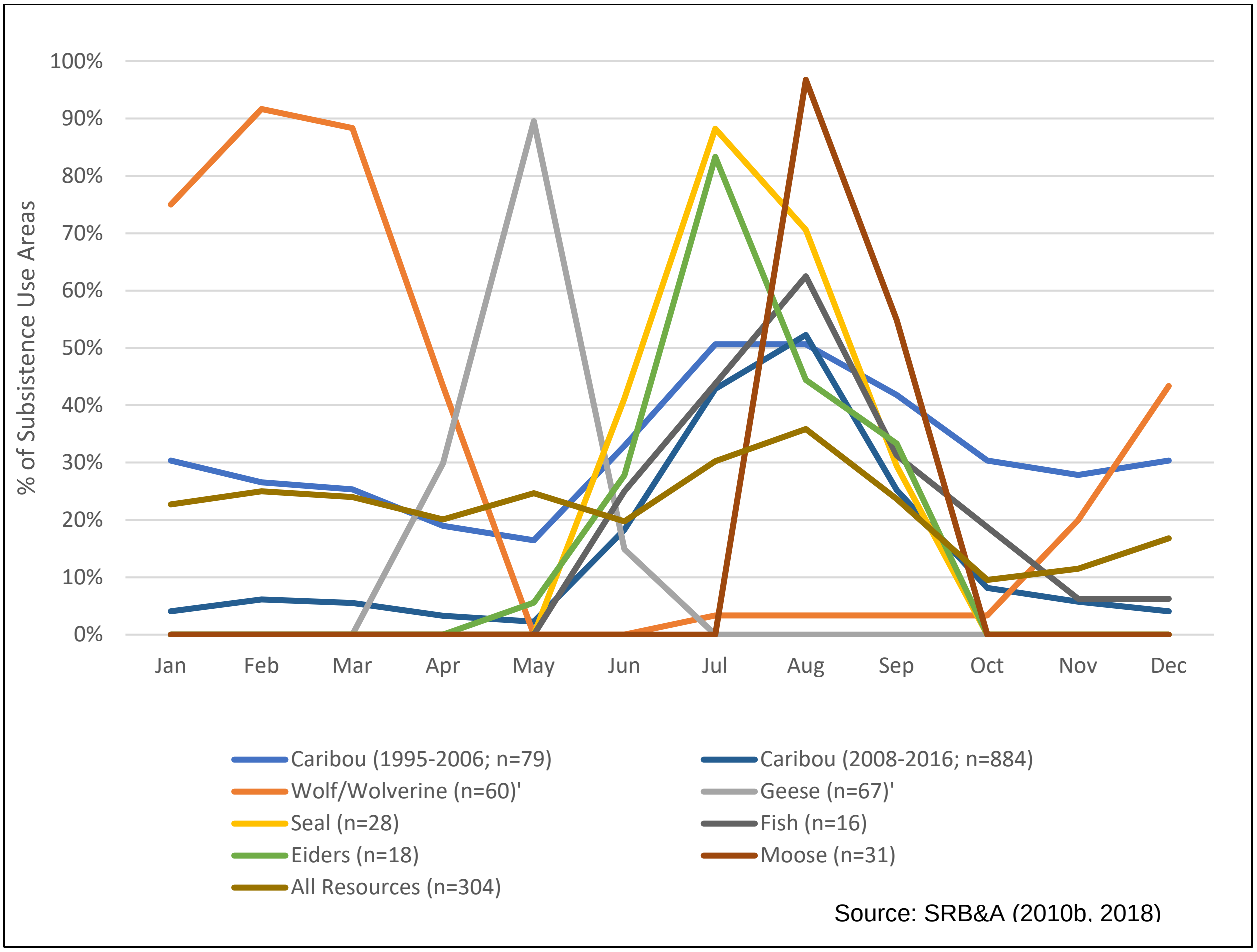


Figure E.16.10. Nuiqsut Subsistence Use Areas by Month in the Direct Effects Analysis Area, by Resource

Table E.16.8. Nuiqsut Travel Method to Subsistence Use Areas

Resource	Boat	Snow Machine	Foot	Car/Truck	ATV	Plane
Arctic cisco and burbot	L	H	L	M	–	–
Arctic char/Dolly Varden and broad whitefish	H	M	M	–	–	–
Caribou	H	M	–	L	M	–
Moose	H	–	M	–	–	–
Wolf and wolverine	M	H	–	–	–	M
Bowhead whale	H	–	–	–	–	–
Seals	H	M	–	–	–	–
Goose	M	H	M	L	L	–
Eider	H	M	–	–	–	–
Total number of resources targeted	**9**	**7**	**4**	**3**	**2**	**1**

Source: 1995–2006 (SRB&A 2010b); 2008–2016 (SRB&A 2018).
Note: "–" (no documented use of travel method); ATV (all-terrain vehicle); L (limited use of travel method); M (moderate use of travel method); H (high use of travel method). Caribou based on SRB&A (2017). All others based on SRB&A (2010a).

1.2.1.4.1 Direct Effects Analysis Area

Because the direct effects analysis area includes terrestrial, riverine, and marine areas, travel methods used by Nuiqsut harvesters vary by location. As shown in Figure E.16.11, for the 1995–2006 time period, snow machine was the primary method used to access the direct effects analysis area, followed closely by boat. No other travel methods were used (except minimally) within the direct effects analysis area. During the 2008–2016 time period, Nuiqsut caribou hunters primarily accessed the direct effects analysis area by boat (67% of use areas). A smaller percentage of use areas were accessed during that time period by snow machine (18%) or ATV (four-wheeler) (14%). Figure E.16.11 shows an increase in the use of ATVs in the direct effects analysis area during the 2008–2016 time period. Recent data from the Nuiqsut Caribou Subsistence Monitoring Project also show the increased use of trucks to access caribou hunting areas west of the community due to the construction of easily accessible gravel roads (SRB&A 2018).

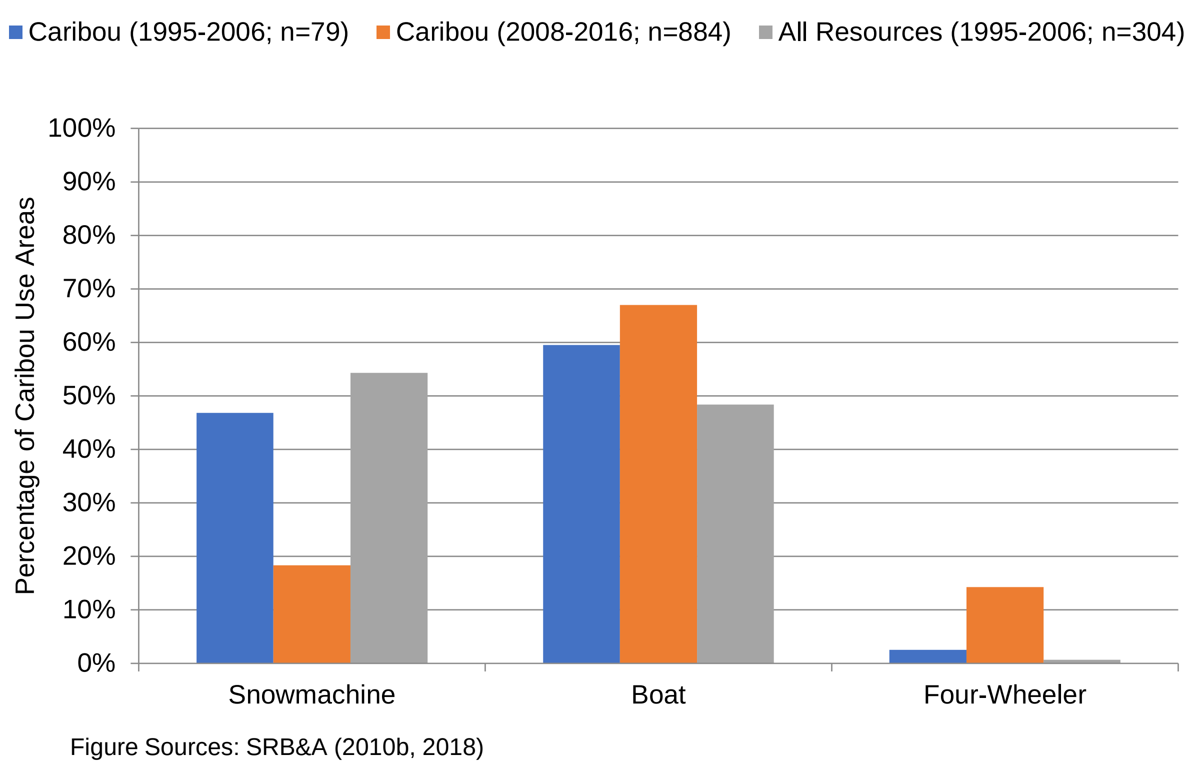


Figure E.16.11. Nuiqsut Travel Methods in the Direct Effects Analysis Area

1.2.1.5 Resource Importance

An analysis of resource importance based on harvest (percentage of total harvest), harvest effort (percentage of households attempting to harvest), and sharing (percentage of households receiving) variables is provided in Table E.16.9. Based on this analysis, resources of major importance in Nuiqsut are Arctic cisco, Arctic grayling, bearded seal, bowhead whale, broad whitefish, burbot, caribou, cloudberry, white-fronted goose, and wood (driftwood).

Table E.16.9. Relative Importance of Subsistence Resources Based on Selected Variables, Nuiqsut

Resource Category	Resource[a]	Percentage of Households Trying to Harvest (%)	Percentage of Households Receiving (%)	Percentage of Total Harvest (%)
Major resources[b]	Arctic cisco	61	57	8.8
Major resources[b]	Arctic grayling	50	24	1.0
Major resources[b]	Bearded seal	32	50	1.6
Major resources[b]	Bowhead whale[c]	30	96	30.4
Major resources[b]	Broad whitefish	69	49	15.5
Major resources[b]	Burbot	51	35	1.0
Major resources[b]	Caribou	73	75	29.9
Major resources[b]	Cloudberry	55	29	0.0
Major resources[b]	White fronted goose	62	36	1.4
Major resources[b]	Wood[d]	50	3.2	0.0

Resource Category	Resource[a]	Percentage of Households Trying to Harvest (%)	Percentage of Households Receiving (%)	Percentage of Total Harvest (%)
Moderate resources[e]	Arctic char	38	22	0.9
Moderate resources[e]	Arctic fox	14	1	0.0
Moderate resources[e]	Beluga	2	24	0.0
Moderate resources[e]	Bird eggs	16	12	0.0
Moderate resources[e]	Blueberries	29	16	0.0
Moderate resources[e]	Brant	17	9	0.1
Moderate resources[e]	Brown bear	14	18	0.2
Moderate resources[e]	Canada goose	42	24	0.4
Moderate resources[e]	Chum salmon	23	11	0.6
Moderate resources[e]	Ground squirrel	45	8	0.1
Moderate resources[e]	Humpback whitefish	26	9	1.0
Moderate resources[e]	King eider	24	19	0.0
Moderate resources[e]	Least cisco	40	17	1.1
Moderate resources[e]	Long-tailed duck	8	13	0.0
Moderate resources[e]	Moose	40	41	2.5
Moderate resources[e]	Pink salmon	28	17	0.4
Moderate resources[e]	Polar bear	7	29	0.2
Moderate resources[e]	Ptarmigan	48	15	0.2
Moderate resources[e]	Rainbow smelt	13	22	0.1
Moderate resources[e]	Red fox	22	2	0.0
Moderate resources[e]	Ringed seal	36	43	1.6
Moderate resources[e]	Snow goose	19	7	0.0
Moderate resources[e]	Spotted seal	13	5	0.1
Moderate resources[e]	Walrus	7	43	0.2
Moderate resources[e]	Wolf	18	6	0.0
Moderate resources[e]	Wolverine	22	5	0.0
Minor resources[f]	Arctic cod	7	7	0.0
Minor resources[f]	Chinook salmon	2	9	0.0
Minor resources[f]	Coho salmon	3	5	0.0
Minor resources[f]	Common eider duck	7	3	0.1
Minor resources[f]	Cranberries	9	5	0.0
Minor resources[f]	Crowberries	7	2	0.0
Minor resources[f]	Dall sheep	–	9	0.0
Minor resources[f]	Dolly Varden	10	3	0.4
Minor resources[f]	Lake trout	3	8	0.0
Minor resources[f]	Muskox	–	8	0.3
Minor resources[f]	Northern pike	7	7	0.0
Minor resources[f]	Northern pintail	5	1.6	0.0
Minor resources[f]	Round whitefish	5	1	0.1
Minor resources[f]	Saffron cod	7	–	0.0
Minor resources[f]	Sheefish	–	6	0.0
Minor resources[f]	Sockeye salmon	3	6	0.0
Minor resources[f]	Sourdock	5	7	0.0
Minor resources[f]	Weasel	5	–	0.0

Source: 1985 (ADF&G 2018); 1992 (Fuller and George 1999); 1993 (Pedersen 1995b); 1994–1995 (Brower and Hepa 1998); 1995–1996, 2000–2001 (Bacon, Hepa et al. 2009); 1999–2000, 2002–2007 (Braem, Kaleak et al. 2011); 2010, 2011, 2012, 2013 (SRB&A 2012, 2013, 2014, 2015); 2014 (Brown, Braem et al. 2016); 2016 (SRB&A 2018)

Note: "–" (No Data).

[a] For space considerations, resources that contributed an average of less than 1% of the harvest, less than 5% attempting to harvest, and less than 5% of receiving resources are categorized as minor and are not shown.

[b] Major resources contribute > 9% of the total harvest, have ≥ 50% of households attempting to harvest, or have ≥ 50% of households receiving resources.

[c] Averages include unsuccessful bowhead whale harvest years.

