PRE-APPLICATION DOCUMENT

NUYAKUK RIVER HYDROELECTRIC PROJECT
FERC NO. 14873

Submitted by:

Nushagak Cooperative

Nushagak Electric & Telephone Cooperative, Inc.
P.O. Box 350
Dillingham, AK 99576

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ACRONYMS AND ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AFFI	Alaska Freshwater Fish Index
AKEPIC	Alaska Exotic Plants Information Clearinghouse
AKNHP	Alaska Natural Heritage Program
ANSCA	Alaska Native Claims Settlement Act
APE	Area of Potential Effects
AWC	Anadromous Waters Catalog
BBNA	Bristol Bay Native Association
BLM	Bureau of Land Management
CEII	Critical Energy Infrastructure Information
cfs	cubic feet per second
Commission	Federal Energy Regulatory Commission
CWA	Clean Water Act
EFH	essential fish habitat
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
HPMP	Historic Properties Management Plan
ILP	Integrated Licensing Process
ISR	Initial Study Report
kW	kilowatt
MCH	Mulchatna Herd
mg/L	milligrams per liter
MOA	Memorandum of Agreement
msl	mean sea level
MW	megawatt
NAVD 88	North American Vertical Datum of 1988
NHPA	National Historic Preservation Act

NMWC	Nushagak-Mulchatna Watershed Council
NOI	Notice of Intent
NPS	National Park Service
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
PA	Programmatic Agreement
PAD	Pre-Application Document
PLP	Preliminary Licensing Proposal
ppt	part per thousand
Project	Nuyakuk River Hydroelectric Project (P-14873)
psig	pounds per square inch, gage
PSP	Proposed Study Plan
SD	Scoping Document
SHPO	State Historic Preservation Office
TCP	Traditional Cultural Properties
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USR	Updated Study Report

1.0 INTRODUCTION

Nushagak Electric & Telephone Cooperative, Inc. (Cooperative) is filing with the Federal Energy Regulatory Commission (FERC) a Notice of Intent (NOI) and Pre-Application Document (PAD) to license the proposed Nuyakuk River Hydroelectric Project (Project), FERC No. 14873. The Project would be located in southwest Alaska on the Nuyakuk River approximately 60 miles north of Dillingham, AK (pop. 2,364) near Tikchik Lake in the watershed that drains the eastern side of the Wood River Mountains. The Project site is inside the current Wood-Tikchik State Park boundary by approximately 4 miles. From the Project site, the Nuyakuk River runs approximately 40 miles before converging with the Nushagak River, which continues to Bristol Bay.

The Cooperative filed a Preliminary Permit Application on March 22, 2018. On June 11, 2018, FERC issued a preliminary permit for the Project effective June 1, 2018 with an expiration date of June 1, 2021. The filing of this NOI and PAD commences the formal licensing process for the proposed Project. This PAD summarizes existing information on natural resources in the proposed Project vicinity and describes preliminary and conceptual Project design and engineering. The PAD documents early consultation efforts to gather existing information and input on the Project. In developing this PAD, the applicants contacted the organizations and individuals listed in Table 1-1 below. Finally, this PAD describes a proposed environmental study program to determine potential Project impacts.

Table 1-1. Cooperative Meetings and Presentations Related to the Nuyakuk River Hydroelectric Project.

Date	Organization/Individual
10/18/2017	P Andrew, B Edgmon Nushagak Board President / Alaska speaker of the House
10/26/2017	Andrew T.Mack, H Hanson / ADNR
11/4/2017	Nush Board
11/6/2017	J Chylook, R Nelson / Community Leaders
11/7/2017	J Liboff, R Samuelson / Community Leaders
11/9/2017	New Stuyahok City/Tribe
11/9/2017	Andy Lehman / Cooperative Lawyer
12/5/2017	BBEDC Land Committee
12/6/2017	BB Heritage Land Trust
12/12/2017	CFC
12/12/2017	RUS
12/12/2017	Senator Murkowski
12/13/2017	Governor's DC Office
12/13/2017	Congressman Young
12/13/2017	Senator Sullivan
12/18/2017	Bouker/Sands/Dunaway Community Leaders
12/28/2017	Eskelin/Park Service Megli/Fish & Game
1/4/2018	Peter Crimp
1/9/2018	Aleknagik City Council
1/12/2018	BBNA
1/16/2018	Koliganek

Date	Organization/Individual
1/16/2018	Curyung Tribal
1/18/2018	Alaska Power Association Executive Director and Staff
1/19/2018	Chioggiung Board
1/22/2018	Chris Rose/REAP
1/26/2018	AIDEA/AEA
1/29/2018	Commissioner Mack/Ed King / Alaska DNR
1/29/2018	Governor Walker/John Hosey
1/30/2018	OMB Pat Pitney
1/30/2018	Speaker Edgmon/Tim Clark
1/30/2018	Sen Hoffman
1/30/2018	Fish & Game Com. Cotton/Dave Rodgers/Tom Burkover
2/7/2018	BBNA RD, Kris Andrew/Jayne Bennett/Patty
2/9/2018	Cameron Poindexter Choggiung
2/13/2018	NEA/BBTC
2/22/2018	Jesse Logan SOA OMB
2/27/2018	SWIM meeting Bristol Bay Campus
2/28/2018	SWAMC Energy Conference
2/28/2018	Quintillion
2/28/2018	Rodney Peach RUS GFR
3/1/2018	ADF&G
3/1/2018	SOA Parks Dept
3/2/2018	SWAMC General Conference
3/2/2018	BBRSDA
3/2/2018	Bob Shavelson/Louie Flora Cook Inlet Keeper
3/6/18	Levelock Tribal Council/Levelock Electric Cooperative Board
3/8/18	Dillingham City Council
3/14/18	Jesse Logan SOA OMB
3/21/18	BBNA CEDS Steering Committee
3/22/18	BBNA Board
3/27/18	BBEDC/Congressman Young
3/27/18	NETC Annual Membership Meeting
3/30/18	Ethan Tyler SOA Parks Director
3/30/18	WTSP Management Council
4/11/18	Aleknagik Tribal/City Joint meeting
4/26/18	Governor’s DC Office
4/26/18	Congressman Young
4/26/18	Senator Murkowski
4/26/18	Senator Sullivan
4/26/18	FERC DC
5/24/18	Choigguing Tribal
6/8/18	Choigguing Limited Land Committee
9/10/18	Voith Hydro Ketchikan
9/20/18	Small Business Administration/BBEDC
9/28/18	Training W/O Walls conference/BBNA
11/19/18	Pacific Seafood Processors Association
11/19/18	University of Washington Fisheries Research Institute

Date	Organization/Individual
1/23/19	CEDS Steering Committee/BBNA
2/11/19	Ben Stevens Governor’s Policy Advisor
2/11/19	Senator Lyman Hoffman
2/12/19	DNR/Commissioner Feige
2/12/19	DNR/Water Reservation
2/12/19	Speaker Edgmon
3/18/19	HB 99 House Fisheries Committee
4/4/19	Congressman Don Young and staff
4/4/19	Kip Knudson Governor’s DC office
4/4/19	Senator Lisa Murkowski and staff
4/5/19	RUS Chris McLean
4/5/19	Senator Sullivan and staff
4/22/19	SB 91 Senate Resources
5/6/19	SB 91 Senate Finance
5/8/19	HB 99 House Resources
5/26/19	WTSP Management Council
6/25/19	Senator Reinbold site visit
6/26/19	Director Gease (Parks) site visit

The proposed Project is a new 10 megawatt (MW) conventional hydropower project consisting of an intake structure, power conduit, powerhouse forebay, powerhouse, and tailrace channel approximately 4 miles downstream of the Tikchik Lake outlet above a natural falls on the Nuyakuk River. Power from the Project would be available to the customers of the Cooperative and potentially other areas in the region. The renewable power provided by the Project would represent a significant improvement in the current distribution system and minimize the reliance of local communities on fossil fuels as their primary source of electricity. Currently, the population that would be served by this Project relies wholly on diesel generation, which is barged upstream through the Nushagak River drainage to requisite locations. The reduction (or elimination) of water transport of fuels will reduce the potential for negative environmental impacts due to spills. The primary industry in the Project service area is related to commercial harvesting and processing of salmon. The long-term demand for more reliable, efficient, and cost-effective power along with the likely limited resource impacts makes this Project a highly viable opportunity.

The information contained in this document was assembled based on the requirements set forth in 18 CFR §5.6(c) and (d) and is organized as follows:

- Section 2—Process plan and schedule for all pre-application activities, 18 CFR §5.6(d)(1).
- Section 3—General description of the project location, facilities, and operations, 18 CFR §5.6(d)(2).
- Section 4—Description of the existing environment and resource impacts, 18 CFR §5.6(d)(3).

- Section 5—Preliminary resource issues and potential studies or information gathering needs associated with the issues, 18 CFR §5.6(d)(4).
- Section 6—Literature and information sources cited in the descriptions and summaries of existing resource data, 18 CFR §5.6(c)(2).
- Appendices:
  - Appendix A—FERC Form 587
  - Appendix B— Flow Duration Curves

2.0 PROCESS PLAN AND SCHEDULE (18 CFR §5.6 (D)(1))

2.1 Integrated Licensing Process

The Cooperative intends to use FERC's default Integrated Licensing Process (ILP) to develop a Project license. The ILP provides a predictable, efficient, and timely licensing process with early identification and resolution of necessary studies. Table 2-1 presents a detailed process plan and schedule with an estimated timetable for the remainder of this licensing process, based on the use of the ILP for this Project.

2.2 Authorized Agent

The exact name, business address, and telephone number of each person authorized to act as agent for the applicant:

Bobby Armstrong
Nushagak Electric & Telephone Cooperative, Inc.
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Table 2-1. Proposed Nuyakuk River Hydroelectric Project Process Plan and Schedule.

Pre-Filing Milestone	Responsible Party	Date and Location (if applicable) [Required FERC ILP Timeframe]
File NOI and PAD with FERC and distribute (via email) to appropriate Federal, state, and interstate resource agencies, Indian tribes, local governments and members of the public likely to be interested in the proceeding	Cooperative	September 30, 2019
Initial Tribal Consultation Meeting	Cooperative	October 30, 2019 [30 days after NOI/PAD submitted]
Early Agency/Stakeholder Meeting	Cooperative (not required under ILP)	November 18-19, 2019, Anchorage AK
Scoping Document (SD) 1 Issued	FERC	November 29, 2019 [60 days after NOI/PAD filed]
Scoping Meeting/Site Visit	FERC	December 30, 2019 [30 days after SD 1 Issued]
PAD, SD1, & Study Request Comments Due	Licensing Participants	January 29, 2020 [30 days after Scoping Meeting/Site Visit]
File Proposed Study Plan (PSP)	Cooperative	March 16, 2020 [45 days after comments on PAD, SD1, and Study Requests]
Comments due on Proposed Study Plan	Licensing Participants	June 15, 2020 [90 days after PSP filed]
File Revised Proposed Study Plan	Cooperative	July 15, 2020 [30 days after PSP comments filed]
Revised Proposed Study Plan Comments Due	Licensing Participants	July 30, 2020 [15 days after Revised PSP filed]
Study Plan Determination Issued	FERC	August 31, 2020 [30 days after revised PSP filed]
Study Year 1	Cooperative	May – October, 2020
File Initial Study Report	Cooperative	December 2020
Study Meeting	Cooperative	February 2021
Requests for Study Plan Modification	Licensing Participants	March 2021
Study Year 2	Cooperative	May – October, 2021
File Updated Study Report	Cooperative	December 2021
File Preliminary Licensing Proposal (PLP)	Cooperative	June 2022
Comments due on PLP	Licensing Participants	[90 days after PLP filed]
File License Application	Cooperative	December 2022
License Issuance	FERC	December 2024 [2 years after FLA filed]

2.3 Proposed Communications Protocol

The Cooperative is proposing a Communication Protocol (Protocol) with the intention to facilitate communication and cooperation among the Cooperative, federal and state agencies, Indian tribes, native corporations, other interested organizations, and members of the public (collectively, Participants) during the preparation of the Cooperative's Application for Original License for the Project.

This Protocol will govern communications among all Participants and provide public access to information regarding the consultation activities related to the licensing of the Project. The Protocol also applies to communications made by contractors or consultants on behalf of the Cooperative or any of the Participants. This Protocol does not apply to communications solely between Participants, or to any Participant's internal communications.

The primary means of communication will be meetings, formal documents, email, and telephone. To establish the Project consultation record, all formal correspondence will be adequately documented.

2.3.1 Contact Lists

The licensing process for the Project is open to the general public and interested parties are encouraged to participate. A contact list, compiled by the Cooperative, will be maintained to identify those agencies, organizations, individuals or groups that have been identified as interested parties or who have requested to be included as Participants. The contact list will be used to provide notice of any public meetings, as well as notice of the availability of information for public review. The contact list will be updated periodically by the Cooperative.

After the Cooperative files its license application, FERC will establish an official Service List for those parties who formally intervene in the proceeding. Intervention is a formal, legal process governed by FERC's regulations. Additional information may be found on FERC's website at http://www.ferc.gov. Once FERC establishes a Service List, any written documents filed with FERC must be served to the Service List.

2.3.2 Document Distribution

The Cooperative will distribute, whenever possible, all documents electronically but may distribute hard copies of some documents for convenience or by request. The Cooperative will develop an online repository of shared documents available for access to registered stakeholders.

If possible, the Applicants prefer to receive all documents electronically in an appropriate format. Email electronic documents to Mr. Bobby Armstrong (barmstrong@nushagak.coop), Mr. Robert Himschoot (rhimschoot@nushagak.coop), and Mr. Cory Warnock (warnock@mcmjac.com) at the addresses provided here. Hard copy documents may be mailed to the Cooperative's address provided in Section 2.2. In either case, all documents received become part of the consultation record and can be made available for distribution.

All formal filings with FERC will be accessible on the FERC eLibrary, the searchable electronic document database (http://elibrary.ferc.gov). Interested parties can register to receive notices of filings made to FERC specific to the Project (P-14873).

2.3.3 Sensitive Information

Certain Project-related documents are considered Critical Energy Infrastructure Information (CEII) and restricted from public viewing in accordance with Section 388.113 of FERC's regulations (18 CFR § 388.113). This information relates to the design and safety of the dams and appurtenant facilities. Anyone seeking information protected as CEII from FERC must file a CEII request. FERC's website at: https://www.ferc.gov/legal/ceii-foia/ceii.asp contains additional details related to CEII. The Cooperative will allow limited access to documents designated as privileged material under 18 CFR § 388.112 containing sensitive information regarding specific cultural and/or protected environmental resources to authorized entities.