[d] The inclusion of wood is based on a single study year (1993); data on wood were not collected during any other study year.

[e] Moderate resources contribute 2% to 9% of the total harvest, have 11% to 49% of households attempting to harvest, or have 11% to 49% of households receiving resources.

[f] Minor resources contribute < 2% of the total harvest, have ≤ 10% of households attempting to harvest, or have ≤ 10% of households receiving resource.

1.2.2 Utqiaġvik

Utqiaġvik (Barrow) is the North Slope's most populous community and is located on the northern coast of the Chukchi Sea. The town site is approximately 7.5 miles south of Point Barrow, the demarcation point between the Chukchi and Beaufort seas. In 2016, the residents of Barrow voted to formally rename the town to its original Iñupiaq name of Utqiaġvik. The community is also traditionally known as Ukpeagvik, which means "place where snowy owls are hunted" (NSB 2018). Continuous occupation of the Utqiaġvik area began approximately 1,300 years ago. Following European contact in the early 1800s, the growth of the commercial whaling and trapping industries brought Iñupiat from across the North Slope to Utqiaġvik in pursuit of employment and trade opportunities. The Naval Petroleum Reserve 4 was established in 1923, and in the late 1940s, the U.S. Navy established a base camp in Utqiaġvik from which to launch oil exploration in the reserve (Jensen 2009). The established mission of the naval base camp shifted away from oil exploration in the 1950s, and the base became the Naval Arctic Research Laboratory. Throughout the late 1900s, Utqiaġvik continued to grow as new economic opportunities, including oil and gas exploration, arose on the North Slope. Today, Utqiaġvik is the headquarters for various regional organizations and corporations, including the NSB and the Arctic Slope Regional Corporation (NSB 2016). In 2014, the population of Utqiaġvik was estimated at 4,825 residents living in 1,588 households; 65.9% were Alaska Native (NSB 2016). The community remains primarily Iñupiat, and subsistence remains an important part of the community's identity and social fabric.

1.2.2.1 Subsistence Use Areas

Figure E.16.12 depicts Utqiaġvik subsistence use areas for all resources for various historic and contemporary time periods (BLM 2004; Brown, Braem et al. 2016; Pedersen 1979; SRB&A 2010b, Unpublished; SRB&A and ISER 1993). Time periods range from lifetime use areas documented in 1979 (Pedersen 1979) to single-year use areas documented in 2014 (Brown, Braem et al. 2016). Lifetime (pre-1979) use areas include locations as far south as the Colville River near Umiat, beyond Nuiqsut in the east, offshore from the community to the southeast and southwest, and inland beyond Wainwright toward Point Lay. Harvest sites and use areas for the 1987–1989 time period are similar to those recorded for the pre-1979 time period but extend farther offshore from the community. The harvest sites for the 1987–1989 time period are concentrated in offshore areas between Peard Bay and Smith Bay and onshore areas extending south from the community beyond the Colville River and into the foothills of the Brooks Range. More recent use areas studies for the 1994–2003 and 1997–2006 time periods show somewhat larger use area extents, with use areas extending well offshore to the north of the community, east toward the Kuparuk River area, south to the Colville River, and as far west as Point Lay. Overlapping subsistence use areas for the 1997–2006 time period show the greatest concentration of use areas occurring offshore from the community up to 20 miles and in an overland area south of the community and along the Chipp and Ikpikpuk rivers. Use areas for the 2014 time period are consistent with these areas of highest overlapping use. In addition, some isolated use areas were reported for the 2014 time period offshore from Icy Cape and near Point Lay.

Resource-specific use area maps for Utqiaġvik are shown in Figures E.16.13 through E.16.20 for the time periods mentioned above. Utqiaġvik subsistence use areas for large land mammals are shown in Figures E.16.13 through E.16.15. Caribou use areas (Figure E.16.13) cover an extensive area from Icy Cape to Prudhoe Bay and as far south as the Colville River. Caribou use areas for the 1997–2006 time period extend farther south and east than previous time periods; the highest number of overlapping caribou use areas extend in an overland area approximately 30 miles south of the community and along local river systems. Caribou use areas for the most recent time period (2014) are generally within those documented for the 1997–2006 time period. Figure E.16.14 depicts Utqiaġvik moose use areas, and for most time periods, shows use concentrated along the Colville River, where moose are more likely to be found. Use areas from the 1997–2006 and 2014 time periods indicate a considerably larger area extending between Utqiaġvik and the Colville River. Utqiaġvik use areas for other large land mammals (e.g., grizzly/brown bear, Dall sheep, and polar bear) are shown on Figure E.16.15. Polar bear use areas occur in the Chukchi Sea at distances of no more than 20 miles from shore, while grizzly bear use areas are concentrated in various inland areas bounded by Wainwright and the Kuk River in the west and the Ikpikpuk River in the east.

Utqiaġvik small land mammal use areas (Figure E.16.16) cover an extensive area from Point Lay to the Kuparuk River and beyond the Colville River in the south. The extent of furbearer and small land mammal use areas has expanded over time. Lifetime furbearer and small land mammal use areas cover areas from Wainwright in the west to Nuiqsut in the east, and as far south as the Colville River, while 1997–2006 use areas for wolf and wolverine extend beyond Icy Cape to Point Lay in the west, past Nuiqsut to the Kuparuk River in the east, and well beyond the Colville River in the south. High numbers of overlapping use areas occur south and east of the community toward the Colville River. Small land mammal use areas for the most recent time period (2014) occurred primarily along the Ikpikpuk River toward the Colville River.

Utqiaġvik fishing areas for all available time periods are depicted in Figure E.16.17 and show residents fishing across a large river and lake system to the south of the community, west to the Kuk River near Wainwright, and as far east as Teshekpuk Lake and the Colville River. Most time periods also show fish harvesting in coastal waters and lagoon systems in the Chukchi and Beaufort seas. More recent use areas from the 1994–2003, 1997–2006, and 2014 time periods occur along river and lake systems to the south and east of the community as far as the Teshekpuk Lake and upper Judy Creek areas.

Utqiaġvik use areas for birds (Figure E.16.18), including eiders and goose, are relatively consistent over time, although they extend considerably farther offshore during the 1997–2006 time period (SRB&A 2010b). Use areas are located offshore at a distance greater than 40 miles from the community, inland beyond Atqasuk in the west, and east as far as Nuiqsut. Bird use areas from more recent time periods (1994–2003, 1997–2006, and 2014) are concentrated along the Meade, Chipp, and Ikpikpuk rivers. Utqiaġvik harvests of vegetation (including berries and plants) and wood are depicted in Figure E.16.19 for various time periods. Vegetation and wood harvests generally occur to the south and southeast of the community, in addition to coastal areas (primarily for driftwood). More recent use areas for the 2014 time period occur over a large area that extends southwest to Wainwright and southeast to the Ikpikpuk River. Several isolated berry and plant harvesting areas have also been reported as far as Point Lay and Colville River.

Utqiaġvik subsistence use areas for marine mammals are shown on Figure E.16.20 and occur at varying offshore distances in the Beaufort and Chukchi seas. The offshore extent of marine mammal use areas has grown over time. SRB&A's (2010b) 1997–2006 marine mammals use areas show Utqiaġvik residents traveling beyond Wainwright in the west and offshore more than 80 miles, with the highest numbers of overlapping use areas occurring between 10 and 25 miles from shore. During the 2014 time period, marine mammal use areas occurred between Icy Cape and Dease Inlet and up to approximately 40 miles from shore.

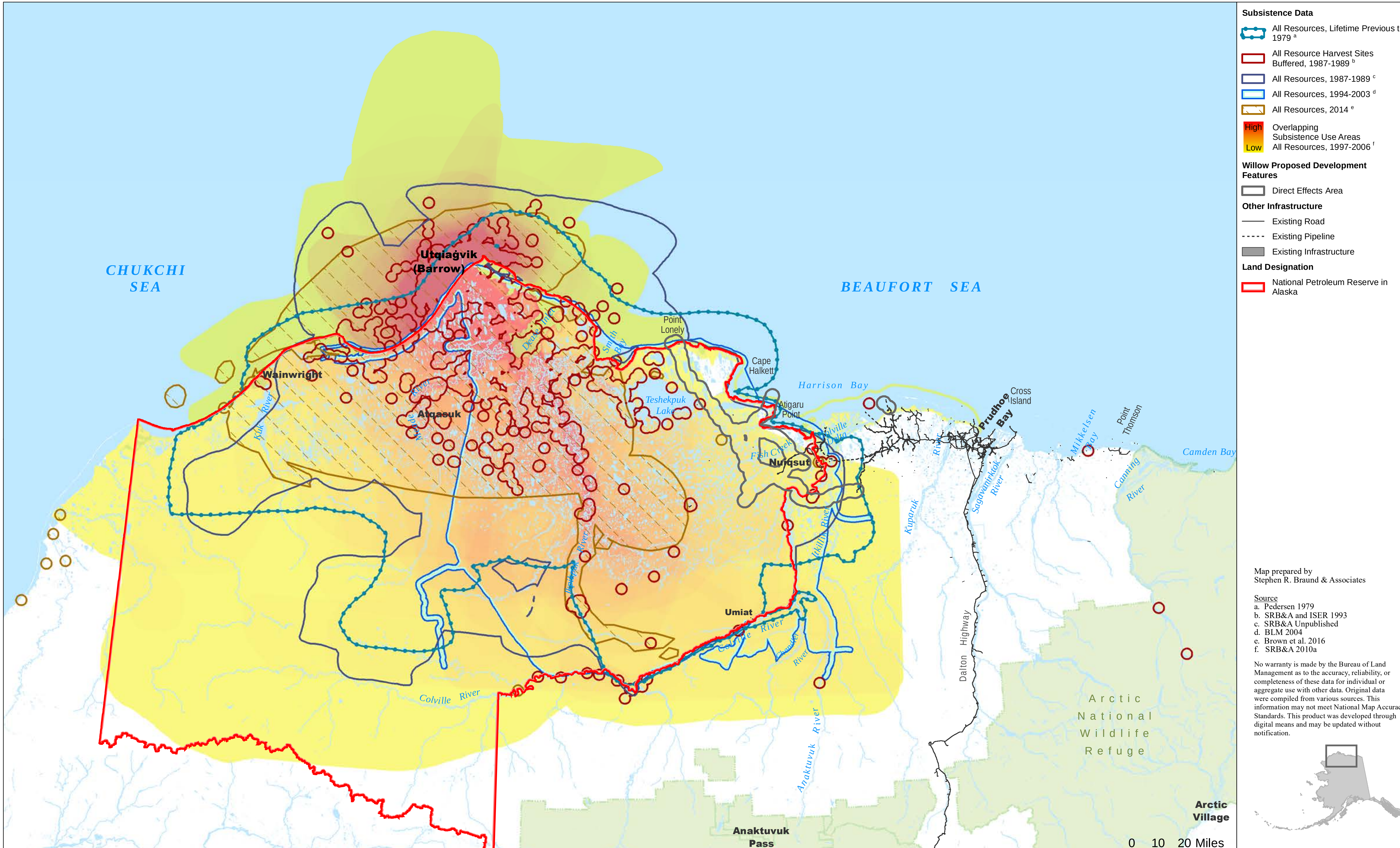
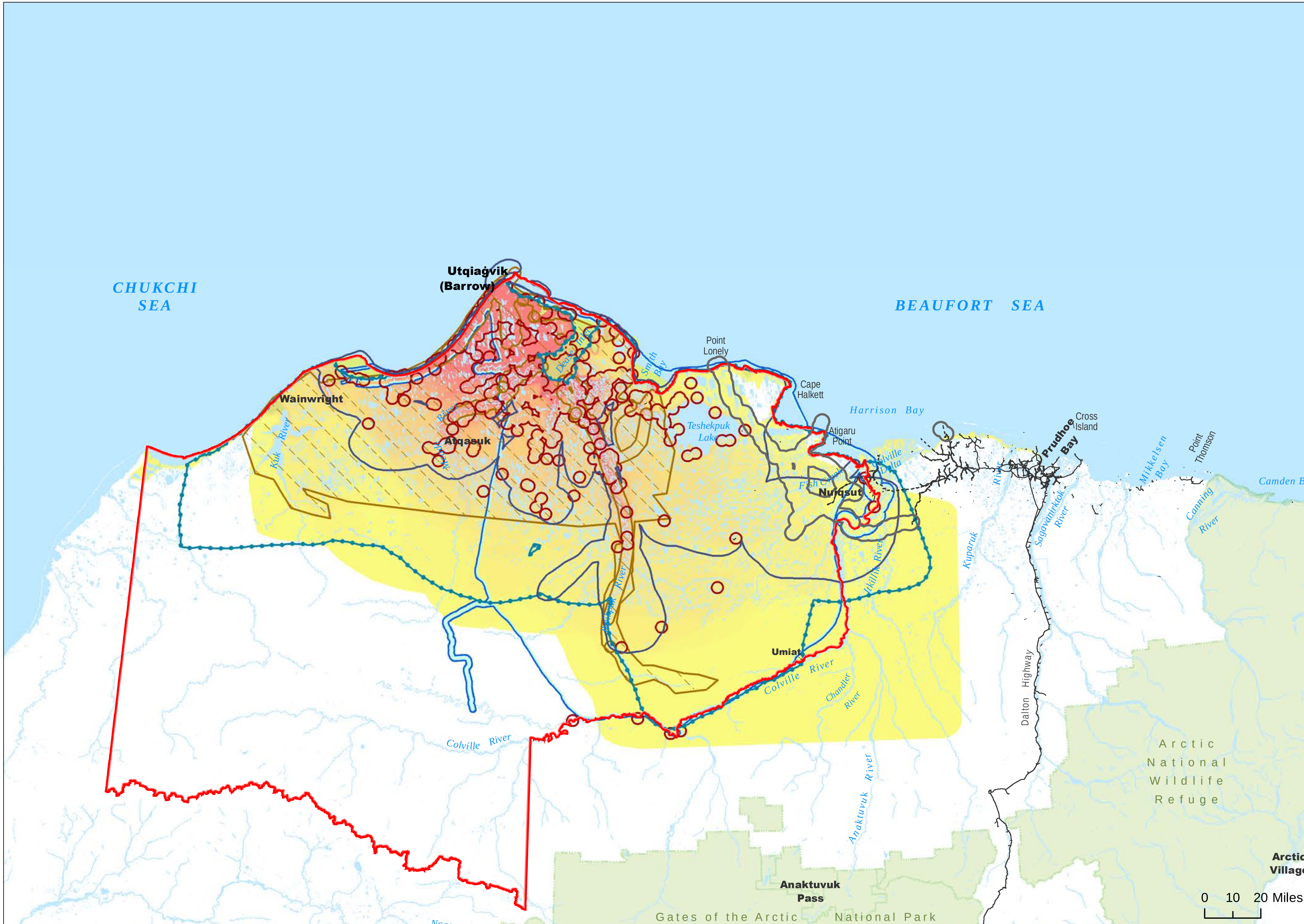


Figure E.16.12



Subsistence Data

- Caribou, Lifetime Prior to 1979 [a]
- Caribou Harvest Sites Buffered, 1987-1989 [b]
- Caribou, 1987-1989 [c]
- Caribou, 1994-2003 [d]
- Caribou, 2014 [e]
- High / Low — Overlapping Subsistence Use Areas Caribou, 1997-2006 [f]

Willow Proposed Development Features

- Direct Effects Area

Other Infrastructure

- Existing Road
- Existing Pipeline
- Existing Infrastructure

Land Designation

- National Petroleum Reserve in Alaska

Map prepared by
Stephen R. Braund & Associates

Source
a. Pedersen 1979
b. SRB&A and ISER 1993
c. SRB&A Unpublished
d. BLM 2004
e. Brown et al. 2016
f. SRB&A 2010a

No warranty is made by the Bureau of Land Management as to the accuracy, reliability, or completeness of these data for individual or aggregate use with other data. Original data were compiled from various sources. This information may not meet National Map Accuracy Standards. This product was developed through digital means and may be updated without notification.

Figure E.16.13

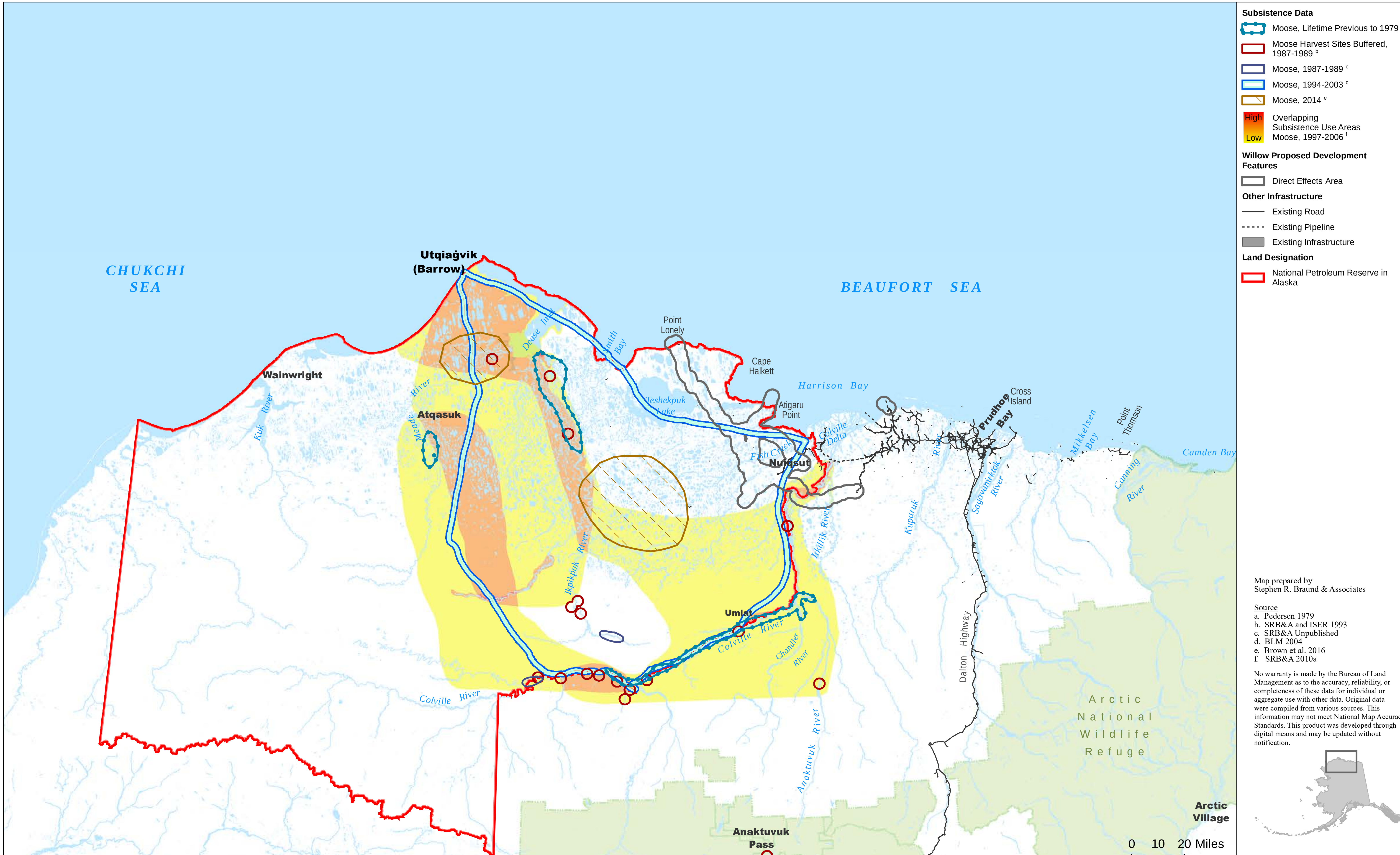
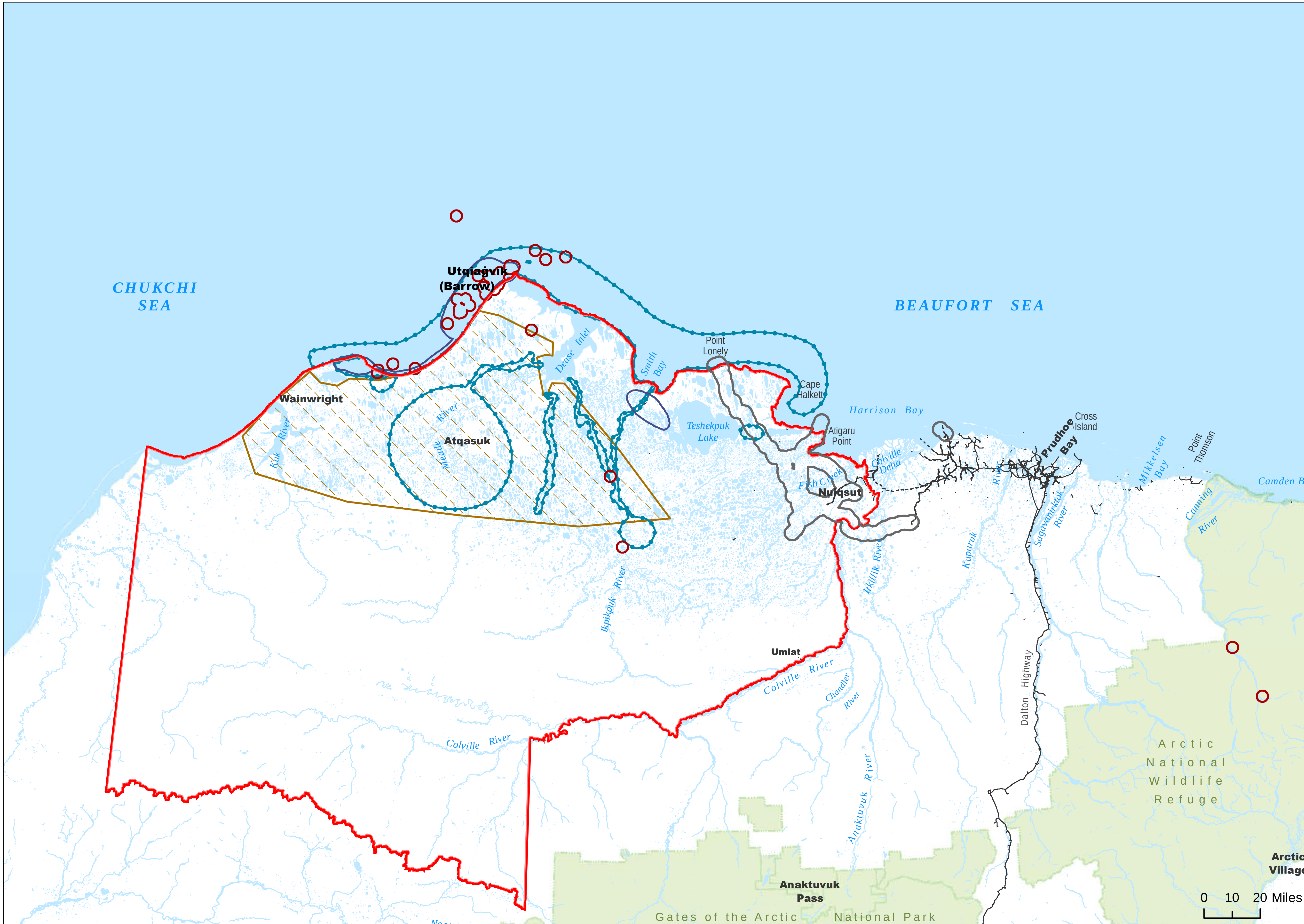


Figure E.16.14



Subsistence Data

- Grizzly Bear and Polar Bear, Lifetime Previous to 1979 [a]
- Brown Bear, Dall Sheep and Polar Bear Harvest Sites Buffered, 1987-1989 [b]
- Brown Bear and Polar Bear, 1987-1989 [c]
- Brown Bear, 2014 [d]

Willow Proposed Development Features

- Direct Effects Area

Other Infrastructure

- Existing Road
- Existing Pipeline
- Existing Infrastructure

Land Designation

- National Petroleum Reserve in Alaska

Map prepared by
Stephen R. Braund & Associates

Source
a. Pedersen 1979
b. SRB&A and ISER 1993
c. SRB&A Unpublished
d. Brown et al. 2016