2.3.4 Meetings

The Cooperative recognizes that a number of agencies, groups, and individuals may want to participate in the licensing process for the Project and will work with all interested parties to develop meeting schedules that include locations and times that accommodate the majority of participants. The Cooperative will follow the notification procedures for meetings as mandated by FERC regulations and may schedule additional meetings to enhance the consultation process, as necessary. Meeting agendas and materials will be distributed to Participants electronically in advance of the meeting.

A written summary of matters addressed at all meetings involving the Cooperative and Participants will be prepared by the Cooperative and distributed to the Participants for review promptly following the meeting. Finalized meeting summaries will be distributed to the stakeholder group and filed with FERC.

3.0 PROJECT LOCATION, FACILITIES, AND OPERATION (18 CFR §5.6 (D)(2))

3.1 Project Location

The proposed Project would be located on the Nuyakuk River approximately 60 miles north of Dillingham, AK (pop. 2,364), within the 1,544 square mile watershed that drains the eastern side of the Wood River Mountains (Figure 3-1). The Project site is inside the current Wood-Tikchik State Park boundary by approximately 4 miles. The Project's river intake would divert water from the Nuyakuk River, above Nuyakuk Falls, located about 4.6 river miles downstream from the Tikchik Lake outlet to the powerhouse located at the base of Nuyakuk Falls, at approximately river mile 5.3. From the Project site, the Nuyakuk River runs approximately 40 miles before converging with the Nushagak River, which continues to Bristol Bay.

3.2 Project Lands

The proposed Project boundary consists of 2,860.60 acres which includes a 75-ft buffer around all Project facilities and on either side of the proposed transmission line. Acreage of proposed Project lands by ownership is presented in Table 3-1. The Alaska Department of Natural Resources (ADNR) manages a total of 1,666.57 acres (58.3 percent) of proposed Project lands. Of this, 265.85 acres (9.3 percent) is land within Wood-Tikchik State Park. Native lands total 707.39 acres (24.7 percent) of proposed Project lands. The remainder of proposed Project lands are owned or managed by the Bureau of Land Management (BLM) (357.08 acres or 12.5 percent) and private or municipal entities own an additional 129.56 acres (4.5 percent). Maps showing detailed land use and land ownership within the proposed Project vicinity are presented in Figures 3-2 through 3-7. Updated FERC Form 587 documents for proposed Project lands are included in Appendix A and references Figures 3-4 through 3-6 shown below. FERC Form 587 documents were previously filed for the Project with the revised Preliminary Permit Application in April 2018, but these forms have been superseded due to adjustments in the proposed transmission corridor since that time. Thus, the Cooperative has included updated Form 587 documents in Appendix A that represent the currently proposed transmission corridor.

Table 3-1. Land ownership within the proposed Project boundary.

Owner/Agency	Acreage
State of Alaska (ADNR – excluding Wood-Tikchik State Park)	1,400.72
State of Alaska (ADNR - Wood-Tikchik State Park)	265.85
Native	707.39
Federal Government (BLM)	357.08
Private or Municipal	129.56
Total proposed Project lands	**2,860.60**

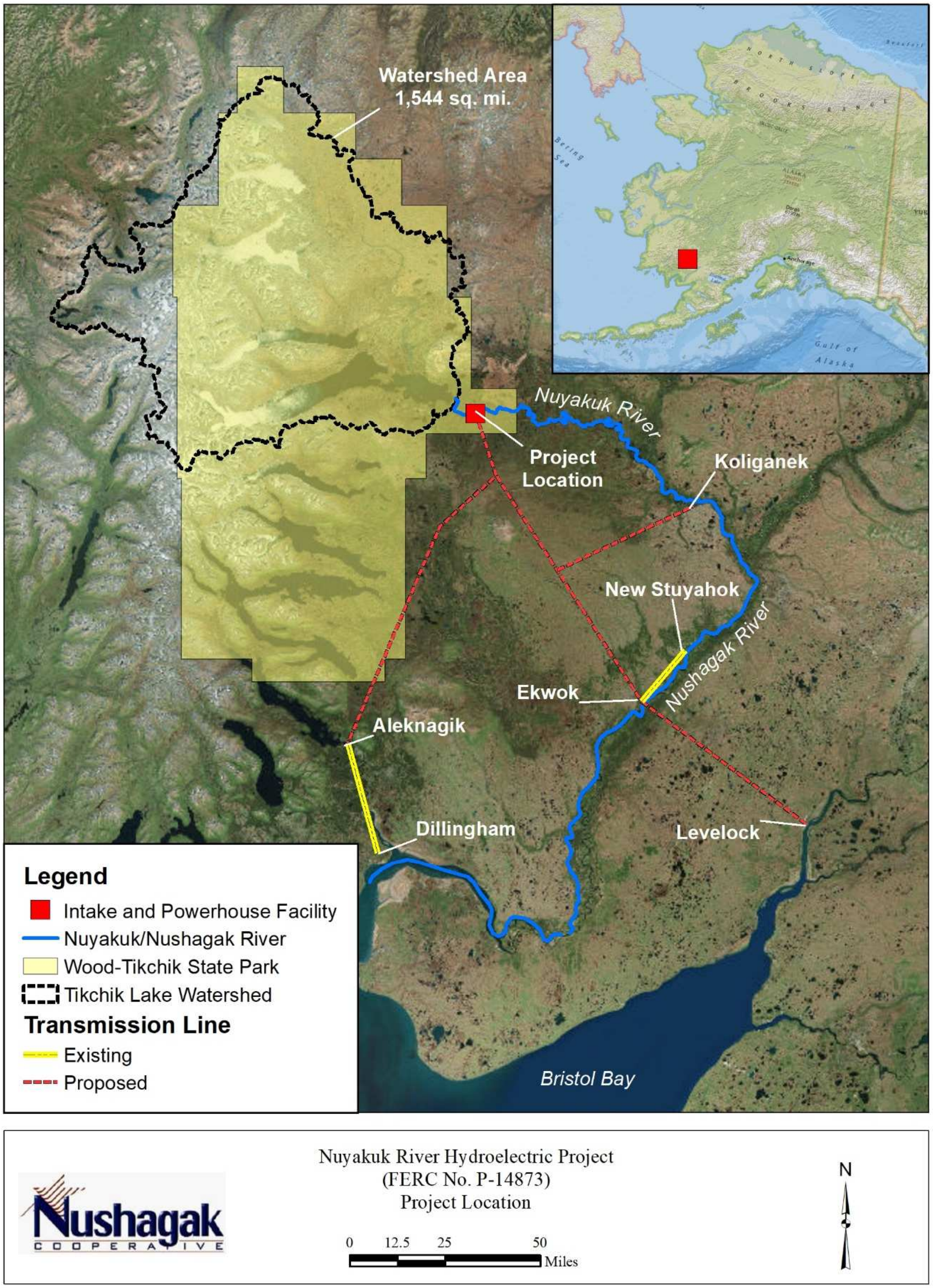

Figure 3-1. Proposed Project location.

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Figure 3-2. Proposed Project boundary overview map.

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Figure 3-3. Proposed Project boundary and land ownership overview map.

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Figure 3-4. Proposed Project boundary and land ownership (map 1 of 3).

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Figure 3-5. Proposed Project boundary and land ownership (map 2 of 3).

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Figure 3-6. Proposed Project boundary and land ownership (map 3 of 3).

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Figure 3-7. Proposed Project boundary and land ownership (Powerhouse and Intake Facility Vicinity).

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3.3 Project Facilities

The Project will consist of a single primary development centered around a river intake/diversion located above Nuyakuk Falls and a single powerhouse facility located downstream below Nuyakuk Falls (Figures 3-8 and 3-9). Additional Project facilities will include a single-bore tunnel arrangement to convey water from the intake to the powerhouse, a tailrace conveyance channel to return water to the Nuyakuk River, an airstrip with local access roads, a small building to house a maintenance shop on the lower level and an operators' residence on the upper level, and an electrical transformer and switchyard area to step power up for high-voltage (34.5 kV) conveyance via overhead transmission to Dillingham, AK. Overhead transmission is currently estimated to cover 140 miles according to the conceptualized route shown in Figure 3-1. The Project will likely also include a lower dock facility located near the powerhouse/tailrace outlet to allow for docking of small water craft that can navigate the Nuyakuk River back to the Nushagak River.

The powerhouse is conceptualized to contain three Kaplan-style reaction turbine generating units to accommodate a combined maximum design flow of approximately 7,550 cfs divided evenly among the units. This combined maximum designed flow is the 75% exceedance flow rate for the months of June, July and August, less 1,000 cfs for instream uses. The rated capacity on each unit would be approximately 3,333 kW. The gross head on the Project is approximately 26 feet, based on site surveying work that occurred in June of 2019.

Figure 3-8. Nuyakuk Falls, looking upriver toward Tikchik Lake. The proposed Project location is on the left side of the photograph.

Figure 3-9. Nuyakuk Falls, looking across the Nuyakuk River to the proposed Project location.

3.3.1 Summary of Project Features

The proposed Project features have been developed based upon existing physical and environmental information and are conceptual in nature. As part of the pre-filing consultation process, additional information will be obtained through technical and environmental studies, further site-specific topographical and bathymetric surveys to be conducted in the spring of 2020, and continuing research and consultation with equipment manufacturers and resource agencies. As new information becomes available, the design features presented below can be expected to be refined and/or modified to accommodate any changed conditions, including maintenance of instream flow requirements. Project features as currently envisioned are summarized in Table 3-2 and described in this section.

Table 3-2. Summary of proposed Project features.

SUMMARY OF PROJECT FEATURES	
Number of Generating Units	3
Turbine Type	Kaplan (Z-style or Vertical)
Runner Diameter (estimated)	17-ft
Operating Speed	108.1 rpm
Generator Type	Synchronous
Rated Generator Output	
Unit 1	3.33 MW
Unit 2	3.33 MW
Unit 3	3.33 MW
Maximum Rated Turbine Discharge	
Unit 1	2,517 cfs
Unit 2	2,517 cfs

Unit 3	2,517 cfs
Diversion Forebay Water Surface Elevation	
Minimum (Preliminary)	250.0 (ft NAVD88)
Maximum (Preliminary)	265.0 (ft NAVD88)
Turbine Centerline Elevation (Preliminary)	231.67 (ft NAVD88)
Normal Tailwater Elevation	
Minimum (Preliminary)	225.0 (ft NAVD88)
Maximum (Preliminary)	235.0 (ft NAVD88)
Average Annual Energy (assuming 18.4 feet of net head and an average monthly intake diversion flow of 4,688 cfs or 6,287 kW)	55,300 MWh
Gross Head	26 feet ± fluctuation
Net Head at Maximum Rated Discharge	18.4 feet
Watershed Characteristics	
Drainage Area	1,544 sq. mi.
Maximum Basin Elevation	5,250 (ft NAVD88)
Minimum Basin Elevation	248 (ft NAVD88)
Mean Annual Precipitation	59.0 inches
Area of Ponds or Lakes	12.4 %
Nuyakuk River Diversion (All aspects to-be-determined (TBD) once bathymetry and sub-bottom profiling work is completed in 2020 and geotechnical reconnaissance work is completed)	
Structure Type	Concrete Diversion / Low Head Weir (TBD)
Structure Length	530 feet
Average Monthly Water Height above Weir (Max)	3.75 feet
Average Monthly Water Height above Weir (Min)	0.25 feet
Crest Elevation	x
Water Conveyance (Pressurized Tunnel from Intake to Powerhouse)	
Intake Style	Possibly a diversion structure feeding a concrete open channel short canal. Single canal could feed three vertical intake shafts (one per turbine unit)
Typical Open Channel Allowable Velocity	< 3.0 ft/sec
Open Channel typical depths	10 to 15 ft
Open Channel width	175 to 250-ft
Tunnel Lip Elevation at Open Channel	245.0 (ft NAVD88)
Tunnel Construction Type	TBD once field geotechnical drilling and data are compiled
Length of inclined tunnels to powerhouse	~500 to 600 feet
Tunnel Velocity at Maximum Turbine Discharge	~ 10 ft/sec
Single Tunnel Configuration (one feeding all three turbines)	
Tunnel Flow Capacity	7,550 cfs
Unlined Tunnel Diameter	32-ft
Final Lined Diameter	30-ft
Base Elevation (Preliminary)	245.0 (ft NAVD88)
Top Elevation (Preliminary)	265.0 (ft NAVD88)
Powerhouse	
Approximate Dimensions (for three-unit powerhouse)	40 feet x 120 feet x 30 feet high
Finished Floor Elevation	250.0 (ft NAVD88)

Tailrace	
Type	Open Channel
Length	200 to 300 feet
Typical Water Depth	8-ft +/-
Typical Width	120 to 150 ft
Transmission Line	
Type	Overhead
Length (to Dillingham)	Approximately 60 miles
Voltage	34.5 kV
Access Roads (from Airstrip Runway to Powerhouse)	
Type	Single lane gravel surfacing with turnouts
Length	0.5 miles

3.3.2 Nuyakuk Falls Diversion & Intake

A concrete gravity diversion structure would be constructed above the falls on the Nuyakuk River. The intake diversion would move water from the southern portion of the river above the falls into an open-channel, concrete canal to convey the diverted water inland (towards the powerhouse) a short distance. The canal is conceptualized to have a length equal to or greater than its width (L/W > 1) in order to follow appropriate hydraulic standards for splitting the water into multiple intakes. As such, the canal length would be on the order of 150 to 200 ft long. At the end of the canal would be three vertical shaft, drop-inlets, with each drop inlet feeding an independent tunnel connected to one turbine unit. The diversion and intake geometry will be advanced once field site investigations (bathymetry, sub-bottom profiling, and geotechnical drilling) are completed. In addition, two-dimensional river hydraulic modeling will be required for approximately 1,000 lineal feet above the falls to aid in proper development of the intake diversion hydraulic and structural design. It is anticipated that river hydraulic modeling and geotechnical studies will be conducted as part of the overall Project licensing study program.

Each conveyance tunnel would be equipped with an isolation gate at the intake to be able to independently shut down each tunnel and corresponding turbine unit for maintenance or other emergency (e.g. turbine runaway) considerations. A canal gatehouse would be constructed with large vertical telescoping control gates that can be designed to effectively isolate one tunnel and shut off flow to that tunnel for maintenance or other reasons. The diversion structure and intake canal would be equipped with redundant level transmitters to continuously monitor water levels in these critical conveyance features.

The inlet zone to the open channel canal would be protected by steel inclined bar-screens (with openings between bars on the order of 1 to 3 inches) to divert both ice and debris away from the open channel and downstream over the natural falls. The trash rack would be oriented parallel to river flow to maximize sweeping velocity on the rack face, thereby increasing passive flushing of debris from the rack. The trash rack would be necessary to protect both the downstream telescoping vertical gates as well as the downstream turbine units. Final concept design would need to investigate whether or not an additional isolation bulkhead or sluice gates would be needed behind the trash rack for further safety or maintenance purposes.