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Figure E.16.15

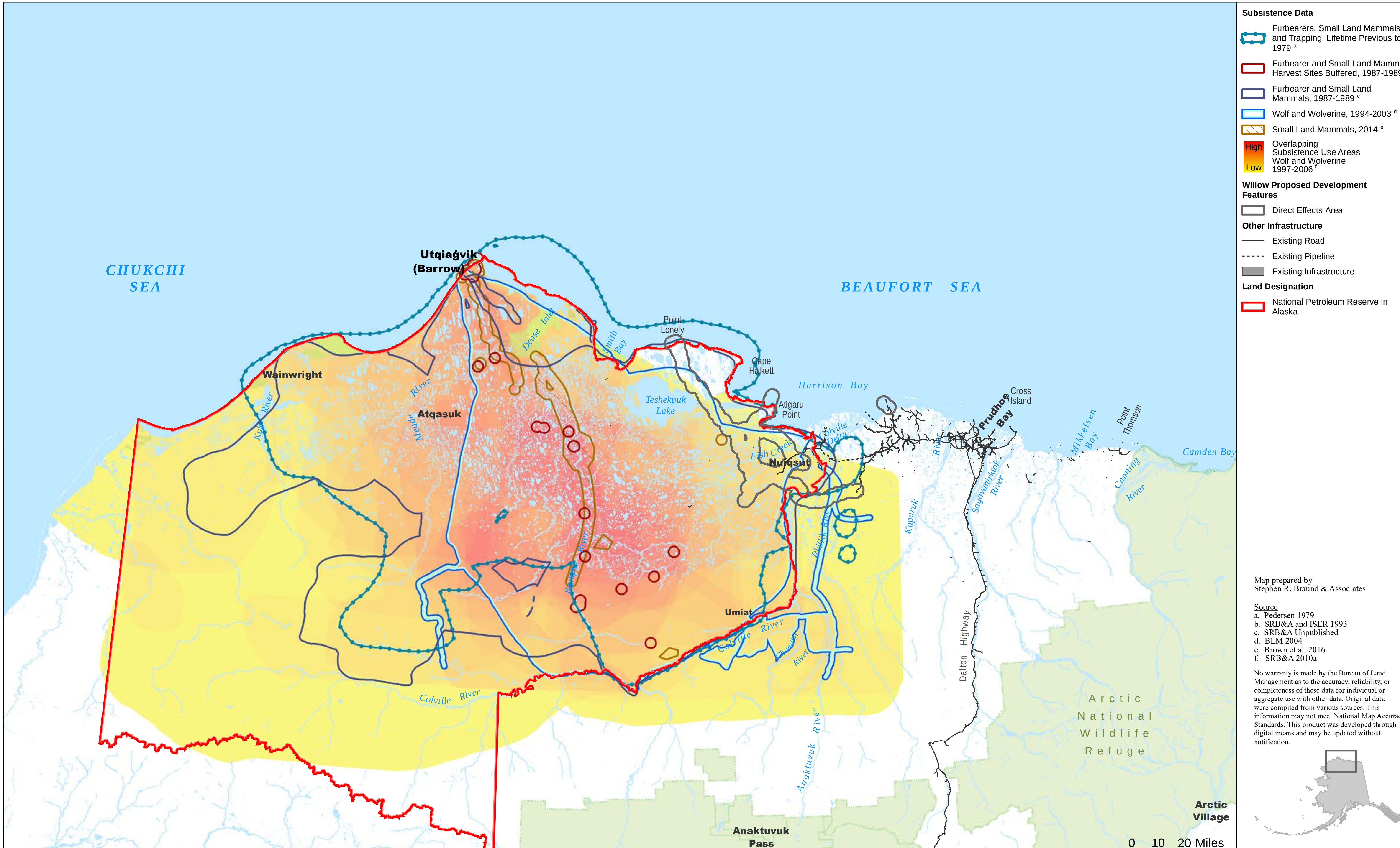


Figure E.16.16

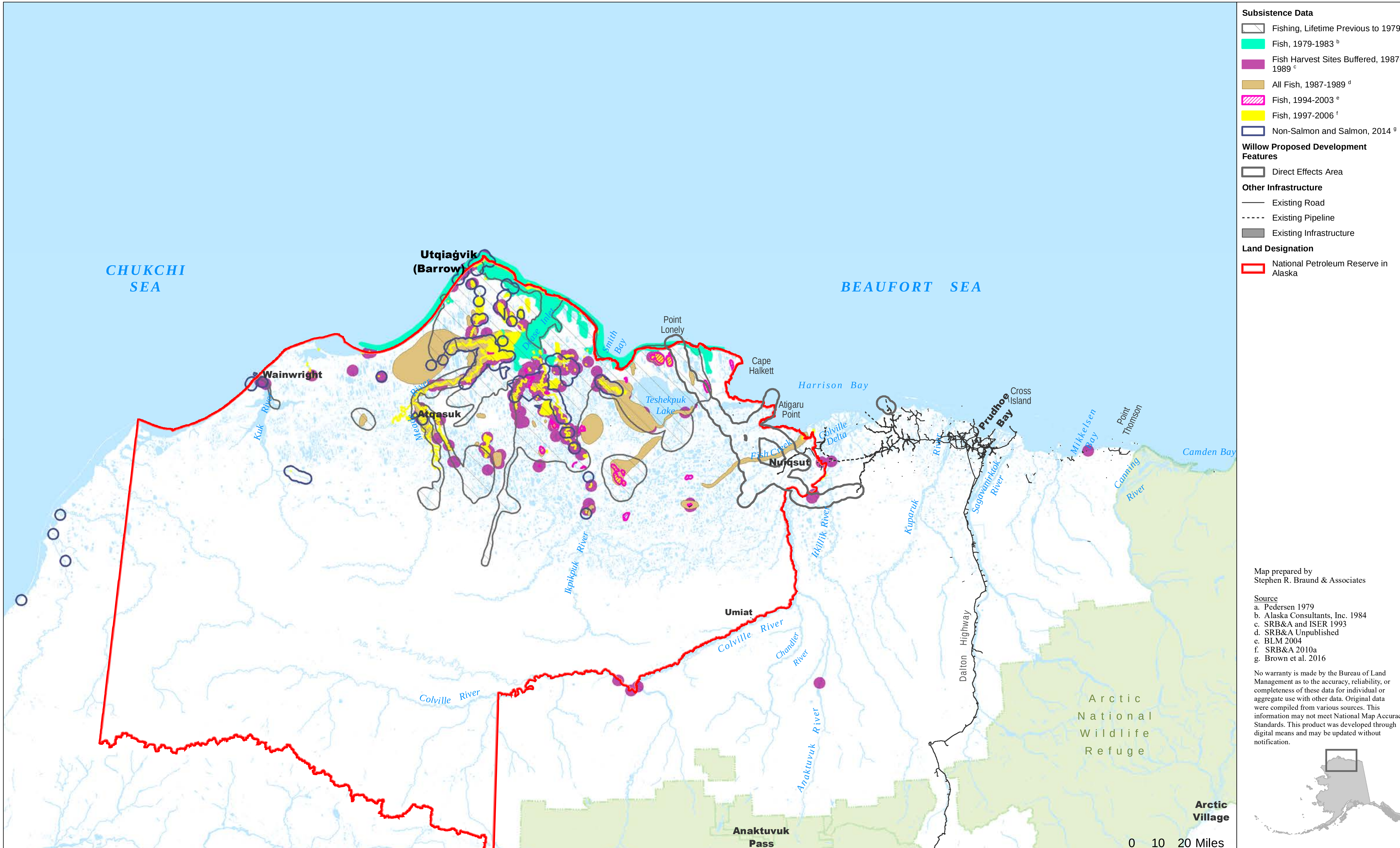


Figure E.16.17

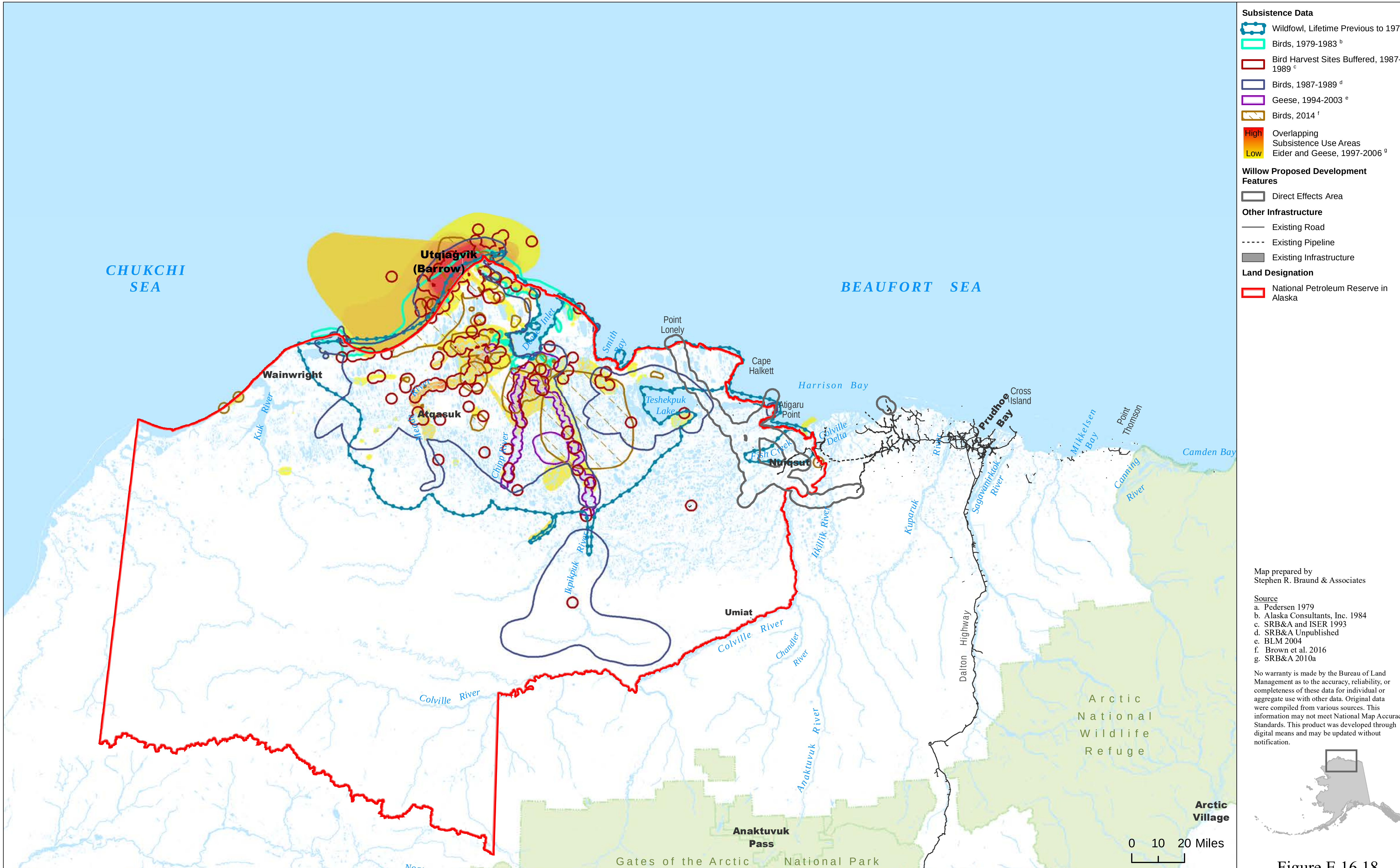


Figure E.16.18

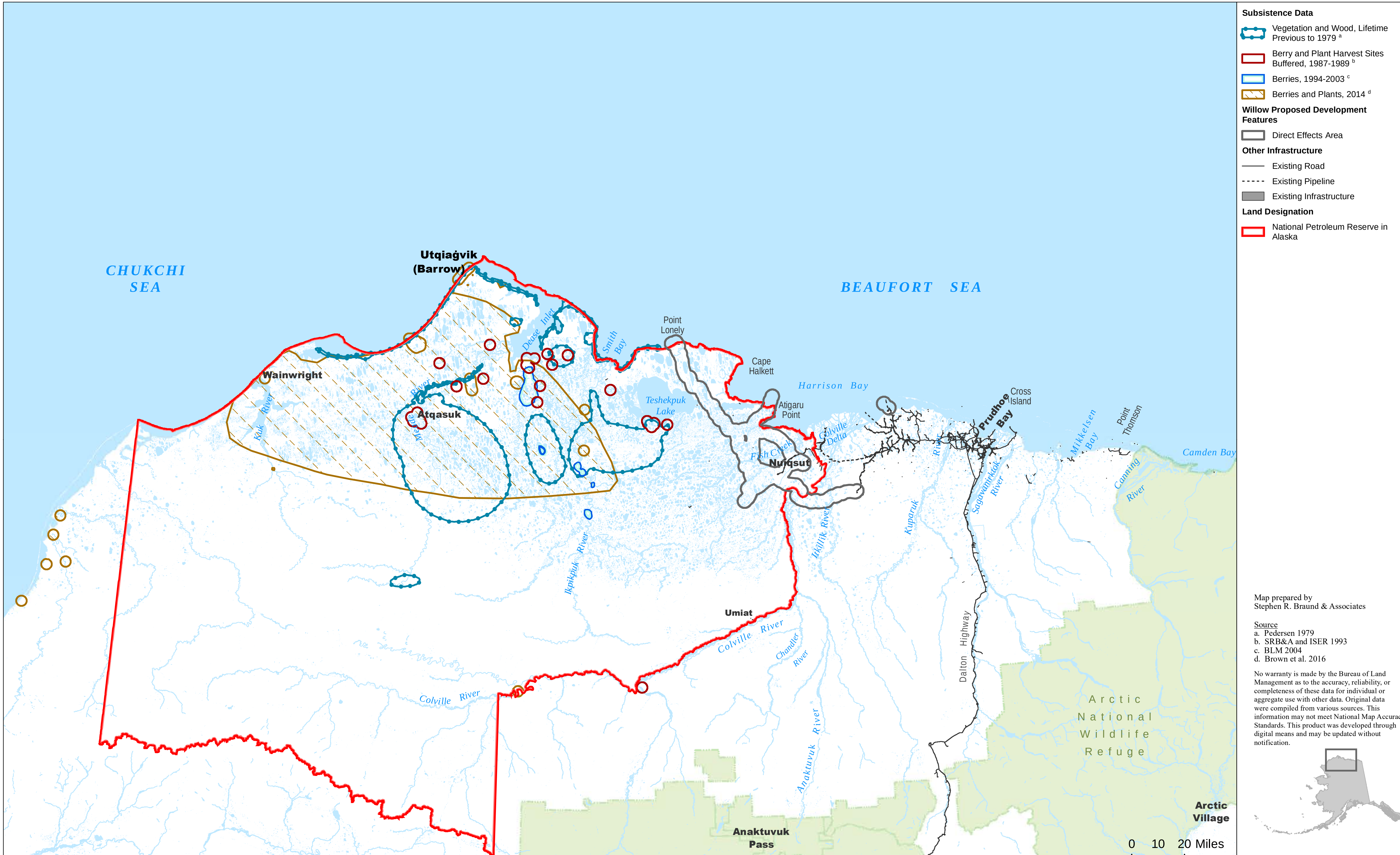
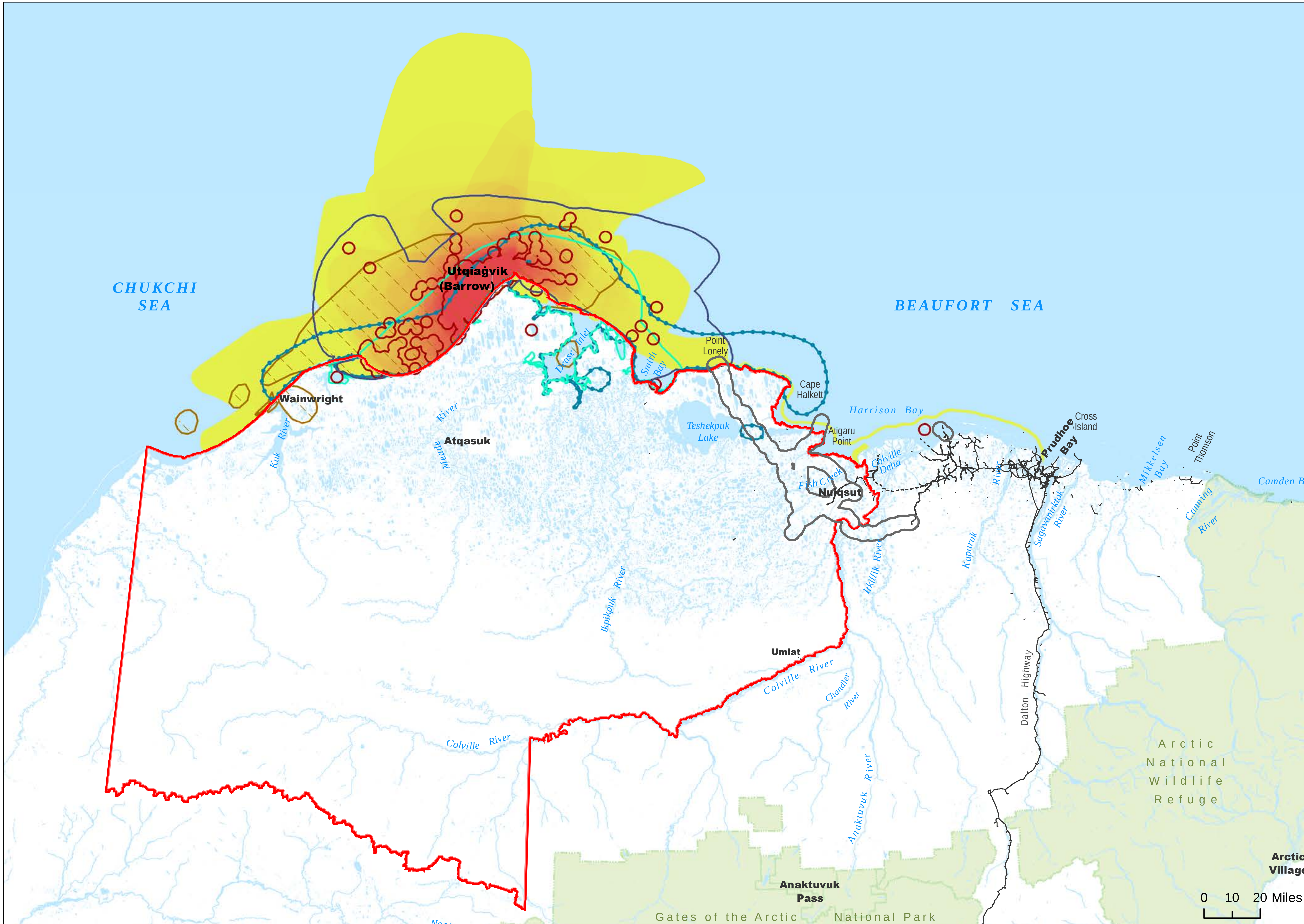


Figure E.16.19



Subsistence Data

- Marine Mammals, Lifetime Previous to 1979 [a]
- Marine Mammals, 1979-1983 [b]
- Marine Mammal Harvest Sites Buffered, 1987-1989 [c]
- Marine Mammals, 1987-1989 [d]
- Marine Mammals, 2014 [e]
- High / Low — Overlapping Subsistence Use Areas Marine Mammals, 1997-2006 [f]

Willow Proposed Development Features

- Direct Effects Area

Other Infrastructure

- Existing Road
- Existing Pipeline
- Existing Infrastructure

Land Designation

- National Petroleum Reserve in Alaska

Map prepared by
Stephen R. Braund & Associates

Source
a. Pedersen 1979
b. Alaska Consultants, Inc. 1984
c. SRB&A and ISER 1993
d. SRB&A Unpublished
e. Brown et al. 2016
f. SRB&A 2010a

No warranty is made by the Bureau of Land Management as to the accuracy, reliability, or completeness of these data for individual or aggregate use with other data. Original data were compiled from various sources. This information may not meet National Map Accuracy Standards. This product was developed through digital means and may be updated without notification.

Figure E.16.20

1.2.2.1.1 Direct Effects Analysis Area

Subsistence use of the direct effects analysis area, defined as the area within 2.5 miles of Project infrastructure, is limited among Utqiaġvik harvesters. For the 1995–2006 time period, use areas overlapping the direct effects analysis area accounted for only 3% of all use areas documented for Utqiaġvik harvesters (Table E.16.10).

Table E.16.10. Utqiaġvik Use Areas within the Direct Effects Analysis Area

Source	Resource Type	Time Period	Total Number of Use Areas	Number (%) of Use Areas in Direct Effects Analysis Area
SRB&A 2010b	All resources	1995–2006	2,029	50 (3%)

In general, the direct effects analysis area is located in the northeastern periphery of Utqiaġvik's extensive subsistence use areas. Resource uses that overlap include caribou, moose, other large land mammals, furbearers and small land mammals, fish, birds, and marine mammals (Figures E.16.12 through E.16.20). Resources that overlap during a majority of study years include caribou, moose, and furbearers and small land mammals. While most resource uses overlap a smaller portion of the direct effects analysis area or overlap areas of low overlapping use, the direct effects analysis area is directly to the east of Teshekpuk Lake, which is an area of high subsistence activity for caribou, furbearers and small land mammals, and fish. In addition, the direct effects analysis area overlaps the Colville River upriver from the community of Nuiqsut, an area used by some Utqiaġvik harvesters for moose hunting during fall.

1.2.2.2 Harvest and Use Data

Tables E.16.11 through E.16.13 provide subsistence harvest data for Utqiaġvik. Intermittent subsistence harvest studies exist for Utqiaġvik harvests from 1987 through 2014, consisting of 10 comprehensive (i.e., all resources) studies (Tables E.16.11 and E.16.13) (Bacon, Hepa et al. 2009; Brown, Braem et al. 2016; Fuller and George 1999; SRB&A and ISER 1993) and three single-resource studies (Table E.16.12) (Naves 2010). Studies show Utqiaġvik households harvesting between 204 and 362 per capita pounds of subsistence resources during available study years. Marine mammals have contributed the highest amount toward the total subsistence harvests in Utqiaġvik (at least 50% of pounds of usable weight), followed by large land mammals (between 20% and 40% of pounds of usable weight). Non-salmon fish and migratory birds provided a smaller, but substantial, portion of the yearly harvest during most years. While bird harvests appear modest in terms of pounds, residents of Utqiaġvik harvest large numbers of both migratory and upland game birds. In 2014, Utqiaġvik residents harvested an estimated 19,049 migratory birds and 911 upland game birds. The single-resource bird harvest study from the mid-to-late 2000s shows varying levels of bird and egg harvests by Utqiaġvik residents from year to year (Table E.16.12).

In terms of species, bowhead whales have been the most harvested resource during all but 2 study years (1987 and 2014), providing between 29.7% and 68.1% of the subsistence harvest (Table E.16.13). Caribou was the second-most harvested resource during all but 2 study years, accounting for between 13.3% and 30.6% of Utqiaġvik harvests. Other species that have contributed highly to Utqiaġvik subsistence harvests over the study years include seal (bearded and ringed), walrus, whitefish (especially broad whitefish), goose, ducks (primarily eiders), polar bear, Arctic grayling, and moose. The most recent comprehensive study year (2014) also showed beluga and salmon (chum and sockeye) among the top 10 species harvested. Although only accounting for a small portion of Utqiaġvik's yearly harvest, vegetation (e.g., berries and plants), marine invertebrates (e.g., clams), and eggs are also harvested annually by Utqiaġvik residents.

Table E.16.11. Utqiaġvik Subsistence Harvest Estimates by Resource Category, All Resources Study Years

Study Year	Resource	Percentage of Households Use	Percentage of Households Try to Harvest	Percentage of Households Harvest	Percentage of Households Give	Percentage of Households Receive	Estimated Harvest Number[a]	Estimated Harvest Total Pounds[b]	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds	Percentage of Total Harvest
1987	All resources	–	–	58	–	–	–	621,067	663	206	100.0
1987	Salmon	–	–	3	–	–	196	1,190	1	< 1	0.2
1987	Non-salmon fish	–	–	–	–	–	45,367	67,262	72	22	10.8
1987	Large land mammals	–	–	–	–	–	1,660	213,777	228	71	34.4
1987	Small land mammals	–	–	–	–	–	233	58	< 1	< 1	< 0.1
1987	Marine mammals	–	–	41	–	–	–	316,229	337	105	50.9
1987	Migratory birds	–	–	–	–	–	8,125	20,618	22	7	3.3
1987	Upland game birds	–	–	16	–	–	2,454	1,717	2	1	0.3
1987	Vegetation	–	–	3	–	–	–	216	< 1	< 1	< 0.1
1988	All resources	–	–	50	–	–	–	614,669	656	204	100.0
1988	Salmon	–	–	1	–	–	80	490	1	< 1	0.1
1988	Non-salmon fish	–	–	14	–	–	38,005	50,571	54	17	8.2
1988	Large land mammals	–	–	27	–	–	1,599	207,005	221	69	33.7
1988	Small land mammals	–	–	–	–	–	152	0	0	0	0.0
1988	Marine mammals	–	–	39	–	–	654	334,069	357	111	54.3
1988	Migratory birds	–	–	34	–	–	7,832	21,419	23	7	3.5
1988	Upland game birds	–	–	9	–	–	1,350	945	1	< 1	0.2
1988	Vegetation	–	–	2	–	–	–	169	< 1	< 1	< 0.1
1989	All resources	–	–	61	–	–	–	872,092	931	289	100.0
1989	Salmon	–	–	10	–	–	2,088	12,244	13	4	1.4
1989	Non-salmon fish	–	–	13	–	–	66,199	106,226	113	35	12.2
1989	Large land mammals	–	–	39	–	–	1,705	214,676	229	71	24.6
1989	Small land mammals	–	–	2	–	–	68	7	< 1	0	< 0.1
1989	Marine mammals	–	–	45	–	–	591	508,181	542	169	58.3
1989	Migratory birds	–	–	37	–	–	12,539	29,215	31	10	3.3
1989	Upland game birds	–	–	5	–	–	329	231	< 1	< 1	< 0.1
1989	Vegetation	–	–	–	–	–	–	1,312	1	< 1	0.2
1992[c]	All resources	–	–	–	–	–	–	1,363,738	–	–	100.0
1992[c]	Salmon	–	–	–	–	–	1,161	8,236	–	–	0.6
1992[c]	Non-salmon fish	–	–	–	–	–	50,596	87,769	–	–	6.4
1992[c]	Large land mammals	–	–	–	–	–	2,033	250,447	–	–	18.4
1992[c]	Small land mammals	–	–	–	–	–	260	35	–	–	< 0.1
1992[c]	Marine mammals	–	–	–	–	–	1,080	991,528	–	–	72.7
1992[c]	Migratory birds	–	37	–	–	–	10,223	22,922	–	–	1.7
1992[c]	Upland game birds	–	–	–	–	–	1,332	933	–	–	0.1

Study Year	Resource	Percentage of Households Use	Percentage of Households Try to Harvest	Percentage of Households Harvest	Percentage of Households Give	Percentage of Households Receive	Estimated Harvest Number[a]	Estimated Harvest Total Pounds[b]	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds	Percentage of Total Harvest
1992[c]	Eggs	–	–	–	–	–	89	13	–	–	< 0.1
1992[c]	Marine invertebrates	–	–	–	–	–	1,774	694	–	–	0.1
1992[c]	Vegetation	–	16	–	–	–	291	1,164	–	–	0.1
1995–1996	All resources	–	–	–	–	–	–	1,194,484	–	–	100.0
1995–1996	Salmon	–	–	–	–	–	301	1,628	–	–	0.1
1995–1996	Non-salmon fish	–	–	–	–	–	29,334	42,778	–	–	3.6
1995–1996	Large land mammals	–	–	–	–	–	2,164	294,236	–	–	24.6
1995–1996	Small land mammals	–	–	–	–	–	220	54	–	–	< 0.1
1995–1996	Marine mammals	–	–	–	–	–	883	789,821	–	–	66.1
1995–1996	Migratory birds	–	–	–	–	–	14,746	61,217	–	–	5.1
1995–1996	Upland game birds	–	–	–	–	–	–	152	–	–	< 0.1
1995–1996	Eggs	–	–	–	–	–	21	3	–	–	< 0.1
1995–1996	Marine invertebrates	–	–	–	–	–	2,208	4,416	–	–	0.4
1995–1996	Vegetation	–	–	–	–	–	27	178	–	–	< 0.1
1996–1997	All resources	–	–	–	–	–	–	1,181,132	–	–	100.0
1996–1997	Salmon	–	–	–	–	–	345	2,063	–	–	0.2
1996–1997	Non-salmon fish	–	–	–	–	–	27,469	44,964	–	–	3.8
1996–1997	Large land mammals	–	–	–	–	–	1,158	157,420	–	–	13.3
1996–1997	Small land mammals	–	–	–	–	–	157	213	–	–	< 0.1
1996–1997	Marine mammals	–	–	–	–	–	486	957,692	–	–	81.1
1996–1997	Migratory birds	–	–	–	–	–	4,472	18,533	–	–	1.6
1996–1997	Upland game birds	–	–	–	–	–	–	224	–	–	< 0.1
1996–1997	Vegetation	–	–	–	–	–	4	23	–	–	< 0.1
2000	All resources	–	–	–	–	–	–	1,285,565	–	–	100.0
2000	Salmon	–	–	–	–	–	2,100	10,247	–	–	0.7
2000	Non-salmon fish	–	–	–	–	–	78,065	114,455	–	–	7.3
2000	Large land mammals	–	–	–	–	–	3,390	460,642	–	–	29.5
2000	Small land mammals	–	–	–	–	–	421	423	–	–	< 0.1
2000	Marine mammals	–	–	–	–	–	1,491	909,927	–	–	58.3
2000	Migratory birds	–	–	–	–	–	15,647	63,826	–	–	4.1
2000	Upland game birds	–	–	–	–	–	–	1,071	–	–	0.1
2000	Eggs	–	–	–	–	–	11	3	–	–	< 0.1
2000	Marine invertebrates	–	–	–	–	–	36	109	–	–	< 0.1
2000	Vegetation	–	–	–	–	–	71	382	–	–	< 0.1
2001	All resources	–	–	–	–	–	–	1,082,241	–	–	100.0
2001	Salmon	–	–	–	–	–	332	1,720	–	–	0.2
2001	Non-salmon fish	–	–	–	–	–	4,453	10,003	–	–	0.9
2001	Large land mammals	–	–	–	–	–	1,840	249,943	–	–	23.1