3.3.3 Conveyance Tunnels to Powerhouse

Assuming that a three-turbine powerhouse is the most practical and reliable configuration for power generation, the Project would be developed with either one larger water conveyance tunnel feeding all three turbine units, or three smaller diameter tunnels, with each tunnel dedicated to one turbine unit. The diameters of these two conveyance tunnel options for the Project are provided in Table 3-2 above. Better system reliability and Project redundancy would be provided by an arrangement that dedicates a tunnel to each unit, but the cost of providing three tunnels could be higher than that of a single tunnel unit. Advantages of a three-tunnel project would include the following:

- Ability to run two turbine units while maintenance is performed on the other isolation gate or turbine unit.
- Design of the steel tunnel liners to fit inside the excavated rock tunnels may be significantly easier with the smaller 15-ft final steel liners than the larger and thicker requirements for the single 25-ft steel lined tunnel.

If on-site geotechnical drilling and investigations show that native rock quality is poor or inconsistent, then it should be assumed that all tunnels would have to be lined with either a welded in-place steel liner (a continuous steel shell liner likely of at least 1/2-inch thickness) or perhaps with a rock-bolt and shotcrete system to protect against the inherent structural weaknesses or deficiencies in the native rock. If steel liners are used, they would be brought in longitudinal arc-sections and seem-welded both longitudinally and horizontally inside the tunnel. Once the steel liners are placed inside the tunnel, the annular void space between the liner and the native rock would be pressure grouted with structural non-shrink grout mixes designed to be pumped and flow through annular spaces.

If on-site geotechnical investigations show that native rock is of high enough quality and consistent enough through the tunnel alignment zone, then it may be possible to omit the need for an interior steel liner or rock-bolt and shotcrete liner system. This configuration would provide a large economic benefit to the project. Detailed on-site geotechnical investigations, including field drilling and logging, will be used to clarify the design needs of the conveyance tunnels.

3.3.4 Trifurcation to Turbine Units

If a single conveyance tunnel system is pursued for the Project design, it will be necessary to provide a trifurcation design near the outlet to the tunnel and prior to the powerhouse. The trifurcation would be designed of steel pipe and would divide the flow to the three Kaplan units with their horizontal spiral cage inlet configurations. Geometric symmetry would be required to ensure an equal division of flow to the three units when all units are in operation. The low system net heads (estimated at 26 feet or 11 psig (pounds per square inch, gage)) and lack of much external groundwater or other external loading conditions suggest that the structural design and resulting plate thickness of a steel pipe trifurcation system should not be very thick.

However, both handling and site-specific seismic considerations will be taken into account in the final trifurcation design.

If three separate conveyance tunnels are pursued for the Project, then the trifurcation structure can be eliminated from the Project.

3.3.5 Powerhouse

The powerhouse would be located on the south bank of the Nuyakuk River near the base of the falls. The powerhouse is estimated to be approximately 40 feet wide by 120 feet long by 30 feet high to accommodate three of the Kaplan vertical shaft turbine units. The powerhouse would have a large underground foundation that houses the entrance cage to the runner along with the impeller section of each turbine unit. The main superstructure above ground would be a pre-engineered metal building anchored to a concrete foundation.

The powerhouse concept is to contain three vertical shaft Kaplan-type turbine/generator units with a rated capacity of 3,333 kW for each unit at a design flow of approximately 2,516 cfs per unit, and associated switchgear and controls. The centerline of the turbine and generator units would be approximately 232 feet above mean sea level (msl). The tailwater elevation at the powerhouse would range from approximate elevations 225 feet above msl to 235 feet above msl depending upon output level. Final values for these elevations will be determined once the site topographic and bathymetric surveys are completed in 2020. The turbines would be designed to operate at high efficiencies over a range of flows from the maximum of 2,516 cfs to a minimum of around 755 cfs depending on conditions.

3.3.6 Tailrace

The tailrace would be an open rectangular concrete channel approximately 200 feet long and120 to 150 feet wide to convey water back to the Nuyakuk River. The tailrace outlet to the river would be designed to reduce velocities relative to the natural river velocities in the discharge zone. This will help prevent native anadromous fish from being attracted to the Project discharge flow instead of the natural river channel flow pathways. In addition, the need for vertical picket barriers or other such fish barrier protection measures on the outlet of the Tailrace will need to be evaluated during Project development.

3.3.7 Switchyard / Transmission Line/Switchyard

The switchyard at the powerhouse will consist of a pad-mounted disconnect switch (i.e., breaker) and a pad-mounted step-up transformer. An overhead 34.5 kV transmission line would run from the powerhouse switchyard approximately 60 miles to a point of interconnection with the NETC electrical system. A right-of-way would be established along the proposed transmission line. This route would be used to construct the transmission line, then serve as a land-based right of way for the Project site. The route would incorporate setbacks from main waterways and alignment changes to minimize visual impacts.

The transmission line poles would be designed as tangent line structures located approximately every 300 feet on center. Transmission line design will also incorporate the latest raptor protection guidelines. Collision avoidance devices will be installed on the line at appropriate locations to protect migratory birds.

3.3.8 Proposed Construction and Development Schedule

The Project would be constructed over a 24-month timeframe after the issuance of the Project license. Construction would begin in the spring with the clearing of a right-of-way along the transmission corridor and the construction of the localized access road at the Project works on the river. A majority of the large equipment necessary to construct Project infrastructure would be barged up the river and stored at the site during construction activities. An airstrip would be constructed adjacent to the Project site to allow air transport of equipment, materials, and manpower to support construction activities. A fully equipped man camp would be erected for the Project construction staff. Portable generation facilities would provide power for the construction work and man camp facilities. Initially, temporary cofferdams would be constructed at the intake and powerhouse tailrace channel exit zone into the river. This would allow the intake structure, power conduit, and powerhouse construction to advance simultaneously to maximize the work completed during a summer construction season. The intake and power conduit would be completed first, with the powerhouse structure completed immediately following. The generation equipment would be installed, and the balance of plant construction advanced during the winter months. The diversion structure and tailrace channel would be the last components constructed followed by removal of the river cofferdams. These work activities would be completed in the last season followed by startup, commissioning, and initiation of commercial power generation.

3.4 Project Operation

3.4.1 Proposed Project Operations

The primary mode of operation for this project will be level control, whereby outflow is balanced to inflow. The project is conceived as a run-of-river project, with no large storage component. As such, power production will mimic some fraction of total river inflow to the project site.

Mean daily discharge in the Nuyakuk River is presented in Figure 3-10, based on USGS gaging data available at station 15302000 located near the outlet of Nuyakuk Lake. From the figure, it is clear that the period of high flow in the river occurs between early summer and early fall. For the remainder of the year, the river is running at near baseflow conditions. Because the project will operate in run-of-river mode, sizing the generating units should be done to either 1) optimize power production during a specific time of year (e.g. during the winter months) or 2) produce power more or less evenly throughout the year. Under the current project conceptualization, units have been sized to provide a stable amount of power from month to month while attempting to minimize overall capital costs associated with the hydroelectric units, tunnel(s), and other project components. Average monthly power generation under this operational configuration is shown in Figure 3-11.

When powerhouse flows do not match the system loads, grid system electricity will have to be supplemented with existing diesel generation. This will most likely be in the winter months when the amount of water available to the powerhouse is less than the power demand would require. The transmission grid will therefore have five diesel generation power plants tied together to complete the electric grid system. The existing power plant in Dillingham has the ability to provide energy for all six villages serviced by the transmission system throughout the year, except for the month of July. This gives NETC the ability to feed the system from different sources as needed for load or maintenance.

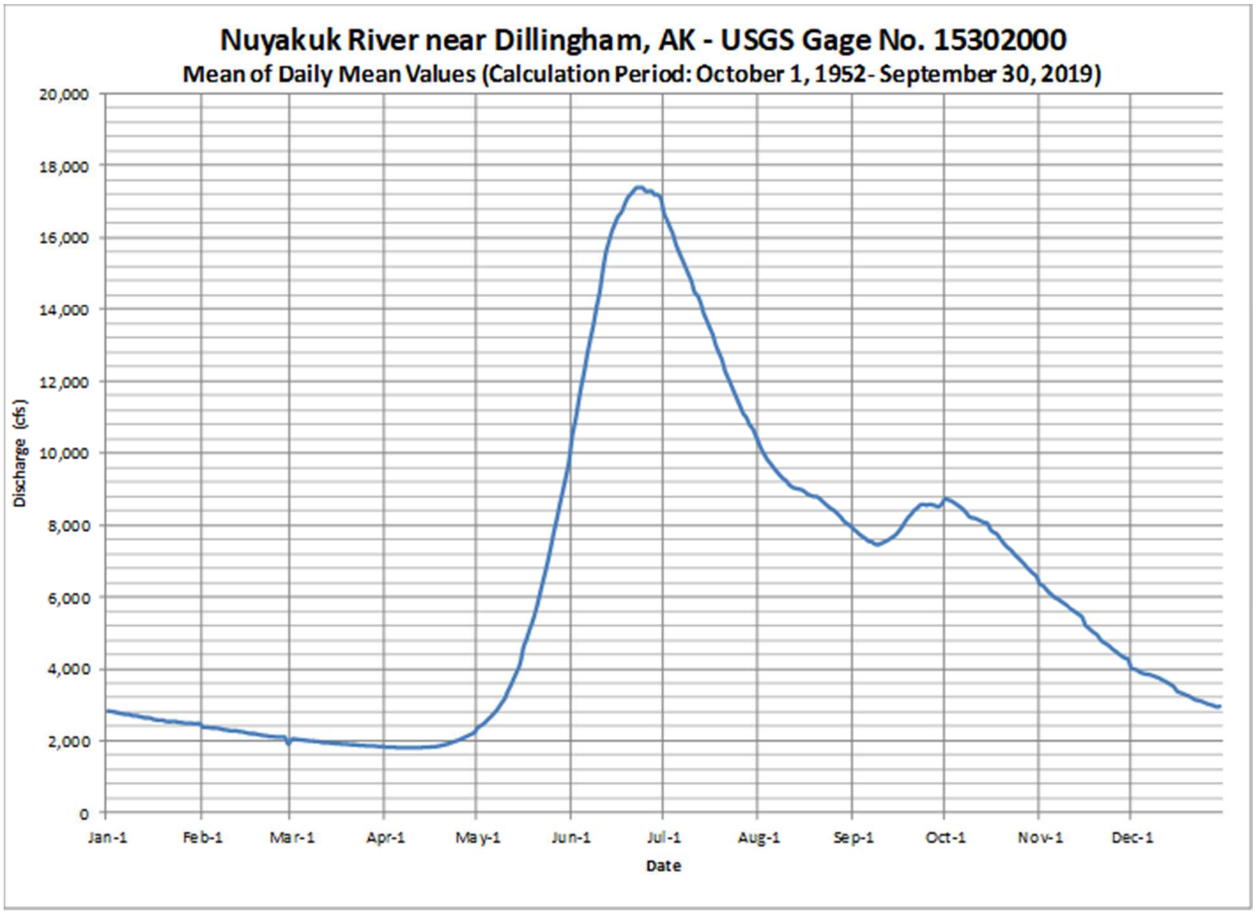

Figure 3-10. Mean daily discharge at USGS Gage No. 1530200 from October 1, 1952 - September 30, 2019.

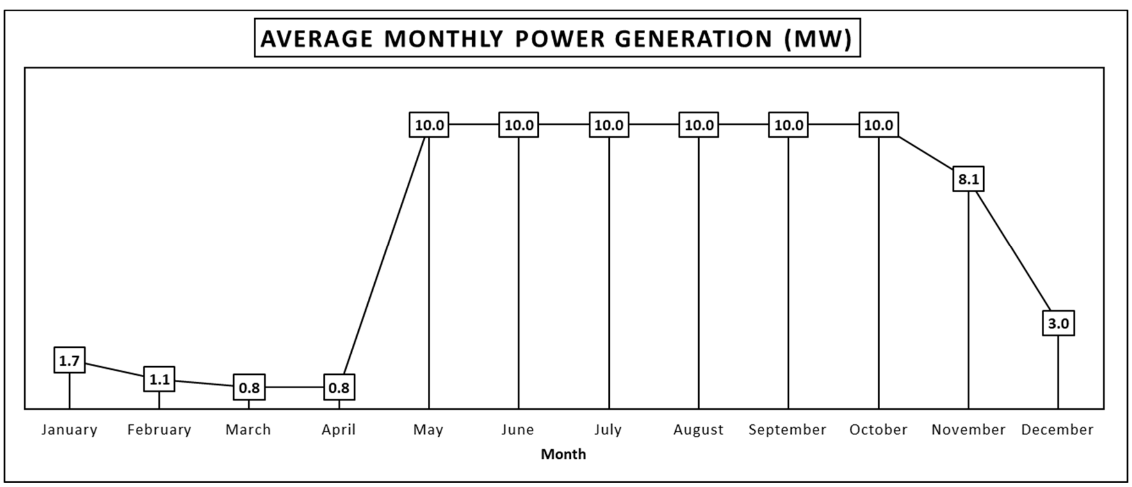

Figure 3-11. Estimated average monthly power generation for the proposed Project.

3.4.2 Project Capacity and Production

The Project will have an installed total capacity of 10.0 MW and is based on the configuration discussed above. Energy production also assumes the project configuration described above, with a single 30-ft diameter tunnel servicing the three units over a distance of 600 feet. For those months in which the total available inflow to the powerhouse is less than the total powerhouse flow capacity, a minimum instream flow of 1,000 cfs is assumed to pass downstream, while the remainder is passed through the powerhouse to generate electricity. The predicted average annual energy from the Project is 55,300 MWh representing a plant factor of 63%. Estimates will be revised once instream flow studies are completed, and any flow accretions below Nuyakuk Lake are determined.

4.0 DESCRIPTION OF EXISTING ENVIRONMENT AND RESOURCE IMPACTS (18 CFR §5.6 (D)(3))

4.1 General Description of the River Basin

4.1.1 Topography

The Nushagak River watershed encompasses a wide variety of terrain and landscape features, including steep and rugged mountains, and lowlands that are composed of forests, tundra, lakes, and rivers (NMWC 2007). The Wood River Mountains, at an elevation of 2,000 to 5,000 feet above msl, border the western edge of a series of large headwater lakes in Wood-Tikchik State Park. The headwater lakes drain into wide, relatively flat river valleys on the eastern edge, where the terrain transitions to forested lowlands and tundra (ADNR 2019). North of the Project vicinity, the rounded Nushagak Hills (elevation 1,000-2,000 feet above msl) contain the headwaters of the Nushagak River. Figure 4-1 shows the landscape features in the Project vicinity.