Study Year	Resource	Percentage of Households Use	Percentage of Households Try to Harvest	Percentage of Households Harvest	Percentage of Households Give	Percentage of Households Receive	Estimated Harvest Number[a]	Estimated Harvest Total Pounds[b]	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds	Percentage of Total Harvest
2001	Small land mammals	–	–	–	–	–	118	0	–	–	0.0
2001	Marine mammals	–	–	–	–	–	777	793,162	–	–	73.3
2001	Migratory birds	–	–	–	–	–	6,390	26,326	–	–	2.4
2001	Upland game birds	–	–	–	–	–	–	1,029	–	–	0.1
2001	Marine invertebrates	–	–	–	–	–	13	36	–	–	< 0.1
2001	Vegetation	–	–	–	–	–	3	22	–	–	< 0.1
2003	All resources	–	–	–	–	–	–	1,245,943	–	–	100.0
2003	Salmon	–	–	–	–	–	4,793	22,617	–	–	1.8
2003	Non-salmon fish	–	–	–	–	–	20,109	36,922	–	–	3.0
2003	Large land mammals	–	–	–	–	–	2,098	285,297	–	–	22.9
2003	Small land mammals	–	–	–	–	–	84	7	–	–	< 0.1
2003	Marine mammals	–	–	–	–	–	1,551	871,568	–	–	70.0
2003	Migratory birds	–	–	–	–	–	8,119	23,349	–	–	1.9
2003	Upland game birds	–	–	–	–	–	443	438	–	–	< 0.1
2003	Eggs	–	–	–	–	–	44	185	–	–	< 0.1
2003	Marine invertebrates	–	–	–	–	–	1,733	5,198	–	–	0.4
2003	Vegetation	–	–	–	–	–	61	362	–	–	< 0.1
2014	All resources	89	57	52	63	87	–		1214	362	100.0
2014	Salmon	69	26	24	26	55	12,087	57,262	36	11	3.0
2014	Non-salmon fish	69	29	27	37	60	106,555	196,049	124	37	10.2
2014	Large land mammals	72	39	33	39	57	4,335	595,004	376	112	30.9
2014	Small land mammals	8	6	5	2	4	1,474	0	0	0	0.0
2014	Marine mammals	71	30	18	45	70	1,792	1,020,943	645	192	53.1
2014	Migratory birds	53	32	29	29	35	19,049	48,271	31	9	2.5
2014	Upland game birds	9	9	8	4	1	911	638	0	0	< 0.1
2014	Eggs	13	7	7	3	7	3,688	1,113	1	0	0.1
2014	Marine invertebrates	7	2	2	2	5	561	1,096	1	0	0.1
2014	Vegetation	43	18	16	15	35	853	2,975	2	1	0.2

Source: 1995–1996, 1996–1997, 2000, 2001, 2003 (Bacon, Hepa et al. 2009); 2014 (Brown, Braem et al. 2016); 1992 (Fuller and George 1999); 1987–1989 (SRB&A and ISER 1993)

Note: "–" (No Data). "All Resources" study years are years where studies addressed all subsistence resources harvested by the community, rather than selected resources or species.

[a] Estimated numbers represent individuals in all cases except vegetation, where they represent gallons. The estimated harvest numbers for the 1995–1996, 1996–1997, 2000, 2001, and 2003 data were derived by summing individual species in each resource category.

[b] Estimated pounds include only edible pounds and therefore do not include estimates for resources that are not typically eaten by community residents (e.g., furbearers). The total pounds for the 1995–1996, 1996–1997, 2000, 2001, and 2003 data were derived from conversion rates found at ADF&G (2018) and total (usable) pounds for bowhead whales were calculated based on the method presented in SRB&A and ISER (1993). These estimates do not account for whale girth and should be considered approximate; more exact methods for estimating total whale weights are available in George et al. (n.d.).

[c] Household participation for the 1992 study year is based on Table A5 in Fuller and George (1999); participation in migratory bird harvests includes waterfowl and eggs. Participation in vegetation harvests includes only berries.

Participation in subsistence activities by Utqiaġvik households is relatively high. Available data show that at least half of Utqiaġvik households successfully harvested subsistence resources during each of the study years (Table E.16.11). An even higher percentage of households used subsistence resources; in 2014, 89% of Utqiaġvik households used subsistence resources. Household participation rates were particularly high in harvests of marine mammals, migratory birds, large land mammals, and non-salmon fish (Table E.16.11). Sharing is an important tool for maintaining social networks and distributing food throughout the community. In 2014, 87% of Utqiaġvik households received subsistence resources and 63% gave subsistence resources away. The most commonly received resources included marine mammals, non-salmon fish, and large land mammals.

Table E.16.12. Utqiaġvik Subsistence Harvest Estimates by Resource Category, Single-Resource Study Years

Study Year	Resource	Percentage of Households Use	Percentage of Households Try to Harvest	Percentage of Households Harvest	Percentage of Households Give	Percentage of Households Receive	Estimated Harvest Number	Estimated Harvest Total Pounds	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds
2005	Birds	–	–	–	–	–	10,943	–	–	–
2007	Birds	–	–	–	–	–	38,152	–	–	–
2008	Birds	–	–	–	–	–	35,250	–	–	–
2005	Eggs	–	–	–	–	–	32	–	–	–
2007	Eggs	–	–	–	–	–	1,783	–	–	–
2008	Eggs	–	–	–	–	–	204	–	–	–

Source: 2005, 2007, 2008 (Naves 2010)
Note: "–" (No Data). Estimated harvest number for birds includes upland game birds and migratory birds combined.

Table E.16.13. Utqiaġvik Subsistence Harvest Estimates by Selected Species, All Study Years

Study Year	Resource[a]	Percentage of Households Use	Percentage of Households Try to Harvest	Percentage of Households Harvest	Percentage of Households Give	Percentage of Households Receive	Estimated Harvest Number[b]	Estimated Harvest Total Pounds[c]	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds	Percentage of Total Harvest
1987	Caribou	–	–	26	–	–	1,595	186,669	199	62	30.1
1987	Bowhead whale	–	–	31	–	–	7	184,629	197	61	29.7
1987	Walrus	–	–	11	–	–	84	64,663	69	21	10.4
1987	Bearded seal	–	–	25	–	–	236	41,518	44	14	6.7
1987	Broad whitefish	–	–	11	–	–	10,579	27,519	29	9	4.4
1987	Moose	–	–	6	–	–	52	25,786	28	9	4.2
1987	Ringed seal	–	–	14	–	–	466	19,574	21	6	3.2
1987	Goose	–	–	20	–	–	2,873	12,740	14	4	2.1
1987	Unknown whitefish	–	–	3	–	–	5,108	10,215	11	3	1.6
1987	Arctic grayling	–	–	14	–	–	12,664	10,131	11	3	1.6
1987	Ducks	–	–	22	–	–	5,252	7,878	8	3	1.3
1987	Least cisco	–	–	–	–	–	–	7,024	8	2	1.1
1988	Bowhead whale	–	–	35	–	–	11	233,313	249	77	38.0
1988	Caribou	–	–	27	–	–	1,533	179,314	191	59	29.2
1988	Walrus	–	–	6	–	–	61	47,215	50	16	7.7
1988	Bearded seal	–	–	11	–	–	179	31,436	34	10	5.1
1988	Broad whitefish	–	–	11	–	–	11,432	29,423	31	10	4.8
1988	Moose	–	–	4	–	–	53	26,367	28	9	4.3
1988	Ringed seal	–	–	10	–	–	388	16,304	17	5	2.7
1988	Goose	–	–	19	–	–	3,334	14,672	16	5	2.4

Study Year	Resource[a]	Percentage of Households Use	Percentage of Households Try to Harvest	Percentage of Households Harvest	Percentage of Households Give	Percentage of Households Receive	Estimated Harvest Number[b]	Estimated Harvest Total Pounds[c]	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds	Percentage of Total Harvest
1988	Least cisco	–	–	2	–	–	–	7,505	8	2	1.2
1988	Arctic grayling	–	–	11	–	–	8,684	6,947	7	2	1.1
1988	Ducks	–	–	20	–	–	4,498	6,747	7	2	1.1
1989	Bowhead whale	–	–	45	–	–	10	377,647	403	125	43.3
1989	Caribou	–	–	39	–	–	1,656	193,744	207	64	22.2
1989	Broad whitefish	–	–	–	–	–	30,047	78,921	84	26	9.0
1989	Walrus	–	–	13	–	–	101	77,987	83	26	8.9
1989	Seal	–	–	11	–	–	440	33,077	35	11	3.8
1989	Moose	–	–	6	–	–	40	20,014	21	7	2.3
1989	Polar bear	–	–	4	–	–	39	19,471	21	6	2.2
1989	Bearded seal	–	–	11	–	–	109	19,152	20	6	2.2
1989	Goose	–	–	13	–	–	3,944	16,289	17	5	1.9
1989	Ringed seal	–	–	11	–	–	328	13,774	15	5	1.6
1989	Ducks	–	–	37	–	–	8,589	12,883	14	4	1.5
1989	Humpback whitefish	–	–	10	–	–	3,648	9,119	10	3	1.0
1992[d]	Bowhead whale	–	–	–	–	–	22	729,952	–	–	53.5
1992[d]	Caribou	–	46	–	–	–	1,993	233,206	–	–	17.1
1992[d]	Walrus	–	26	–	–	–	206	159,236	–	–	11.7
1992[d]	Bearded seal	–	–	–	–	–	463	81,471	–	–	6.0
1992[d]	Broad whitefish	–	–	–	–	–	23,997	59,993	–	–	4.4
1992[d]	Moose	–	–	–	–	–	34	17,115	–	–	1.3
1995–1996	Bowhead whale	–	–	–	–	–	16	525,413	–	–	44.0
1995–1996	Caribou	–	–	–	–	–	2,155	293,094	–	–	24.5
1995–1996	Bearded seal	–	–	–	–	–	431	181,146	–	–	15.2
1995–1996	Walrus	–	–	–	–	–	74	51,520	–	–	4.3
1995–1996	Ducks	–	–	–	–	–	12,118	50,200	–	–	4.2
1995–1996	Ringed seal	–	–	–	–	–	345	25,530	–	–	2.1
1995–1996	Broad whitefish	–	–	–	–	–	5,130	13,337	–	–	1.1
1995–1996	Whitefish	–	–	–	–	–	6,005	12,610	–	–	1.1
1996–1997	Bowhead whale	–	–	–	–	–	28	803,891	–	–	68.1
1996–1997	Caribou	–	–	–	–	–	1,158	157,420	–	–	13.3
1996–1997	Bearded seal	–	–	–	–	–	192	80,766	–	–	6.8
1996–1997	Walrus	–	–	–	–	–	78	54,320	–	–	4.6
1996–1997	Broad whitefish	–	–	–	–	–	6,684	22,726	–	–	1.9
1996–1997	Least cisco	–	–	–	–	–	–	16,519	–	–	1.4
1996–1997	Ringed seal	–	–	–	–	–	180	13,298	–	–	1.1
2000	Bowhead whale	–	–	–	–	–	18	472,651	–	–	30.3
2000	Caribou	–	–	–	–	–	3,359	456,851	–	–	29.3
2000	Bearded seal	–	–	–	–	–	729	306,012	–	–	19.6
2000	Walrus	–	–	–	–	–	115	80,710	–	–	5.2
2000	Broad whitefish	–	–	–	–	–	21,318	72,480	–	–	4.6
2000	Ringed seal	–	–	–	–	–	586	43,334	–	–	2.8
2000	Goose	–	–	–	–	–	7,818	32,564	–	–	2.1
2000	Ducks	–	–	–	–	–	7,827	31,257	–	–	2.0
2001	Bowhead whale	–	–	–	–	–	27	545,558	–	–	50.4
2001	Caribou	–	–	–	–	–	1,820	247,520	–	–	22.9
2001	Bearded seal	–	–	–	–	–	327	137,340	–	–	12.7
2001	Walrus	–	–	–	–	–	123	86,380	–	–	8.0
2001	Ringed seal	–	–	–	–	–	287	21,216	–	–	2.0
2001	Goose	–	–	–	–	–	4,146	17,214	–	–	1.6

Study Year	Resource[a]	Percentage of Households Use	Percentage of Households Try to Harvest	Percentage of Households Harvest	Percentage of Households Give	Percentage of Households Receive	Estimated Harvest Number[b]	Estimated Harvest Total Pounds[c]	Estimated Harvest Average Household Pounds	Estimated Harvest Per Capita Pounds	Percentage of Total Harvest
2003	Bowhead whale	–	–	–	–	–	16	476,693	–	–	38.3
2003	Bearded seal	–	–	–	–	–	776	325,962	–	–	26.2
2003	Caribou	–	–	–	–	–	2,092	284,444	–	–	22.8
2003	Ringed seal	–	–	–	–	–	413	30,525	–	–	2.4
2003	Walrus	–	–	–	–	–	313	29,380	–	–	2.4
2003	Broad whitefish	–	–	–	–	–	8,207	27,905	–	–	2.2
2003	Goose	–	–	–	–	–	3,629	14,369	–	–	1.2
2014	Caribou	70	38	33	38	52	4,323	587,897	371	111	30.6
2014	Bowhead	70	24	12	43	67	18	546,085	345	103	28.4
2014	Bearded seal	44	22	15	27	32	1,070	306,097	193	58	15.9
2014	Broad whitefish	54	22	20	29	40	43,962	140,679	89	26	7.3
2014	Walrus	31	11	4	17	27	135	103,602	65	19	5.4
2014	Goose	46	26	24	22	29	35,642	35,642	23	7	1.9
2014	Ringed seal	19	10	8	11	11	428	24,402	15	5	1.3
2014	Beluga	15	4	0	9	14	25	24,341	15	5	1.3
2014	Chum salmon	24	13	11	10	15	4,039	24,312	15	5	1.3
2014	Sockeye salmon	29	9	9	11	23	4,630	18,667	12	4	1.0