The proposed Project lies in the Bristol Bay Lowlands, east of the Wood River Mountains and Tikchik Lake. The lowlands have elevations ranging from 500 feet above msl to sea level and contain numerous morainal and thaw lakes and ponds. Streams originate from headwater lakes and drain into large meandering rivers that flow to Bristol Bay (ADFG 2006).

Figure 4-1. Project vicinity major watersheds and landscape features.

4.1.2 Climate

The climate in the Project vicinity is generally cool and humid and can be characterized as transitional between a maritime and continental climate (ADNR 2019, ADFG 2006). Daily high and low temperatures in July average 65°F and 46°F, respectively (ADNR 2019). Average winter lows range from 5°F to 14°F (ADFG 2006). Most of the area's precipitation occurs in the summer, and nearby Dillingham receives approximately 26 inches of precipitation annually, although large local variations occur. Annual snowfall in the region ranges from 60 inches near Dillingham to 160 inches to the north near Lake Nerka. Winds are generally 0-30 miles per hour and originate from the southeast/southwest in the summer and from the north and east in the winter. Fog and low clouds are common during July and August (ADNR 2019).

It is anticipated that the climate in the Project vicinity will be somewhat similar to the climate in Dillingham, which is located approximately 60 miles south of the Project site on Bristol Bay (Figure 4-1). Dillingham lies within a climatic transition zone between a cool, moist maritime climate and a cold, dry continental climate. During the summer months, the maritime influence of Bristol Bay and the Bering Sea to the west and the Pacific Ocean to the south dominate the local weather patterns. Temperatures are mild; strong and persistent surface winds are common. Skies are frequently cloudy, precipitation is moderate to heavy, and periods of fog are common, particularly in the later part of the summer. During the winter months, a colder, drier climate dominates, with strong and persistent surface winds still common.

The weather station in Dillingham has been operated by the NWS since February 1951. For the period of record, the mean annual temperature was 34° F. The average maximum monthly temperature was 41° F and the average minimum monthly temperature was 27° F. December is typically the coldest month, with a long-term mean of 14° F. The warmest temperatures usually occur in July, with a long-term mean of 55° F. A record high temperature of 91° F occurred in the summer of 1953 and a record low temperature of –53° F occurred in the winter of 1989.

Mean annual precipitation at Dillingham is 26 inches. Most of the year's precipitation falls during the summer and fall, with approximately 50 percent of mean annual precipitation occurring between July and October. Winter precipitation is typically light to moderate, with a mean annual snowfall of 83 inches.

A weather station was operated by the NWS at Aleknagik from September 1958 to February 1973. Aleknagik is located 17 miles north of Dillingham. For the 1958–1973 time period, the average maximum monthly temperature in Aleknagik was 43° F and the average minimum monthly temperature was 25° F. A record high temperature of 88° F occurred in the summer of 1963 and a record low temperature of –44° F occurred in the winter of 1973.

4.2 Geology and Soils

4.2.1 Geology

The geology of southwest Alaska includes a collection of three primary rock groups: 1) continental margin rocks associated with the northern Kuskokwim Mountains and southwestern Alaska Range; 2) tectonically accreted rock formations; and 3) younger sedimentary, volcanic, and plutonic rocks. These rock groups are variably overlain by recent, unconsolidated alluvial and glacial deposits, and by Quaternary extrusive deposits in localized areas.

The tectonically accreted rock units have been subdivided by genetic relations collectively known as the Terranes of Southwestern Alaska (Decker et al. 1994). In the Project area the primary unit is the Goodnews Terrane. The Goodnews Terrane is subdivided into several subterranes, but only the Tikchik Subterrane occurs in the Project area. The Tikchik Subterrane surrounds the Tikchik Lake area within the northwestern corner of the Dillingham quadrangle. The Tikchik Subterrane is a complex assemblage of clastic rocks, chert, limestone, pillow basalts, and mafic volcanic rocks.

Unconsolidated Quaternary deposits comprise the entire area downstream of the Project area and comprise most of the central and eastern regions of the Dillingham quadrangle, also referred to as the Nushagak-Bristol Bay Lowlands (Wahrhaftig 1965 as cited in Wilson 2018). Recently, a geologic map of the Dillingham quadrangle in Southwest Alaska was created by the USGS (Wilson 2018). The scale of the Dillingham quadrangle (1:250,000) encompasses the entire Project vicinity from the Ahklun Mountains and Tikchik Lake, downstream to the proximity of where the Nushagak River confluences into Nushagak Bay near the town of Dillingham (Figure 4-2). In general, the study area indicates "surficial unconsolidated deposits, many of which are alluvial or glacial in nature. The map area, part of Alaska that was largely not glaciated during the late Wisconsin glaciation, has a long history of reflecting local and more distant glaciations. Late Wisconsin glacial deposits have limited extent in the eastern part of the quadrangle but are quite extensive in the western part to the quadrangle." (Wilson 2018). Details of the surficial geology in the Project vicinity are described in Section 4.2.2. It is anticipated that Project vicinity geology will be investigated as part of the overall Project licensing study program.

4.2.2 Soils

Detailed surficial geologic maps of the Project vicinity are provided in Figures 4-2, 4-3 and 4-4. Adjacent to the Project area, the primary features are glacial deposits of ground moraine from the late Pleistocene (lw). Specifically, the late Pleistocene ground moraine (lw) feature is a glacial deposit of the Okstukuk and Kvichak advances of the late Wisconsin age, reflecting the late Wisconsin glacial maximum. The moraine primarily consists of unsorted till, and may also include minor outwash, alluvial, and eolian deposits (Wilson 2018). In addition, there are fine grain deposits (fg) interspersed along the river banks away from the wetted channel and areas of bedrock within the wetted channel and right bank (looking downstream) of the Nuyakuk River falls/Project area. The resolution of the geologic map does not clearly delineate the areas of bedrock, but a site visit in July of 2018 confirms its presence. Additional surficial geologic features upstream of the Project include drift and outwash from the Aleknagik glaciation as well as deposits from alluvial fans, talus, and abandoned channels. Downstream of the Project, terrace deposits (Quaternary), flood plain deposits (Holocene), drift from the Okstukuk glaciation, and late Pleistocene outwash are the substantial geologic features. It is anticipated that Project vicinity soils will be investigated as part of the overall Project licensing study program.

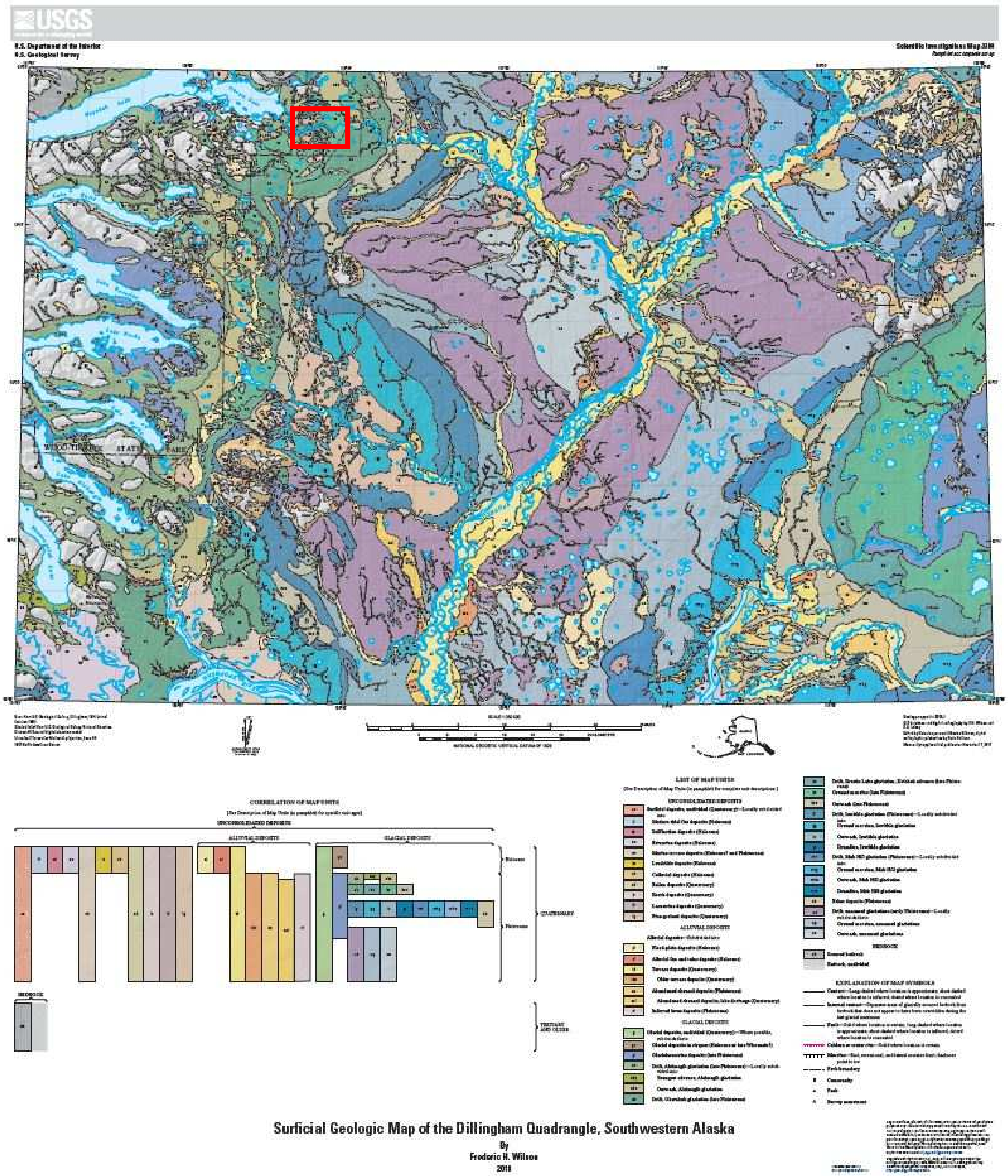

Figure 4-2. Surficial geologic map study area for the Dillingham quadrangle (Project area indicated by red rectangle) (Wilson 2018).

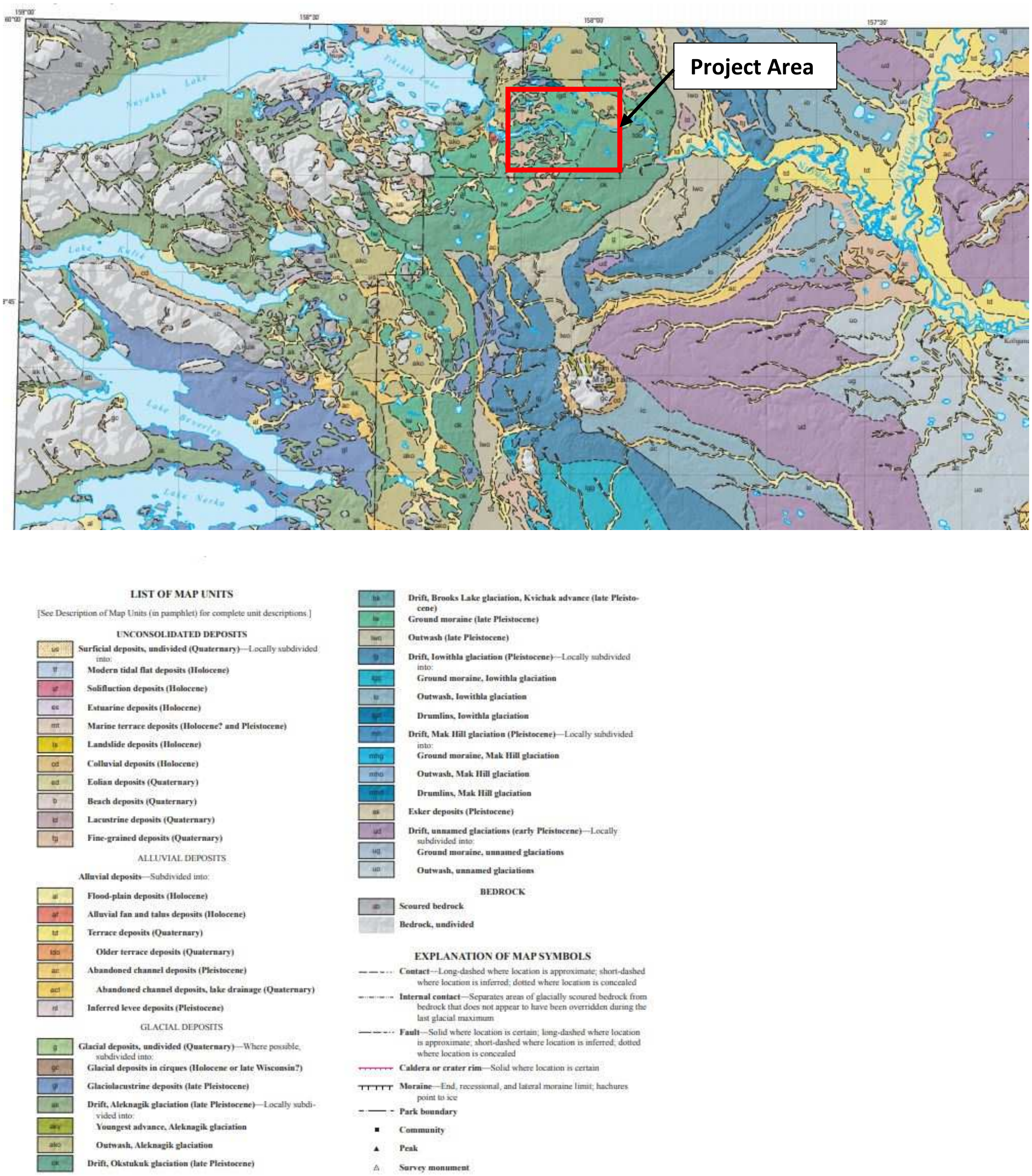

Figure 4-3. Surficial geologic map study area for the Dillingham quadrangle and Project area (indicated by red outline) (Wilson 2018).

Figure 4-4. Soil survey map for the proposed Project vicinity (NRCS 2019).

4.2.3 Seismicity

Southwest Alaska is characterized by low to moderate seismicity as compared to many other regions of Alaska (Page et al. 1991). The region is dominated by a series of north-northeast and northwest trending faults (Figure 4-5). The primary north-northeast fault is the Denali fault system, which includes the Togiak-Tikchik section in the mountains well upstream of the Project. The Denali fault is categorized within fault class B, has an age of undifferentiated Quatenary (<130,000 years) with an undefined slip rate due to insufficient data (USGS 2019). As shown in Figure 4-6, seismic activity in the Project area had very few seismic events in 2018 when compared to other areas of Alaska (AEC 2019). The AEC also provides monthly summaries of seismic activity within the state of Alaska, and these data can be tracked for future assessment of seismic risk of proposed Project location.

Figure 4-5. Quarternary fault lines in the Project vicinity (USGS 2019).

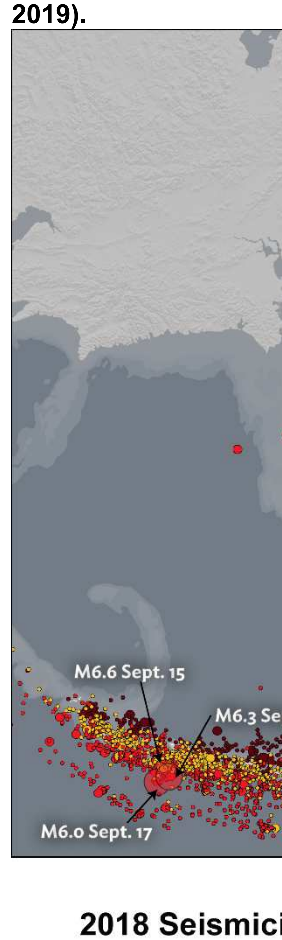

Figure 4-6. 2018 Seismicity summary with general Project area outlined in the blue rectangle (AEC 2019).

4.2.4 Potential Adverse Effects

Potential adverse impacts will be discussed with stakeholders during study planning and ultimately assessed during the licensing study process. Based on the current conceptual layout and operational regime identified for the Project, Table 4-1 below identifies potential adverse impacts related to Geology and Soils.

Table 4-1. Potential adverse impacts related to geology and soils.

Potential Adverse Impact	Associated Resource Effect
Construction of Project infrastructure in or immediately adjacent to the Nuyakuk River	Potential for short-term increase in sediment load in the Nuyakuk river associated with construction efforts
Construction of transmission lines and associated corridor	Increased erosion potential associated with both construction and operation of the transmission line and corridor

4.3 Water Resources

4.3.1 Introduction

The Nuyakuk River originates at the outlet of Lake Tikchik and flows 45 miles downstream where it terminates at the confluence with the Nushagak River. Except for the high gradient falls at the proposed Project site, the Nuyakuk River is a wide, low gradient channel with frequent braiding in the lower reaches of the river. It is anticipated that various aspects of Project vicinity water resources will be investigated as part of the overall Project licensing study program.

4.3.2 Drainage Basin Hydrology

In 1954, the USGS installed a stream gage (#1530200) approximately 0.3 miles downstream of the Lake Tikchik outlet. This gage provides 65 years of streamflow data between 1953 and 2018 (average annual flow 6,382 cfs; drainage area at gage site is 1,510 square miles; Figure 4-7). Flow was generally lower in the winter months (December through April, <3,500 cfs). During the ice-free seasons (June through September), mean monthly flows can exceed 25,000 cfs with a peak mean monthly flow of 26,220 cfs occurring during the month of July in 1977. Nuyakuk River mean monthly flows rarely exceed 20,000 cfs or drop below 1,100 cfs. A monthly flow duration curve is shown in (Figure 4-7). In addition, Appendix B provides flow duration curves of mean daily flow data by month. Both flow duration curves will be utilized to determine the availability of water for power production.

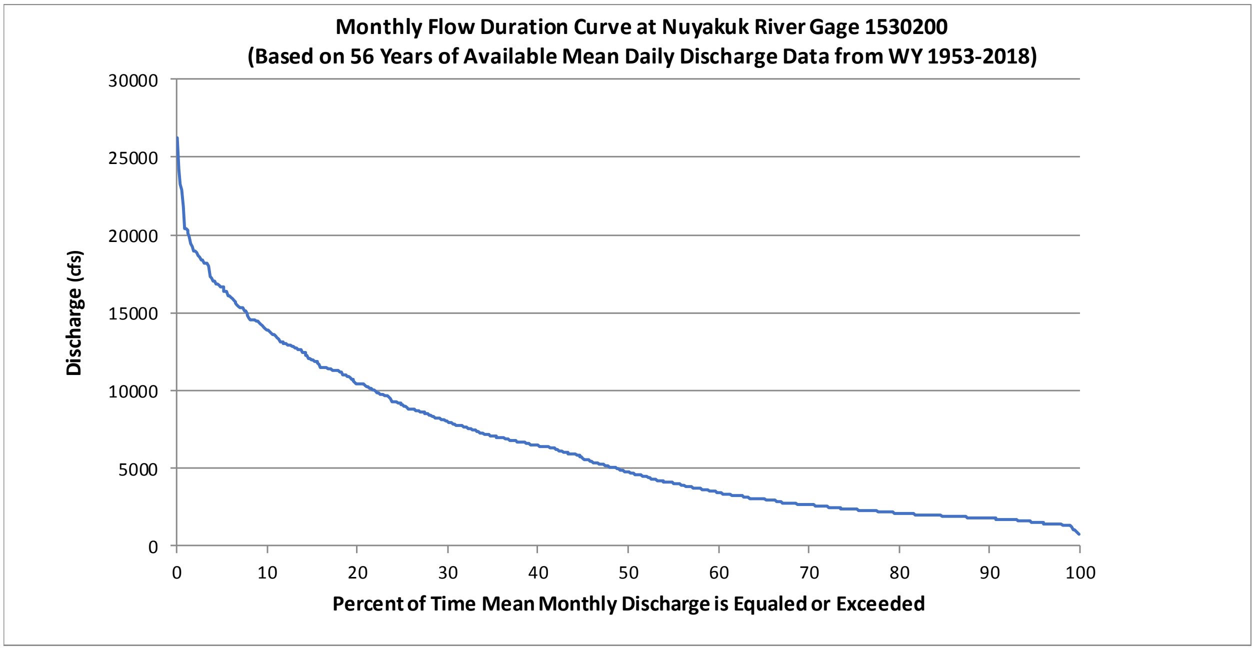

Figure 4-7. Mean monthly flow duration curve for the Nuyakuk River.

4.3.3 Water Uses

Water in the Nuyakuk River is not used for irrigation, domestic water supply, or industrial purposes. Currently, ADFG holds an instream flow reservation for the entire length of the Nuyakuk River. Certificate of Reservation LAS 28250 is a reservation of stream flows allocated "[t]o protect fish and wildlife habitat, migration, and propagation" (ADNR 2013). A summary of the time periods and flows allocated for Certificate of Reservation LAS 28250 is provided in Table 4-2.

Table 4-2. ADF&G instream flow reservation for the Nuyakuk River based on ADNR Certificate of Reservation LAS 28250.

Time Period	Flow Rate (cfs)
January	2,150
February	1,800
March	1,700
April	1,600
May 1-7	1,900
May 8-15	2,400
May 16-23	3,500
May 24-31	5,800
June 1-7	9,200
June 8-15	12,500
June 16-30	15,400

Time Period	Flow Rate (cfs)
July 1-15	13,100
July 16-31	9,700
August 1-15	7,690
August 16-31	6,600
September 1-15	6,100
September 16-30	6,350
October 1-15	6,600
October 16-31	5,750
November 1-15	4,630
November 16-30	3,800
December	2,700

4.3.4 Historical Water Quality Data

Alaska's water quality standards are established under Administrative Code 18 AAC 70, amended as of April 6, 2018 and overseen by the Alaska Department of Environmental Conservation (ADEC 2018). The standards established by ADEC must be approved by the U.S. Environmental Protection Agency (EPA) to comply with regulations under the federal Clean Water Act. Based on ADEC regulations, water quality within the Nuyakuk River watershed is protected by water quality criteria for the following fresh water designated water use classes and subclasses:

- Water supply (drinking water, agriculture, aquaculture, industrial)
- Water recreation (contact and secondary recreation)
- Growth and propagation of fish, shellfish, other aquatic life, and wildlife

Alaska Water Quality Standards identify acceptable levels for designated use for categories of pollutants, including: pH, temperature, turbidity, fecal coliform bacteria; dissolved oxygen (DO); nutrients; sediment; metals; and toxic substances. Water quality criteria for designated water use classes are provided in two unique documents: 1) 18 AAC 70 Water Quality Standards, amended as of April 6, 2018; and 2) Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances (ADEC 2008).

Available water quality data within the Project vicinity comes from two primary sources. Upstream of the Project, the USGS analyzed water samples between 1954 to 1972. In 2005 and 2006, ADEC collected water quality data on the Nushagak River, just downstream of the confluence with the Nuyakuk River and above the village of Koligenik. A summary of available water quality data from these two sampling programs is provided in Tables 4-3 and 4-4.

Table 4-3. USGS water quality data at Gaging Station No. 1530200 from 1954-1972 (USGS 2019).

Analyte	Range	Units	No. of Samples	ADEC Criteria
pH	6.6-7.6	--	12	6.5-8.5. May not vary 0.5 pH units from ambient conditions
Temperature	0-11.5	º C	19	20º C
Specific Conductance	49-73	µS/cm	22	
Turbidity	0-1	JTU	5	
Carbon Dioxide	1.1-11	mg/L	12	
Bicarbonate	20-34	mg/L	12	
Organic Nitrogen	0.4	mg/L	1	
Ammonia	0	mg/L	1	
Nitrate	0-1.0	mg/L	24	
Phosphate	0.2	mg/L	1	
Hardness as $CaCo_3$	21-30	mg/L	12	
Calcium	6.4-9.5	mg/L	12	
Magnesium	0.7-1.6	mg/L	12	
Sodium	0.7-2.0	mg/L	12	
Potassium	0.1-0.4	mg/L	12	
Chloride	0-1.5	mg/L	12	230,000
Sulfate	3.7-8.0	mg/L	12	
Fluoride	0-0.5	mg/L	10	1,000
Silica	2.6-4.6	mg/L	12	
Manganese	0-10	mg/L	10	200
Iron	0-500	mg/L	12	1,000
Dissolved Solids	29-40	mg/L	12	1,000
Suspended Sediments	0-420	mg/L	16	

Table 4-4. ADEC water quality data on the Nushagak River downstream of the confluence with the Nuyakuk River and above the village of Koligenik from 2005-2006* (ADEC 2019).

Analyte	8/30/2005	6/13/2006	Units	No. of Samples	ADEC Criteria
pH	6.9	5.9-6.4	--	6	6.5-8.5. May not vary 0.5 pH units from ambient conditions
Temperature	11.6	6.0-6.4	°C	6	20°C
Specific Conductance	63	33-34	µS/cm	6	

Analyte	8/30/2005	6/13/2006	Units	No. of Samples	ADEC Criteria
Turbidity	2.3-2.6	4.4-5.2	NTU	10	
Dissolved Oxygen	9.9	11.2-11.3	mg/L	6	
Dissolved Oxygen	91.2	90.4-90.9	% Saturation	6	
Total Coliform	0-100	--	cfu/100 ml	5	
Fecal Coliform	1	18	cfu/100 ml	2	
Escherichia Coliform	0	--	cfu/100 ml	5	
Calcium Carbonate	25	40	mg/L	2	
Hardness as $CaCO_3$	26.1	20.9	mg/L	2	
Beryllium	0.4	0.4	µg/L	2	
Barium	7.55	5.27	µg/L	2	2,000
Cadmium	0.5	0.5	µg/L	2	5
Copper	1	1	µg/L	2	200
Iron	250	250	µg/L	2	1,000
Lead	0.2	0.2	µg/L	2	50
Magnesium	2030	1550	µg/L	2	
Manganese	4.04	5.19	µg/L	2	200
Mercury	0.2	0.2	µg/L	2	0.77
Molybdenum	10	10	µg/L	2	10
Nickel	2	2	µg/L	2	
Total Nitrogen	0.1	0.161	mg/L	2	
Potassium	500	500	µg/L	2	
Selenium	5	5	µg/L	2	5
Silicon	2,580	2,500	µg/L	2	
Silver	1	1	µg/L	2	
Sodium	1,790	1,270	µg/L	2	
Thallium	1	1	µg/L	2	
Tin	1	1	µg/L	2	
Titanium	7.14	5	µg/L	2	
Vanadium	20	20	µg/L	2	100
Zinc	5	5	µg/L	2	2,000
Total Phosphorus	0.1	--	mg/L	1	

Analyte	8/30/2005	6/13/2006	Units	No. of Samples	ADEC Criteria
Dissolved Phosphorus	200	200	µg/L	2	
Calcium	6,880	5,820	µg/L	2	
Chromium	3.77	1	µg/L	2	11
Cobalt	4	4	µg/L	2	50
Aluminum	20	20	µg/L	2	87
Antimony	1	1	µg/L	2	6
Arsenic	5	5	µg/L	2	10

* Data ranges provided when multiple samples were collected.

4.3.4.1 Turbidity, Dissolved Solids, and Suspended Sediments

The USGS and ADEC data indicate very low turbidity levels ranging from 0-1 Jackson Turbidity Units (JTU) upstream of the Project and 2.5-5.2 Nephelometric Turbidity Units (NTU) at the sampling station downstream. Concentrations of dissolved solids are provided by the USGS and range from 29-40 mg/L based on 12 sampling events. Dissolved solids in the Nuyakuk River are well below the ADEC criteria of 1,000 mg/L. The USGS also sampled for suspended sediments on 16 occasions, with concentrations ranging from 0-420 mg/L. The 420 mg/L suspended sediment sample was collected on October 1, 1967 and is a unique event, with the second highest suspended sediment concentration at 16 mg/L. The remaining 14 suspended sediment samples ranged from 0-6 mg/L (mean of 2.9 mg/L).

4.3.4.2 Nutrients

The USGS dataset contains nutrient data for various aqueous forms of nitrogen and phosphorus, with nitrate being the most frequently sampled analyte (n= 24) with ammonia and phosphate sample once in July of 1970. Ammonia was recorded at a concentration of 0 mg/L, phosphate at 0.2 mg/L, and nitrate concentrations ranging from 0-1.0 mg/L, well below the 10 mg/l ADEC criteria for nitrate.

The more recent ADEC data also indicates low nutrient concentrations downstream of the Project. Total nitrogen concentrations slightly exceed the 0.1 mg/L detection limit with 0.16 mg/L measured in June of 2006. Total and dissolved phosphorus concentrations did not exceed method detection limits of 0.1 mg/L and 200 ug/L respectively.

4.3.4.3 Trace Metals, Hardness, and Conductivity

Both the USGS and ADEC provide data for a variety of trace metals. The USGS data indicates that all of the analytes tested are in low concentrations and well below ADEC criteria. Similarly, the ADEC data are within ADEC criteria, with a majority of the analytes below detections limits. The only metals detected at concentrations above detection limits include barium, magnesium, manganese, silicon, sodium, titanium, calcium, and chromium.