Source: 1995–1996, 1996–1997, 2000, 2001, 2003 (Bacon, Hepa et al. 2009); 1995–1996, 1996–1997, 2000, 2001, 2003 (Brown, Braem et al. 2016); 1992 (Fuller and George 1999); 1987, 1988, 1999 (SRB&A and ISER 1993).
Note: "–" (No Data).
[a] Except in the case of ducks and goose, which are lumped into more general species categories, this table shows individual species unless they are not available for a given study year. For all resources study years (1987, 1988, 1989, 1992, 1995–1996, 1996–1997, 2000, 2001, and 2003), species are listed in descending order by their percentage of the total harvest and are limited to species accounting for at least 1% of the total harvest; for single-resource study years, species are listed in descending order by the total estimated pounds (or total number harvested in the case of salmon study years) and limited to the five top species. Years lacking "percentage of total harvest" data were not comprehensive (i.e., all resources) study years.
[b] Estimated numbers represent individuals in all cases except vegetation, where they represent gallons. The estimated harvest numbers for the 1995–1996, 1996–1997, 2000, 2001, and 2003 data were derived by summing individual species in each resource category.
[c] Estimated pounds include only edible pounds and therefore do not include estimates for resources that are not typically eaten by community residents (e.g., furbearers). The total pounds for the 1995–1996, 1996–1997, 2000, 2001, and 2003 data were derived from conversion rates found at ADF&G (2018), and total (usable) pounds for bowhead whales were calculated based on the method presented in SRB&A and ISER (1993). These estimates do not account for whale girth and should be considered approximate; more exact methods for estimating total whale weights are available in George et al. (n.d.).
[d] Household participation for the 1992 study year based on Table A5 in Fuller and George (1999).

1.2.2.2.1 Direct Effects Analysis Area

Utqiaġvik harvesters primarily use the direct effects analysis area to hunt for wolf, wolverine, moose, and caribou; a small number of Utqiaġvik harvesters have reported using the area for harvests of seal and goose. As shown in Table E.16.13, caribou are among the top species harvested, in terms of edible weight, by the community of Utqiaġvik. During the most recent study year (2014), over one-third (38%) of Utqiaġvik households participated in hunting caribou (the percentage would likely be higher among Native households only). Moose harvests have accounted for up to 4% of the harvest in some years; however, in recent years, these harvests have contributed less than 1% of the harvest. Similar to Nuiqsut, wolf and wolverine hunting is practiced by a smaller proportion of households; 6% of households participated in the harvest of small land mammals in 2014 (Table E.16.11; this percentage was also likely higher among Native households). However, furbearer hunting and associated income and activities are an important component of Iñupiat culture, and Utqiaġvik furbearer harvesters often expend substantial time, money, and effort in their pursuits. Data on harvest amounts specific to the direct effects analysis area are not available for Utqiaġvik.

Based on data from SRB&A (2010b), which collected subsistence use areas for key resources for the 1997–2006 time period, the direct effects analysis area is used by moose hunters (44% of harvesters), wolf and wolverine hunters (29% of harvesters), and caribou hunters (26% of harvesters) (Table E.16.14).

The Colville River drainage is a primary moose hunting area on the North Slope, and some Utqiaġvik residents will travel to the Nuiqsut area by plane or boat to access this harvesting area. A small number of individuals have reported traveling to the direct effects analysis area to harvest bearded seal, ringed seal, and goose (2% of harvesters or less). For resources as a whole, approximately one-quarter (31%) of Utqiaġvik harvesters reported using the direct effects analysis area for subsistence purposes during the 1997–2006 time period (Table E.16.14).

Table E.16.14. Utqiaġvik Harvesters Using the Direct Effects Analysis Area, 1997–2006

Resource Category	Total Number of Respondents for Resource	Number of Respondents in Direct Effects Analysis Area	Percentage of Utqiaġvik Resource Respondents
Wolverine	31	9	29%
Wolf	31	9	29%
Caribou	73	19	26%
Moose	9	4	44%
Bearded seal	63	1	2%
Ringed seal	48	1	2%
Goose	71	1	1%
All resources	**75**	**23**	**31%**

Source: SRB&A 2010b

1.2.2.3 Timing of Subsistence Activities

Table E.16.15 provides data on the timing of Utqiaġvik subsistence activities based on reports from the 1980s through the 2010s. Overall, Utqiaġvik harvesters target the greatest number of resources in August and September. These months are a primary time for harvests of non-salmon fish, salmon, caribou, moose and other large land mammals, marine mammals, and plants and berries.

Table E.16.15. Utqiaġvik Annual Cycle of Subsistence Activities

Resource	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Freshwater non-salmon	L	L	L	L	M	M	H	H	H	H	M	L
Marine non-salmon	L	L	L	–	–	L	M	H	H	M	L	–
Salmon	–	–	–	–	L	L	H	H	M	L	–	–
Caribou	L	L	L	L	L	L	H	H	H	H	L	L
Moose	–	L	L	M	M	M	M	H	H	–	–	–
Bear	–	–	–	L	L	L	L	M	H	L	–	–
Dall sheep	–	–	H	–	–	–	–	L	–	–	–	–
Muskox	–	–	H	–	–	–	–	–	H	–	–	–
Furbearers	H	H	H	M	L	L	–	–	L	M	H	H
Small land mammals	–	L	L	H	H	L	M	L	M	L	L	–
Marine mammals	L	L	L	M	M	M	H	H	H	M	M	L
Upland birds	L	L	L	M	H	M	L	L	L	L	L	L
Waterfowl	L	L	L	M	H	M	L	L	L	L	L	L
Marine invertebrates	–	–	–	–	–	M	L	M	H	L	L	–
Plants and berries	–	–	–	–	L	L	L	H	M	–	–	–
Total number of resource categories by month	**7**	**9**	**11**	**9**	**11**	**13**	**12**	**13**	**14**	**11**	**9**	**6**

Source: (Bacon, Hepa et al. 2009; Braem, Kaleak et al. 2011; Brown, Braem et al. 2016; EDAW Inc., Adams/Russel Consulting et al. 2008; Schneider, Pedersen et al. 1980; SRB&A 2010b; SRB&A and ISER 1993)

Note: "–" (no documented activity and/or harvests); H (high activity and/or harvests); L (limited activity and/or harvests); M (moderate activity and/or harvests).

The spring subsistence season (April and May) in Utqiaġvik is primarily dedicated to hunting bowhead whales, with some additional harvests of other marine mammals, including seals and polar bears. Hunting waterfowl such as eiders and white-fronted goose begins during these spring months (Brown, Braem et al. 2016) and, particularly for eiders, continues into the summer months. Harvests of goose peak in May and eider hunting occurs offshore during the spring whaling season (generally when leads are closed and whaling crews are not actively hunting whales).

The summer months (June–August) are a time of diversified subsistence activity when residents travel into the ocean and along various river systems in pursuit of marine, terrestrial, and riverine resources. A primary focus during the summer and fall months is hunting marine mammals (e.g., bearded and ringed seals, walruses) offshore as they migrate north with the floe ice, with eiders often a secondary target. Residents travel along the coast and inland during the summer months to hunt caribou and harvest a variety of fish in lagoons and rivers. The peak caribou hunting season is in July and August when they are available to hunters traveling by boat along the coast and on local waterways. Residents also harvest berries and other vegetation during these boating trips.

The fall bowhead whale hunt is a major focus during September and October. In addition, caribou, fish, and birds remain sought-after resources throughout fall. During August and September, some Utqiaġvik residents may travel to the Colville River to harvest moose and berries (Brown, Braem et al. 2016; Fuller and George 1999). Bacon et al. (2009) and SRB&A (2010b) also show some eider duck harvesting continuing into these fall months. The subsistence fish harvest generally peaks in October (under-ice fishery) when whitefish and Arctic grayling are concentrated at overwintering areas. The winter months (November–March) are primarily spent hunting and trapping furbearers, in addition to harvesting caribou, ringed seals, upland birds (ptarmigan), the occasional polar bear, and fish.

1.2.2.3.1 Direct Effects Analysis Area

Utqiaġvik harvesters use the direct effects analysis area at varying levels throughout the year (Figure E.16.21). For all resources for the 1997–2006 time period, use of the direct effects analysis area is highest in February and March, with lower levels occurring throughout the rest of the year. Caribou hunting in the direct effects analysis area peaks during February and March and during July and August. Moose hunting occurs solely in August and September. Wolf and wolverine hunters use the direct effects analysis area solely during November through April, with a peak in February and March, when snow conditions allow for extensive overland travel and furs are prime. The limited seal and goose hunting reported by Utqiaġvik harvesters occurs primarily during the spring (April and May for seal; May and June for goose).

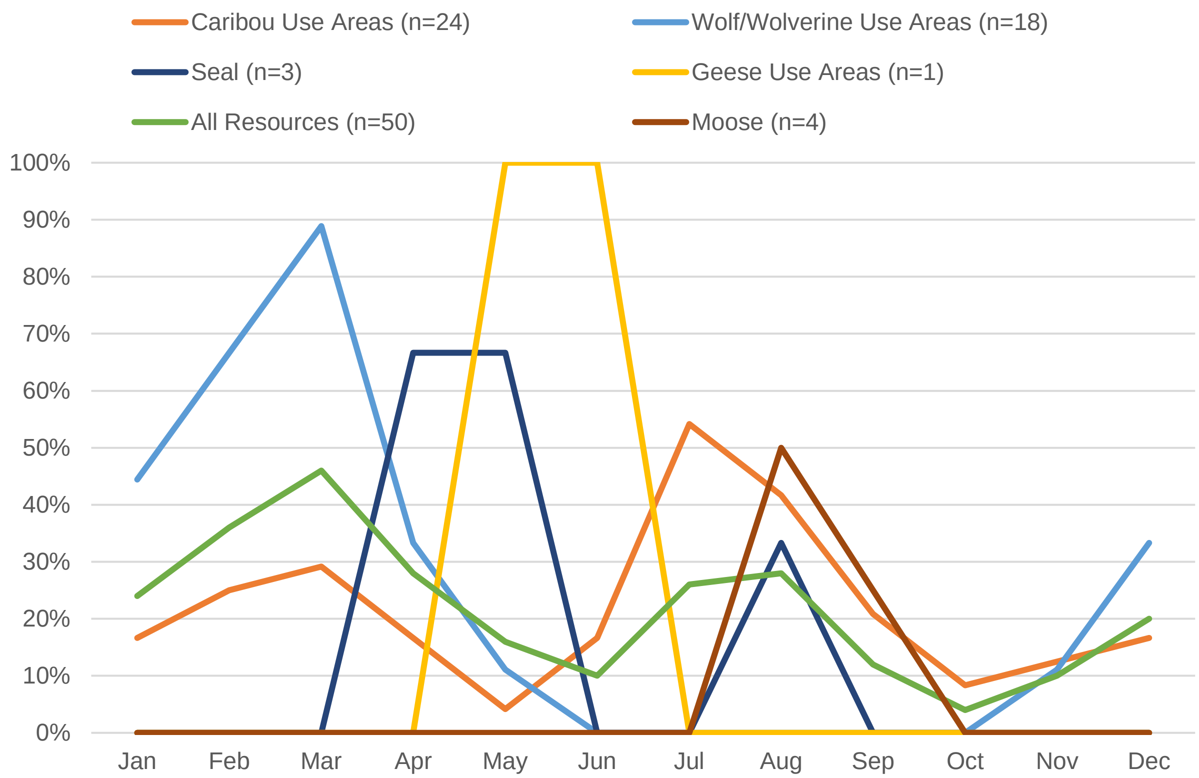


Figure Source: SRB&A (2010b)

Figure E.16.21. Utqiaġvik Subsistence Use Areas by Month in the Direct Effects Analysis Area, by Resource

1.2.2.4 Travel Methods

Table E.16.16 shows the primary travel methods used for key species, as documented in SRB&A (2010b). Boat is the primary method of travel used by Utqiaġvik residents for subsistence pursuits of certain non-salmon fish, caribou, bowhead whale, seals, walrus, and eider. Snow machine is the primary method for late fall and winter pursuits of Arctic cisco, burbot, moose, wolf, wolverine, and goose. To a lesser extent, Utqiaġvik residents also travel by foot, car/truck, ATV, and plane to access subsistence use areas.

Table E.16.16. Utqiaġvik Travel Method to Subsistence Use Areas

Resources	Boat	Snow Machine	Foot	Car/Truck	ATV	Plane
Arctic cisco and burbot	M	H	–	L	L	M
Arctic char/Dolly Varden and broad whitefish	H	M	–	M	M	L
Caribou	H	M	L	L	M	L
Moose	M	H	–	–	–	–
Wolf and wolverine	–	H	–	–	–	–
Bowhead whale	H	M	–	–	–	–
Seals	H	M	–	–	–	–
Walrus	H	L	–	–	–	–
Goose	M	H	L	L	M	L
Eider	H	M	L	M	L	–

Source: 1996–2007 (SRB&A 2010b)
Note: "–" (no documented use of travel method); ATV (all-terrain vehicle); H (high use of travel method); L (limited use of travel method); M (moderate use of travel method).