Hardness as calcium carbonate ($CaCO_3$) ranged from 21-30 mg/L (n = 12) upstream of the Project while the downstream location ranged from 20.9 – 26.1 mg/L CaCO3 (n=2). With a method detection limit of 20 mg/L, these water hardness data indicate the Nuyakuk River falls within the low range.

Conductivity data confirms the low ion concentration in the Nuyakuk River system. Twenty-two USGS samples measured a specific conductance (conductivity at 25ºC) range of 49-73 uS/cm upstream of the Project. Downstream, ADEC measured specific conductance at a similar range of 33-63 uS/cm.

4.3.4.4 Coliform Bacteria

ADEC sampled for total, escherichia, and fecal coliform bacteria downstream of the Project site. Despite the presence of total coliform and low concentrations of fecal coliform, zero escherichia coliform bacteria were detected. Therefore, the majority of coliform bacteria present in these samples is most likely from non-pathogenic sources such as soil or vegetation.

4.3.4.5 pH

Upstream of the Project, pH data from the USGS ranges from 6.6 – 7.6 (n = 12) and meets ADEC criteria. However, the downstream site has slightly more acidic conditions with ADEC data showing a pH range of 5.8 to 6.9. It is likely that the decreased pH values downstream of the Project can be attributed to the influence of the Nushagak River.

4.3.4.6 Dissolved Oxygen and Temperature

Dissolved oxygen data are not available upstream of the Project, however, there are some spot data available on the Nuyakuk River from ADFG Fish Inventory Sampling in August of 2006 (ADFG 2006). Site FSN06-09B01 is located near the base of falls and measured a DO concentration of 10.7 mg/L. Another sampling station well downstream of the falls (FSN06-08B01) measured DO at 10.7 mg/L. Downstream of the Project, ADEC sampling show DO concentrations and percent saturation ranging from 9.9 – 11.3 mg/L and 90.4 – 91.2 percent saturation respectively.

Spot temperature readings from the USGS ranged from 0 – 11.5ºC between 1956-1972 (n= 22). Two ADFG spot measurements just downstream of the Project were 13.1ºC on August 11-12, 2006 (ADFG, 2006). ADEC spot temperature data in August of 2005 was 11.6ºC with multiple measurements in June of 2016 ranging from 5.8 - 6.4ºC.

4.3.5 Current Water Quality Data

4.3.5.1 Temperature

Since May of 2014, the USGS has been continuously monitoring water temperatures at gaging station 15302000, approximately 4 miles upstream of the Project location (Figure 4-8). ADEC criteria state that maximum temperatures may not exceed 20ºC at any time. From the May 19, 2014 to December 31, 2018 monitoring period, maximum daily temperatures have exceeded 20ºC on two occasions, July 18 and July 19 of 2016. Daily temperature statistics are calculated from data readings collected every 15 minutes (i.e., 96 readings per day). Therefore, it is possible that a single daily water temperature reading exceeded 20ºC, and the duration of criteria exceedance was for a short period of time. Daily average water temperatures for July 18-19, 2016 were 18.3 ºC on both days.

In addition to the USGS temperature monitoring station, Nushagak Cooperative installed thermaloggers at the Project location in July of 2018. Temperature data from the Project location have not been downloaded but shall be summarized and presented as a part of FERC progress reports and stakeholder meetings.

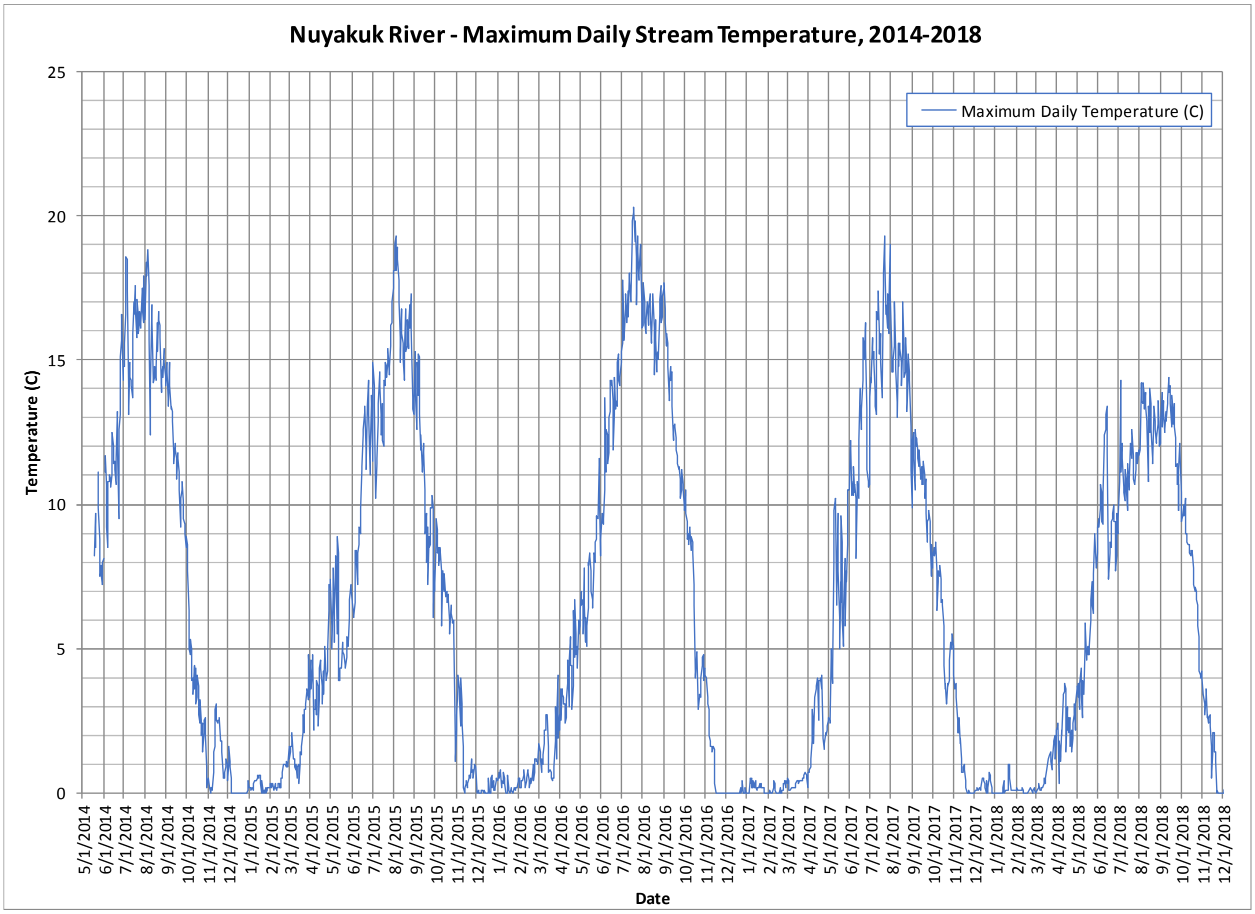

Figure 4-8. Maximum Daily Temperatures for the Nuyakuk River from May 19, 2004 – Dec 31, 2018 at Gaging Station No. 1530200 (USGS 2018).

4.3.6 Potential Adverse Effects

Potential adverse impacts to water resources, including water temperature, dissolved oxygen, or other physical and chemical parameters will be discussed with stakeholders during study planning and ultimately assessed during the licensing study process. Based on the current conceptual layout and operational regime identified for the Project, Table 4-5 below identifies potential adverse impacts related to water resources.

Table 4-5. Potential adverse impacts related to water resources.

Potential Adverse Impact	Associated Resource Effect

Construction of Project infrastructure in or immediately adjacent to the Nuyakuk River	Potential for short-term water quality impacts associated with the use of heavy machinery near the river associated with construction.

4.4 Fish and Aquatic Resources

4.4.1 Fish and Aquatic Resources Overview

The Nuyakuk River is approximately 29 miles long and flow in a generally southeast direction from its headwaters in Tikchik Lake to its confluence with the Nushagak River (ADNR 1990). The Nuyakuk River drains a complex of large lakes known as the Tikchik Lakes. The Tikchik Lakes are comprised of Nishlik Lake, Upnuk Lake, Chikuminuk Lake, Lake Chauekuktuli, Nuyakuk Lake, and Tikchik Lake. The lakes occupy glacially-carved, east-west oriented troughs along the eastern front of the rugged Wood River Mountains, which rise to elevations of more than 5,000 feet near their northern extent.

The Nuyakuk River is generally navigable downstream of a natural falls within Wood-Tikchik State Park, just upstream of the proposed Project location. The Nuyakuk River and Mulchatna Rivers are the two primary tributaries to the Nushagak River, which flows approximately 240 miles from its headwaters to Bristol Bay. Of these, the Nuyakuk River drains large headwater lakes, while the Mulchatna River drains only very small lakes or ponds (ADFG 2019b). The Nushagak River system in the fifth largest river in the State of Alaska by volume of water discharged (NMWC 2007).

The physiographic setting, hydrology, and water quality of the lakes, streams and rivers of the Tikchik Lakes system have been described in Section 4.3 (Water Resources). The adjacent Wood River Lakes system, that lies to the southwest, has a history of state, federal, and independent academic scientific fish studies (reviewed in ABR 2012); however, considerably fewer studies have been conducted on the Tikchik Lakes system leading to a paucity of site-specific background information. The majority of survey efforts in the Tikchik Lakes system have occurred during the last fifteen years. Administered by ADFG's Anadromous Waters Catalog (AWC) and Alaska Freshwater Fish Index (AFFI) programs, these studies primarily documented anadromous and resident fish populations (ADFG 2019a). Limited studies of lake trout have occurred in Heart Lake, Chikuminuk Lake, and Tikchik Lake (MacDonald 1996, Bosch et al.1995, Walsh et al. 2006). In addition, the southern three lakes of the system, Chauekuktuli, Nuyakuk, and Tikchik lakes were surveyed in 1961and 1962 for primary productivity, lake thermodynamics, bathymetry, and salmon spawning distributions (Burgner et al. 1969). The University of Washington's Fisheries Research Institute (FRI) has conducted studies on the region over the past 10 years which, if obtained, would provide valuable information regarding fish and aquatic resources. The Cooperative met with FRI on November 19, 2018 (Table 1-1). FRI indicated that they would be willing to provide the Cooperative with these data, but to date, the Cooperative's requests for data have not yielded responses. The Cooperative will continue to engage in collaborative communication with FRI during the Project licensing process.

Overall, twenty-four species of resident and anadromous fishes have been observed in the Wood–Tikchik lakes system, including all five species of Pacific salmon (Tables 4-6 and 4-7) (Burgner and Reeves 1965; Grumman Ecosystems Corporation 1971; Rogers 1977a, 1977b; Page and Burr 1991; ADFG 2019a). The Wood and Nuyakuk rivers have been estimated to account for upward of 20 percent of the total Bristol Bay sockeye salmon *(Oncorhynchus nerka*) escapement (Grumman Ecosystems Corporation 1972). Past sockeye salmon spawning surveys conducted by the ADFG have revealed that spawning occurs in several areas of Tikchik Lake, Tikchik River, Lake Nuyakuk, Lake Chauekuktuli, and in the lower Allen River (Weiland et al. 1994). Sockeye salmon have not been found in Lake Chikuminuk, most likely due to the presence of several potential fish migration impediments in the Allen River which limit the upstream extent of sockeye movement.

Table 4-6. Fish species likely to occur within the Wood-Tikchik Lakes system.

Common Name	Scientific Name	Life History
Pink salmon	*Oncorhynchus gorbuscha*	Anadromous
Sockeye salmon	*O. nerka*	Anadromous
Coho salmon	*O.kisutch*	Anadromous
Chum salmon	*O. keta*	Anadromous
Chinook salmon	*O. tshawytscha*	Anadromous
Rainbow trout	*O. mykiss*	Resident or Anadromous
Dolly Varden char	*Salvelinus malma*	Resident or Anadromous
Arctic char	*S. alpinus*	Resident
Lake trout	*S. namaycush*	Resident
Arctic grayling	*Thymallus arcticus*	Resident
Least cisco	*Coregonus sardinella*	Amphidromous
Humpback whitefish	*C. pidschian*	Amphidromous
Round whitefish	*Prosopium cylindraceum*	Resident
Pygmy whitefish	*P. coulteri*	Resident
Burbot	*Lota lota*	Resident
Northern pike	*Esox lucius*	Resident
Alaska blackfish	*Dallia pectoralis*	Resident
Arctic lamprey	*Lampetra japonica*	Anadromous
Alaskan brook lamprey	*L. alaskens*	Anadromous
Rainbow smelt	*Osmerus dentex*	Anadromous
Slimy sculpin	*Cottus cognatus*	Resident
Coastrange sculpin	*C. aleuticus*	Catadromous
Ninespine stickleback	*Pungitius pungitius*	Resident
Threespine stickleback	*Gasterosteus aculeatus*	Resident

Sources: ADFG 2019a, Grumman Ecosystems Corporation 1971, Burgner and Reeves 1965.

Table 4-7. Anadromous and resident fish species identified by ADFG Anadromous Waters Catalog and Alaska Freshwater Fish Inventory within the Tikchik Lakes system.

Waterbody	Anadromous Species	Resident Species
Nishlik Lake	sockeye salmon, Dolly Varden [b]	
Upnuk Lake	sockeye salmon	arctic char
Tikchik River	sockeye salmon, Chinook salmon, coho salmon, chum salmon, pink salmon, arctic lamprey, Alaskan brook lamprey	arctic char, arctic grayling, lake trout, burbot, northern pike, round whitefish, slimy sculpin
Chikuminuk Lake	Dolly Varden [b]	lake trout, slimy sculpin, ninespine stickleback
Allen River	sockeye salmon	
Chauekuktuli Lake	sockeye salmon	arctic char
Nuyakuk Lake	sockeye salmon, Chinook salmon, coho salmon, chum salmon, pink salmon, unspecified whitefish[c]	arctic char
Nuyakuk River	sockeye salmon, Chinook salmon, coho salmon, chum salmon, pink salmon, unspecified whitefish[c]	arctic char
Nushagak River	sockeye salmon, Chinook salmon, coho salmon, chum salmon, pink salmon, arctic lamprey, Alaskan brook lamprey unspecified whitefish[c]	arctic char, arctic grayling, rainbow trout, burbot, northern pike, round whitefish, slimy sculpin, longnose sucker, ninespine stickleback, threespine stickleback

[a] Lakes listed include species also observed in inlet streams. Major tributaries and connecting streams are listed separately.

[b] Dolly Varden are considered to exist as resident and anadromous populations (ADFG 2019a, Armstrong and Morrow 1980).

[c] Depending on species, may be resident or amphidromous.