1.2.2.4.1 Direct Effects Analysis Area

As shown in Figure E.16.22, for the 1997–2006 time period, snow machine was the primary method used to access the direct effects analysis area (60% of use areas), followed by boat (42%). Snow machine/overland travel generally occurs between November and April (Figure E.16.21), whereas coastal and riverine boat travel generally occurs from June through September.

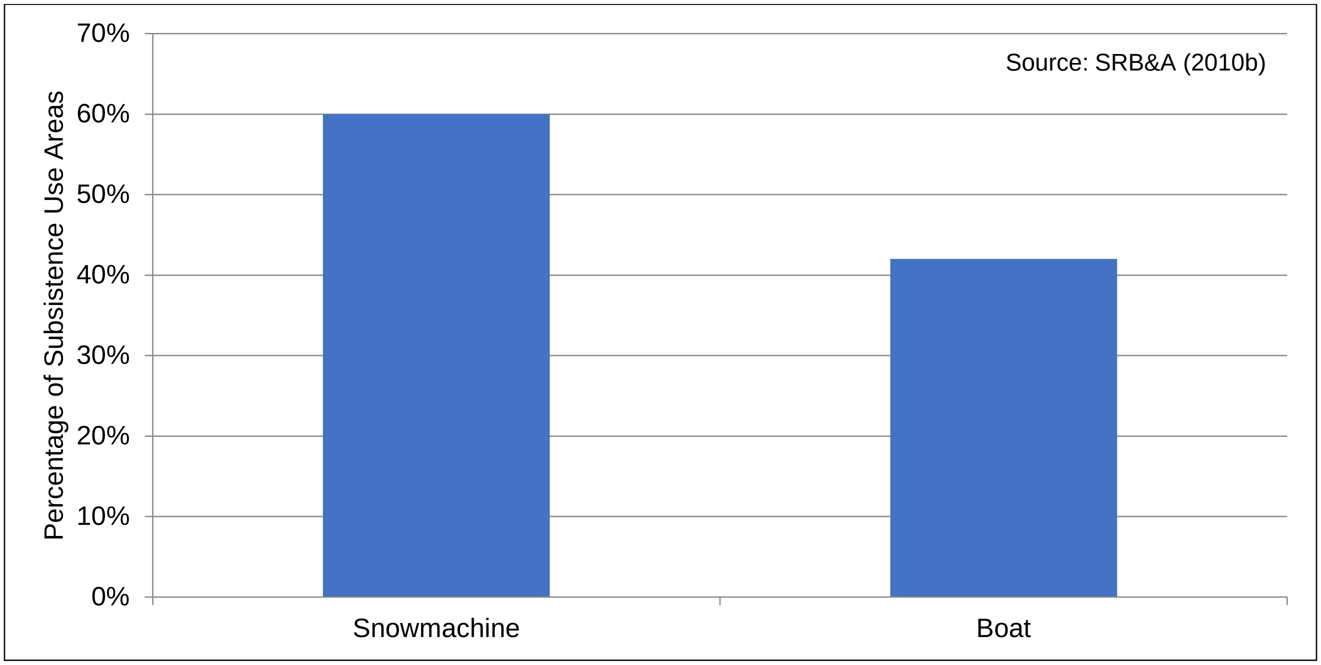


Figure E.16.22. Utqiaġvik Travel Methods, Direct Effects Analysis Area

1.2.2.5 Resource Importance

An analysis of resource importance for Utqiaġvik based on harvest (percentage of total harvest), harvest effort (percentage of households attempting to harvest) and sharing (percentage of households receiving) variables is provided in Table E.16.17. Based on this analysis, resources of major importance in Utqiaġvik are bearded seal, bowhead whale, and caribou.

Table E.16.17. Relative Importance of Subsistence Resources Based on Selected Variables, Utqiaġvik

Resource Importance	Resource[a]	Average Percentage of Total Harvest	Percentage of Households Trying to Harvest	Percentage of Households Receiving
Major resources[b]	Bearded seal	12	22	32
Major resources[b]	Bowhead whale	42	24	67
Major resources[b]	Caribou	24	53	68
Moderate resources[c]	Arctic cisco	< 1	5	33
Moderate resources[c]	Arctic grayling	1	13	17
Moderate resources[c]	Beluga	< 1	4	14
Moderate resources[c]	Blueberry	< 1	4	14
Moderate resources[c]	Broad whitefish	4	22	40
Moderate resources[c]	Chinook/king salmon	< 1	5	12
Moderate resources[c]	Chum/dog salmon	< 1	13	15
Moderate resources[c]	Coho/silver salmon	< 1	9	20
Moderate resources[c]	King eider	< 1	16	14
Moderate resources[c]	Moose	2	2	13
Moderate resources[c]	Pink/humpback salmon	< 1	9	12
Moderate resources[c]	Rainbow smelt	< 1	2	18

Resource Importance	Resource[a]	Average Percentage of Total Harvest	Percentage of Households Trying to Harvest	Percentage of Households Receiving
Moderate resources[c]	Ringed seal	2	10	11
Moderate resources[c]	Salmonberry/Cloudberry	< 1	12	30
Moderate resources[c]	Sockeye salmon	1	9	23
Moderate resources[c]	Walrus	7	19	27
Moderate resources[c]	White-fronted goose	1	23	22
Minor resources[d]	Common eider	< 1	9	9
Minor resources[d]	Halibut	< 1	3	8
Minor resources[d]	Humpback whitefish	< 1	7	5
Minor resources[d]	Least cisco	1	6	7
Minor resources[d]	Other birds	< 1	9	1
Minor resources[d]	Polar bear	1	2	6
Minor resources[d]	Ptarmigan	< 1	9	1
Minor resources[d]	Sheefish	–	–	6
Minor resources[d]	Snow goose	< 1	5	2
Minor resources[d]	Wolf	< 1	< 5	< 5
Minor resources[d]	Wolverine	< 1	< 5	< 5

Source: 1995 to 1996, 1996 to 1997, 2000, 2001, 2003 (Bacon, Hepa et al. 2009); 2014 (Brown, Braem et al. 2016); 1992 (Fuller and George 1999); 1987 to 1989 (SRB&A and ISER 1993)
Note: "–" (resource was not harvested or no households attempted to harvest the resource).
[a] For space considerations, resources that contributed an average of less than 1% of the harvest, less than 5% attempting to harvest, and less than 5% receiving resources are categorized as minor and are not shown.
[b] Major resources contribute > 9% of the total harvest, have ≥ 50% of households attempting to harvest, or have ≥ 50% of households receiving resources.
[c] Moderate resources contribute 2% to 9% of the total harvest, have 11% to 49% of households attempting to harvest, or have 11% to 49% of households receiving resources.
[d] Minor resources contribute < 2% of the total harvest, have ≤ 10% of households attempting to harvest, or have ≤ 10% of households receiving resources. For space considerations, resources contributing an average of less than 1% of the harvest, less than 5% attempting to harvest, and less than 5% receiving resources are categorized as minor and are not shown. While wolf and wolverine fall below the threshold for inclusion (less than 1% of material importance and less than 5% of cultural importance), they are included because of their relevance to the analysis area.

2.0 COMPARISON OF ACTION ALTERNATIVES AND OPTIONS

Tables E.16.18 and E.16.19 summarize and compare impacts to subsistence use areas among the action alternatives and module delivery options.

Table E.16.18. Comparison of Impacts to Subsistence Uses for Nuiqsut

Effects To	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
Resources (importance)	Caribou (major) Furbearers (minor)[a] Waterfowl (major) Fish (major)	Same as Alternative B	Same as Alternative B	Caribou (major) Furbearers (minor)[a] Waterfowl (major) Seals (major)	Caribou (major) Furbearers (minor)[a] Waterfowl (major)	Caribou (major) Furbearers (minor) Waterfowl (major)
Resource abundance	No impacts to overall abundance expected	Same as Alternative B	Same as Alternative B	No impacts to overall abundance expected	Same as Option 1	Same as Option 1
Resource availability	Caribou: Greatest potential for impacts to resource availability Furbearers: High likelihood of reduced furbearer availability near the Project Waterfowl, fish: Low likelihood as Project does not overlap with areas of high overlapping subsistence use and large-scale contamination events are unlikely	Caribou: Impacts to caribou resource availability reduced from Alternative B. Increase in air traffic impacts would be offset by decreased infrastructure and potential for deflection. Furbearers, waterfowl, fish: Same as Alternative B	Caribou: Least potential for impacts to resource availability. Increase in air traffic impacts would be offset by decreased infrastructure and potential for deflection. Furbearers, waterfowl, fish: Same as Alternative B	Caribou: Impacts are minimal due to the winter timing of activities Furbearers: High likelihood of reduced availability near ice roads Waterfowl: Moderate likelihood of reduced availability during one spring hunting season Seals: Moderate likelihood of reduced availability to individual hunters during multiple summers	Caribou: Impacts are minimal due to the winter timing of activities Furbearers: High likelihood of reduced furbearer availability near ice roads Waterfowl: Moderate likelihood of reduced waterfowl during one spring hunting season	Caribou: Impacts are minimal due to the winter timing of activities Furbearers: Moderate likelihood of reduced furbearer availability near ice roads during two hunting seasons Waterfowl: Low likelihood of reduced availability during two spring hunting seasons

Effects To	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
Harvester access	High likelihood of impacts during the construction phase due to the lack of ice road access on gravel haul ice roads near the community and barriers to overland travel due to high traffic levels Moderate likelihood of impacts during operation due to physical obstructions and safety considerations while hunting along roads Moderate likelihood of increased access although the use of roads may decrease with distance from the community	Same as Alternative B	High likelihood of impacts during the construction phase due to the lack of ice road access on gravel haul ice roads near the community and barriers to overland travel due to high traffic levels Lower likelihood of impacts to access during operation due to fewer physical obstructions to access. Impacts related to safety considerations would remain Low likelihood of increased access although the use of roads may decrease with distance from the community	Caribou, furbearers, waterfowl: High likelihood of impacts during the construction phase due to the lack of ice road access on gravel haul and module transport ice roads near the community and barriers to overland travel due to high traffic levels Seals: Low to moderate likelihood of impacts as the module transfer island is on the periphery of the hunting area General: Low likelihood of changes to access in nearshore/coastal areas due to erosion/sedimentation	Caribou, furbearers, waterfowl: High likelihood of impacts during the construction phase due to the lack of ice road access on gravel haul ice roads near the community and barriers to overland travel due to high traffic levels	Caribou, furbearers: Moderate likelihood of impacts during the construction phase due to the periodic lack of ice road access on module transport ice roads in high-use winter hunting areas and potential barriers to overland travel
Community-level impacts	Impacts are most likely to occur for Nuiqsut Harvesters (up to 91% directly affected)	Same as Alternative B	Same as Alternative B	Impacts are most likely to occur for Nuiqsut Harvesters (up to 94% directly affected)	Impacts are most likely to occur for Nuiqsut Harvesters (up to 94% directly affected)	Impacts are most likely to occur for Nuiqsut Harvesters (up to 91% directly affected)

[a] Despite being characterized as a resource of minor importance based on selected measures, furbearer hunting and trapping is a specialized activity with unique importance to Nuiqsut and Utqiaġvik.

Table E.16.19. Comparison of Impacts to Subsistence Uses for Utqiaġvik

Effects To	Alternative B: Proponent's Project	Alternative C: Disconnected Infield Roads	Alternative D: Disconnected Access	Option 1: Atigaru Point Module Transfer Island	Option 2: Point Lonely Module Transfer Island	Option 3: Colville River Crossing
Resources (importance)	Caribou (major) Furbearers (minor)[a]	Same as Alternative B	Same as Alternative B	Caribou (major) Furbearers (minor)[a]	Same as Option 1	Same as Option 1
Resource abundance	No impacts to overall abundance expected	Same as Alternative B	Same as Alternative B	No impacts to overall abundance expected	Same as Option 1	Same as Option 1
Resource availability	Caribou: Low potential for impacts to resource availability Furbearers: Low to moderate likelihood of reduced availability as the Project does not overlap with areas of high overlapping subsistence use but occurs to the east of moderate overlapping use	Same as Alternative B	Same as Alternative B	Caribou: Low potential for impacts to resource availability Furbearers: Low to moderate likelihood of reduced availability as the Project does not overlap with areas of high overlapping subsistence use but occurs to the east of moderate overlapping use	Furbearers and caribou: Low to moderate likelihood of reduced availability as high-volume ice roads would occur directly to the east of high overlapping use to the south of Teshekpuk Lake	Caribou and furbearers: Low potential for impacts to resource availability due to the location of the ice road in the periphery of community use areas
Harvester access	Low likelihood of reduced access as the Project does not overlap with areas of high overlapping subsistence use Low likelihood of increased access	Same as Alternative B	Same as Alternative B	Low likelihood of reduced access as the Project does not overlap with areas of high overlapping subsistence use	Same as Option 1	Same as Option 1
Community-level impacts	Impacts may occur for Utqiaġvik but are less likely (up to 12% directly affected)	Same as Alternative B	Same as Alternative B	Impacts may occur for Utqiaġvik but are less likely (up to 11% directly affected)	Impacts are more likely to occur for Utqiaġvik harvesters under Option 2 (up to 23% of harvesters) compared to Option 1 (up to 11% of harvesters). In addition, the Point Lonely option is more likely to cause indirect impacts to Utqiaġvik harvesters than Option 1 because of its proximity to key Utqiaġvik harvesting areas at Teshekpuk Lake	Impacts could affect a higher percentage of Utqiaġvik harvesters under Option 3 (15% of harvesters) compared to Option 1 (11% of harvesters) but would be less likely because of the greater distance of the ice road infrastructure from the community

[a] Despite being characterized as a resource of minor importance based on selected measures, furbearer hunting and trapping is a specialized activity with unique importance to Nuiqsut and Utqiaġvik.

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