Resident fish species are also abundant in the Wood–Tikchik State Park. Rainbow trout (*Oncorhynchus mykiss*), arctic grayling (*Thymallus arcticus*), lake trout (*Salvelinus namaycush*), arctic char (*Salvelinus alpinus*), Dolly Varden (*Salvelinus malma malma*), and northern pike (*Esox lucius*) are all common sport fish found in waters within the area (ADNR 2002). In addition to popular sport fish, Burgner and Reeves (1965) collected humpback whitefish (*Coregonus pidschian*), pygmy whitefish (*Prosopium coulterii*), least cisco (*Coregonus sardinella*), round whitefish (*Prosopium cylindraceum*), lake trout, burbot (*Lota lota*), threespine stickleback (*Gasterosteus aculeatus*), ninespine stickleback (*Pungitius pungitius*), and slimy sculpin (*Cottus cognatus*) in combination across the two lake systems.

Most fish species of the Project area are of management interest because of their use in subsistence and/or recreational activities and also their role in ecosystem dynamics. For these reasons, freshwater habitats for fish are protected by many state and federal water-quality and fish-habitat regulations. Because of their importance in commercial, sport, and subsistence harvest, anadromous fish (salmon, trout, and some whitefish populations) are of particular conservation interest, and development activities that could potentially affect anadromous fish waterbodies are regulated by ADFG, ADNR, and the National Marine Fisheries Service (NMFS).

Wood–Tikchik State Park is noted for its 12 primary interconnected lakes, six each in the Tikchik lakes and Wood River lakes systems. All lakes of the Wood–Tikchik lakes have been classified as temperate, deep (>30 m maximum depth) and generally nutrient poor (Grumman Ecosystems Corporation 1971, 1972). Both the Wood River and Tikchik lake systems are in the Nushagak fishing district of the Bristol Bay region and are managed by ADFG (Weiland et al. 1994). The Tikchik Lakes system experiences low to moderate sport fishing pressure and minor subsistence usage (Grumman Ecosystems Corporation 1971, 1972; ADNR 2002). In contrast, navigable water, road access, and several lodges in the southern Wood River lakes have resulted in increased sport fishing pressure and subsistence activities compared to the Tikchik lakes (Grumman Ecosystems Corporation 1971; Chihuly 1979).

The Wood River Lakes system has a relatively long history of state, federal, and independent academic scientific fish studies compared to the Tikchik Lakes system. The U.S. Fish and Wildlife Service (USFWS) started conducting surveys of sockeye salmon spawning and escapement in 1946 and ADFG has monitored salmon escapement for over 60 years by visual means and, more recently, by sonar estimation (Marriott 1964; Nelson 1966, 1967; Dunaway and Sonnichsen 2001). The University of Washington FRI has conducted frequent studies of anadromous and resident fishes over the last 50 years focusing on the Wood River lakes. FRI maintains three field stations throughout the Wood–Tikchik State Park, where past and current projects have collected data on primary productivity, bathymetry, and the climatology of the Wood River lakes. Additional data associated with spawning distribution and age structure of sockeye salmon populations are widely available (Church 1963; Burgner and Reeves 1965; Rogers 1967; Burgner et al. 1969; Rogers 1973, 1977a, 1977b; Chihuly 1979; Rogers and Rogers 1998; Ruggerone et al. 2000; Schindler et al. 2005; Lin et al. 2011; McGlauflin 2011).

The Nushagak River contributes to the world's largest wild sockeye salmon fishery, in Bristol Bay. From 1989-2008, Nushagak sockeye runs averaged 1.8 million fish. The River system also supports populations of chum, king, coho, and pink salmon. The Nushagak River is known for one of Alaska's largest king salmon runs, which averaged more than 150,000 from 1989 to 2009. A sonar site managed by ADFG is located 25 miles upstream of Bristol Bay on the Nushagak River and is used to monitor sockeye, king, and chum salmon during the months of June and July. Nushagak sockeye, king, and chum salmon runs occur in June and July, while pink and coho arrive in late summer (ADFG 2019b).

ADFG has established management plans for king and sockeye salmon in the Nushagak River. The king salmon fisheries management plan calls for a sustainable escapement goal of 40,000 to 80,000 fish and an in-river goal of 75,000 fish to support subsistence and sport fishing. The sockeye salmon fisheries management plan calls for a sustainable escapement goal of 340,000 to 760,000 sockeye salmon. However, when the projected Nushagak sockeye salmon run is less than 1,000,000 fish and the ratio of Wood River to Nushagak River sockeye exceeds three to one, ADFG manages the Nushagak River sockeye fishery on a lower optimum escapement goal of 235,000 fish, in order to allow for greater opportunity for harvests of strong Wood River sockeye salmon runs (ADFG 2019b).

The Nuyakuk River also supports anadromous species and is listed in ADFG's AWC (ADFG 2019a). According to the AWC, anadromous species found at the mouth of the Nuyakuk River include spawning chum, coho, Chinook, pink, and sockeye salmon, and rearing Chinook salmon. Arctic char and whitefishes are also present at the mouth of the Nuyakuk River. Arctic char, whitefishes, and spawning sockeye salmon are also present in the upper Nuyakuk River at Tikchik Lake.

ADFG conducted field fish inventories along the Nuyakuk River from August 11-12, 2006, and data from this field study are summarized in Table 4-8 below (ADFG 2006). Over 14 species of fish were identified during these surveys, including four species of salmon. It is anticipated that fish and aquatic resources will be investigated as part of the overall Project licensing study program.

Table 4-8. ADFG Fish Inventory Site Observations on the Nuyakuk River August 11-12, 2006 (ADFG 2006).

Common Name	Scientific Name	Life Stages Observed	Count
Arctic grayling	*Thymallus arcticus*	Juvenile/Adult	31
Arctic-Alaskan brook lamprey paired species	*Lampetra camtschatica/Lampetra alaskense*	Juvenile	5
Burbot	*Lota lota*	Juvenile	1
Chinook salmon	*Oncorhynchus tshawytscha*	Juvenile	255
Coho salmon	*Oncorhynchus kisutch*	Adult	2
Longnose sucker	*Catostomus catostomus*	Juvenile/Adult	162
Northern pike	*Esox lucius*	Juvenile/Adult	87
Pink salmon	*Oncorhynchus gorbuscha*	Adult	22,300
Rainbow trout	*Oncorhynchus mykiss*	Adult	5
Round whitefish	*Prosopium cylindraceum*	Juvenile/Adult/Spawning	16
Sculpin, unspecified	*Cottus* spp.	Juvenile	30
Slimy sculpin	*Cottus cognatus*	Juvenile/Adult	79
Sockeye salmon	*Oncorhynchus nerka*	Adult/Spawning	27
Threespine stickleback	*Gasterosteus aculeatus*	Juvenile/Adult	2

4.4.2 Invasive Fish and Aquatic Species

Currently there are no known invasive fish or aquatic species in the Project vicinity.

4.4.3 Federal and State Designated Habitats

The federal Magnuson-Stevens Fishery Conservation and Management Act (as amended by the Sustainable Fisheries Act of 1996) was constructed in congress to provide Fishery Management Plans (FMP) for the nation's important fisheries. The plans are administered by NMFS which has created management plans for the five Pacific salmon species. As required by law, FMP's for anadromous species extend into freshwaters. Special provisions under this legislation are in place to protect Essential Fish Habitat (EFH) for fisheries that have a management plan (NMFS 2019). EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". Specific areas of the major rivers, tributaries, lakes, and ponds that would be classified as sensitive anadromous fish spawning and rearing habitats will need to be identified as EFH for all waterbodies in the Project area. Once EFH components are fully identified, steps to ensure minimal disturbance to these areas both during and after construction of the Project will be required. Chief concerns during and after the construction periods will be the minimization of effluent releases, eliminating any alterations to EFH connectivity, and monitoring for and eliminating any potential behavioral changes in anadromous fish caused by increased anthropogenic activity in these streams.

Alaska's Title 16 is the state regulatory statute devised to protect aquatic habitat important to anadromous and resident fish. Information on aquatic habitat important to anadromous fish is maintained by ADFG in the AWC. NOAA Fisheries Service generally refers to the ADFG catalog when determining whether inland freshwater habitats warrant special protection under the Magnuson-Stevens Act. Because the AWC documents sockeye salmon in the Nuyakuk River, the habitat in these waters is automatically afforded special protection as EFH. Thus, any aquatic studies in the Project area would be required to identify and classify habitat important to sockeye salmon and special care must be taken to further identify potential Project impacts to EFH for these waterbodies. Additional information on resident fish habitat is maintained in ADFG's Alaska Freshwater Fish Index Database (AFFID). Under Title 16, maintenance of fish habitat for fish passage is required for all waterbodies where fish are known to be present. Thus, for all waterbodies in the Project area where habitat change may occur due to Project activities, including activities associated with baseline data collection (e.g., installation of flow gages, water quality monitors, and water temperature recorders; completion of geological core sample surveys, etc.) as well as construction activities a permit from the ADFG Division of Habitat will be required.

4.4.4 Aquatic, Fish, and Riparian Habitat

Fish and aquatic habitat in the Project area can be broadly categorized as stream and river (i.e., lotic or riverine) habitat or lake (i.e., lentic or lacustrine) habitat. The relative amounts of these habitats are determined by the physiographic characteristics of the area and geomorphic processes such as the ice, hydrologic, and sediment transport capacity of the system. Within lakes, habitat can be further categorized as littoral, pelagic, and benthic zones. Littoral zones are adjacent to the shoreline, interact with the riparian zone surrounding the lake, and may also have aquatic vegetation. The pelagic zone includes open water areas that are generally deep, while the benthic zone is the lowest level in a body of water and has interactions with sediment.

Riverine habitat can be classified in a variety of ways. The USFS (2001) uses a hierarchical approach that provides increasingly detailed classifications at each level. At the broad scale, stream habitats can be classified as slow water (i.e. pools) and fast water. Pools can be further classified as backwater, scour, and slough, while fast water can be classified as glide, riffle, and cascade. Fish can use different habitat types at different life stages or different times of the year (Bjornn and Reiser 1991). The character of the substrate with respect to relative amounts of fines, gravels, cobble, boulder and bedrock, also factor in to the quality and quantity of aquatic habitat for different species and life stages. For example, Hansen and Richards (1985) associated different aquatic insect behavioral types (i.e., burrower, swimmer, clinger, and sprawler) to different combinations of water velocity, depth, and substrate type in the Susitna River basin of south-central Alaska. An important physiographic factor affecting riverine habitat is gradient. Lower gradient reaches tend to have a higher frequency of pools with lower velocity water and finer substrate particles. Lower gradient reaches also tend to have wider flood plains and a higher prevalence of off-channel habitat such as side channels, side sloughs, and beaver ponds. The presence of pools and off-channel habitat is generally considered favorable for stream rearing salmonids while pool-tailouts and runs with coarse gravel are considered favorable for salmonid spawning (Bjornn and Reiser 1991).

The Tikchik and Wood Lake systems result from land-locked fiords created during the advancement and recession of glaciers. All lakes of the Wood–Tikchik systems have been classified as temperate, deep (>98 ft maximum depth; i.e., >30 m) and generally nutrient poor (Grumman Ecosystems Corporation 1971, 1972). Shorelines are generally steep except in areas where tributaries have created deltas. None of the Tikchik lakes have been surveyed in detail.

4.4.4.1 Fish Passage Barriers

Given the anadromous species known to be present upstream of the Project site and the available data, no permanent barriers to anadromous species are present on the Nuyakuk River up to and including the Project location. Based on initial observations, Nuyakuk Falls has the potential to be a velocity barrier to certain migratory species at distinct times of the year. Further assessment of the falls is anticipated to be a key study element of the natural resources study program associated with the Project licensing effort.

4.4.4.2 Sediment, Ice, and Geomorphology

As indicated above, fluvial geomorphic conditions are fundamental physical attributes that contribute to the quantity and quality of fish and aquatic spawning and rearing habitats. Bedload and suspended load transport rates for the Nuyakuk River are unknown at this time. As previously noted, the large, deep lakes in the Tikchik basin are sediment sinks that allow fine sediment delivered from upstream tributaries to settle out. Consequently, outlet rivers such as the Nuyakuk River have relatively low levels of fine sediment.

The presence of frazil ice, anchor ice, and continuous ice cover during the winter months can affect fish use in riverine habitats. Salmonids often redistribute to overwintering habitat near the onset of winter (Bjornn 1971). While portions of the Nuyakuk River both upstream and downstream of the Project area are known to fully ice over in the winter months, the area immediately above and below Nuyakuk Falls consistently remains ice free due to the gradient and associated velocity of water in this area.

Habitat utilization by salmonids can also change near the time of ice break-up in the spring (Jennings 1985). With the onset of warmer air temperatures during mid to late spring, the low-elevation snowpack melts first, causing the river discharge to increase. The rising water level puts pressure on the ice, causing fractures to develop in the ice cover. The severity of breakup is dependent upon the snow melt rate, the depth of the snowpack, and the amount of rainfall. Flooding and erosion that may occur during breakup are important factors influencing channel morphology. In addition, rising flows can make off channel habitats accessible for rearing by emerging fry. Lake Aleknagik (elevation 37 ft), in the Wood River system is usually ice-free from early June to late October. It is the first of the lakes to breakup with the others following successively within a two-week period (BLM 2005). Ice breakup on Tikchik Lake at elevation 305 ft would likely follow shortly thereafter.

4.4.4.3 Riparian Habitat

There are no previous riparian community studies or riparian baseline information specific to the Project location. It is anticipated that the riparian habitat in the Project vicinity will be assessed as part of the overall Project licensing study program. Because of the isolated nature of the Project site inside the Wood-Tikchik State park, it is expected that the riparian conditions along the Nuyakuk River have been largely undisturbed. The riparian community is an important component to fish and aquatic resources that provides streambank stability, nutrients, and woody debris. Large woody debris (LWD) (logs, stumps, and branches) is an important component of stream ecosystems. It increases aquatic habitat diversity through the formation of pools, meanders, undercut banks, and backwater areas, aids in energy dissipation and in the deposition of spawning gravel, and it traps sediment and organic debris that can retain nutrients in the ecosystem and influence the development of riparian habitat communities.

4.4.5 Instream Flows

The timing and magnitude of streamflow in a river are primary determinants of its physical, chemical and biological characteristics, including fish species composition and abundance. In a broad sense, streamflow serves two functions relative to fish and fish habitat; 1) streamflow provides physical space within which fish and other aquatic organisms can live, and 2) streamflow provides the necessary energy and forces to create and maintain physical structures and ecological function in and along the channel including pools, riffles, spawning areas (deposition of new gravels and flushing of fine sediments within existing gravels), off-channel habitats, and riparian communities. Both functions are important relative to promoting stream conditions conducive to fish production. The habitats of many riverine species including salmonids are influenced by streamflow and will vary by life history stage, which include upstream migration, spawning and egg incubation, fry and juvenile rearing, and juvenile/smolt downstream migration. The timing of when these life history stages occur within a given stream is termed species periodicity, which depends on the particular species of fish.

Fish and other aquatic fauna such as aquatic insects, often have specific flow-related requirements of water depth and velocity, and substrate types (Gore and Judy 1981), that along with other physical factors determine the quantity and quality of habitat. Streamflow also influences fish passage and other physical characteristics such as water temperature, substrate size distribution, stream bed morphology, and riparian function.

Physical habitat models are often used to develop functional relationships between the quantity of habitat and instream flow levels in a stream or river (i.e., habitat-flow relationships). These models often include habitat mapping, hydraulic modeling, hydrologic data analysis, and development of species and life stage specific habitat suitability criteria that define their water depth, water velocity, and substrate/cover affinities. However, no basic aquatic habitat mapping of the Project vicinity or development of habitat-flow relationships have been accomplished to date for the Nuyakuk River. Consequently, how streamflow regulation may influence the quantity and quality of habitats in the Nuyakuk River is currently unknown.

In addition to the provision of spatial elements that define fish habitat, streamflows are also important for creating and maintaining these habitats. Such flows generally fall into the category of peak flows which typically occur as part of the natural runoff cycle associated with snowmelt and glacial melt processes. The peak flows in the Nuyakuk River are poorly understood because of the lack of a sufficiently long record of mean daily flows. The peak flow regime (frequency and amplitude of hydrologic events) of a watershed is ecologically important because many biotic, riparian, geomorphic, and fluvial processes are tied to peak flow events. Altering the timing, frequency, or duration of peak flow events can reduce habitat diversity, cause river channels to degrade and disconnect from floodplains, disrupt migration and spawning cues for fish, affect the breeding and dispersal of amphibians, and alter the survival and distribution of juvenile fish and macroinvertebrates (NRC 1996; Richter et al. 1996). It is also well documented that extremely high flow events can scour spawning habitat and result in increased mortality to incubating salmonid eggs (Montgomery et al. 1996; Seiler et al. 1999; Schuett-Hames et al. 2000). Regulation of peak flow events can influence biological processes including species distribution and abundance, the transport of sediment and organic material such as large woody debris, and channel forming processes.

Groundwater flow can, in some systems provide a substantial contribution of the overall flow in a river. However, the majority of flow in the Nuyakuk River comes directly from Tikchik Lake, although there are likely locations of groundwater inflow occurring over the entire extent of the river down to its mouth. The locations and magnitude of groundwater inflows to the river is currently unknown. Groundwater inflow occurring in sloughs and side channels can provide flow and temperature constancy that creates is important spawning/egg incubation, juvenile rearing, and overwintering habitats.

It is important to note that if the Project is constructed as currently proposed, the overall footprint would be extremely small and all flow utilized for power production would essentially be removed immediately above the Nuyaukuk Falls and returned (via the tailrace) immediately below the falls. This short bypass reach would consist almost wholly of the falls (less than ½ mile) in an area where habitat value for all life stages is low.

4.4.6 Potential Adverse Effects

Potential adverse impacts will be discussed with stakeholders during study planning and ultimately assessed during the licensing study process. Based on the current conceptual layout and operational regime identified for the Project, Table 4-9 below identifies potential adverse impacts related to fish and aquatic resources.

Table 4-9. Potential adverse impacts related to fish and aquatic resources.

Potential Adverse Impact	Associated Resource Effect
Construction of Project infrastructure in or immediately adjacent to the Nuyakuk River	In-water work has the potential to have a short-term impact to spawning and rearing habitat immediately upstream of Nuyakuk falls
Bypass of a portion of the river flow around Nuyakuk Falls during operations	Potential for periodic delayed or prohibited migratory upstream passage of certain resident and anadromous fish species
False attraction flow from the Project tailrace during operations	Potential for delayed migration or mortality to upstream migrating resident and anadromous salmonids associated with tailrace outflow
Increased sediment load during construction of infrastructure in adjacent to the Nuyakuk River	Potential for short-term increases in sediment load during construction may have limited impact on fish habitat downstream of the Project area

4.5 Wildlife and Botanical Resources

4.5.1 Wildlife Resources

The diverse landscape of the Nushagak-Mulchatna watershed is composed of mountains, forest, tundra, lakes, and rivers, and supports a variety of wildlife species. Large mammalian species, including moose, caribou, and bears utilize the habitat for breeding, foraging, migration habitat (NMWC 2007). A 1990 Recreation Management Plan for the Nushagak and Mulchatna Rivers states that the density of moose in the area is moderate, and the density of caribou is low (ADNR et al. 1990). The watershed also provides habitat for smaller terrestrial mammals, such as wolverine, wolves, porcupine, and fox. Beaver and river otter utilize aquatic habitat including the streams and lakes in the region. Table 4-10 lists mammals that may be found in the Nushagak-Mulchatna watershed (NMWC 2007). Additionally, more than 150 avian species, waterfowl, shorebirds, raptors, owls, and songbirds, among others, use the Nushagak watershed for staging, nesting, molting, or year-round habitat (NMWC 2007, Brna and Verbrugge 2013).

The proposed Project is located in ADFG Game Management Unit (GMU) 17, subunit GMU 17B (Figure 4-9). Much of the information regarding wildlife ranges and populations is documented by ADFG according to GMU, and information regarding wildlife in GMU 17 is summarized in this section. It is anticipated that wildlife resources in the vicinity of the proposed Project will be investigated as part of the overall Project licensing study program.

Table 4-10. Mammals that may inhabit the Nushagak-Mulchatna watershed (NMWC 2007 and Brna and Verbrugge 2013).

Common Name	Scientific Name
Alaska tiny shrew	*Sorex yukonicus*
American beaver	*Castor canadensis*
American marten	*Martes americana*

Common Name	Scientific Name
American mink	*Neovision vision*
Arctic ground squirrel	*Spermophilus parryii*
Black bear	*Ursus americanus*
Brown bear, grizzly bear	*Ursus arctos*
Brown lemming	*Lemmus trimucronatus*
Caribou	*Rangifer tarandus*
Cinereus shrew, masked shrew, common shrew	*Sorex cinereus*
Collared pika	*Ochotona collaris*
Coyote	*Canis latrans*
Dall sheep	*Ovis dalli*
Dusky shrew, montane shrew	*Sorex monticolus*
Ermine, short-tailed weasel	*Mustela erminea*
Hoary marmot	*Marmota caligata*
Least weasel	*Mustela rixosa*
Little brown bat, little brown myotis	*Myotis lucifugus*
Lynx	*Lynx canadensis*
Meadow jumping mouse	*Zapus hudsonius*
Meadow vole	*Microtus pennsylvanicus*
Moose	*Alces alces*
Muskrat	*Ondatra zibethicus*
North American porcupine	*Erethizon dorsatum*
Northern bog lemming	*Synaptomys borealis*
Northern collared lemming	*Dicrostonyx groenlandicus*
Northern red-backed vole	*Myodes rutilus*
Porcupine	*Erethizon dorsatum*
Pygmy shrew	*Sorex hoyi*
Red fox	*Vulpes vulpes*
Red-backed vole	*Myodes rutilus*
Red squirrel	*Tamiasciurus hudsonicus*
River otter	*Luntra canadensis*
Singing vole	*Microtus miurus*
Snowshoe hare, varying hare	*Lepus americanus*
Tundra hare, Alaska hare	*Lepus othus*
Tundra shrew	*Sorex tundrensis*

Common Name	Scientific Name
Tundra vole, root vole	*Microtus oeconomus*
Weasel	*Mustela erminea*
Wolf	*Canis lupus*
Wolverine	*Gulo gulo*

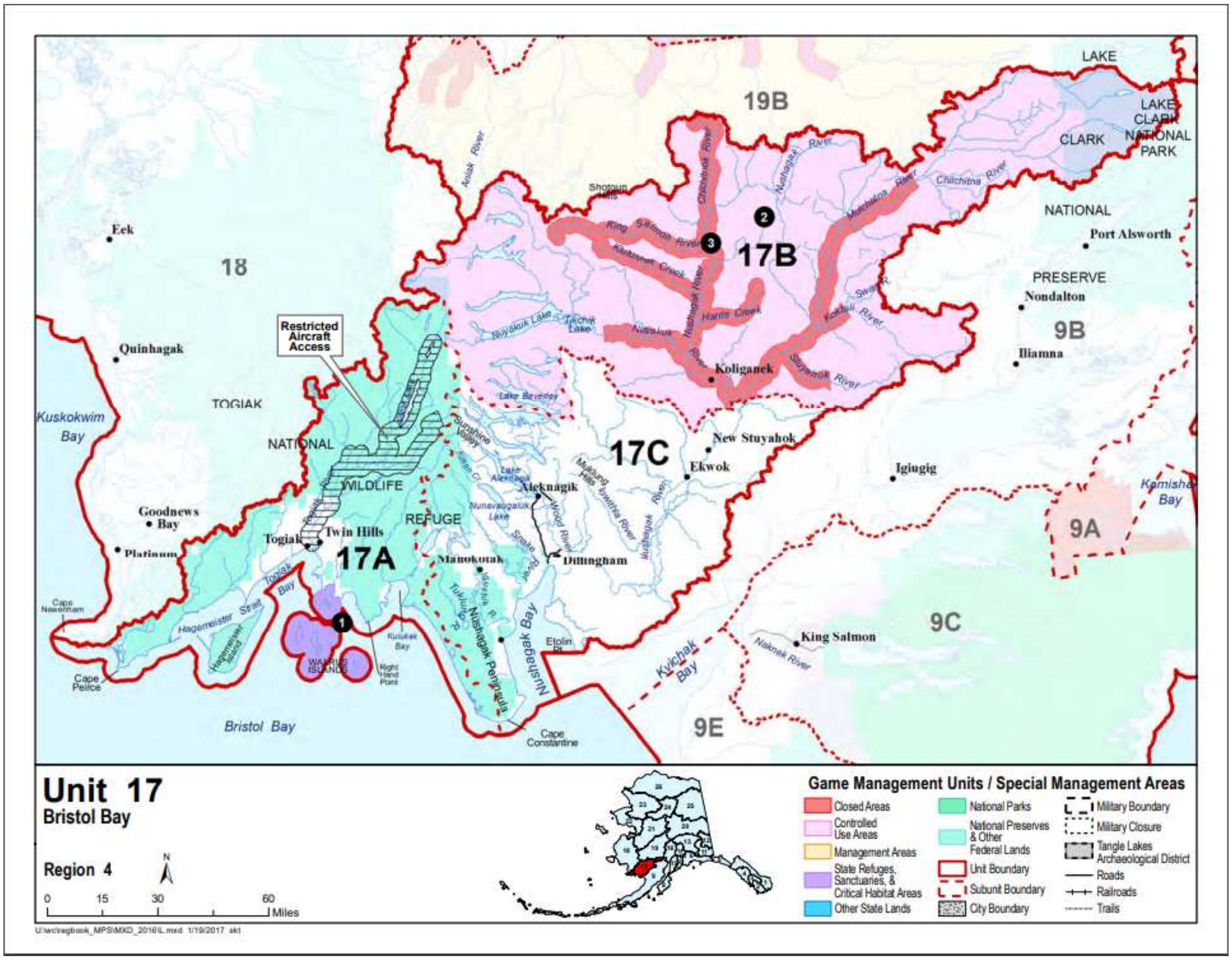

Figure 4-9. Map of Alaska GMU 17 (ADFG 2019a).

4.5.1.1 Moose

Specific information regarding moose populations does not currently exist for the Project location, so information available for the region and GMU 17 is presented in this section. Moose habitat varies seasonally and geographically based on their requirements for forage, protection from predators, specific nutrients, and refuge from deep winter snow. Productive areas of shrub growth, especially willows (Salix spp.), provide high-quality forage; aquatic areas provide important nutrients such as sodium and early emerging, high-quality spring vegetation (MacCracken et al. 1993, Kellie 2005); and mature forests with closed canopies provide areas with lower snow depths in winter. In mountainous areas, moose often move to higher elevations during the rut in fall and early winter but remain in low-elevation areas almost exclusively during winter, due to deep snow accumulations at higher elevations (Modaferri 1999). Snow deeper than about 70 cm limits moose mobility and covers many of the preferred forage species (Coady 1974, Collins and Helm 1997).

Moose have only recently moved into the Bristol Bay region, with the first reports occurring in the Wood–Tikchik area in the early 1900s (Grumman Ecosystems Corporation 1971. ADFG began collecting data on moose in GMU 17 in 1971, a time at which moose were not abundant (Faro 1973, cited in Woolington 2010a). High harvest of moose of either sex by local residents was suspected to be a major factor in keeping the population low in that period (Woolington 2010a). In the last several decades, however, the moose population has grown substantially and extended its range westward into the Togiak River drainage; moose are now common in the Wood–Tikchik area (Woolington 2010a). Possible reasons for the increase in population include relatively mild winters, decreased harvest of cows, and increased use of caribou by local hunters as an alternative resource (Woolington 2010a).

Based on the most recent moose surveys conducted by ADFG, the upper Nushagak watershed (GMU 17B) has an estimated 2,800-3,500 moose, and the lower drainage has an estimated 2,900-3,600 moose (ADFG 2019b). These moose comprise about 73 percent of the total populated in the Nushagak and Kvichak watersheds. Moose habitat has not been formally assessed in GMU 17, however, much of the watershed has large areas of riparian habitat including felt-leaf willow, which is a preferred browse species for moose (Brna and Verbrugge 2013).

Moose have been expanding rapidly in the Togiak National Wildlife Refuge (NWR). Aderman et al. (1995) estimated a density of 0.33 moose/mi^2 in the Togiak River drainage and Wood River Mountains west of the Wood River Lakes system. In a recent study, 83 radiotelemetry collars were deployed on female moose and it was reported that yearling moose in the Togiak NWR were among the heaviest on record, and that moose had very high rates of productivity, high calf survival, and high rates of calving for two-year-old moose (Aderman and Woolington 2011).

4.5.1.2 Caribou

Specific information regarding caribou populations does not currently exist for the Project location, so information available for the region and GMU 17 is presented in this section. Caribou are highly mobile animals with the lowest net cost of locomotion measured for any species of terrestrial mammal (Fancy and White 1987). Their distribution and habitat selection vary seasonally in response to different forage availability, predation threats, and insect harassment levels. Caribou generally prefer tundra and other open areas where predators are visible, but they also can be found in spruce forest or other closed habitats in some seasons. In winter, caribou feed primarily in areas with abundant lichens and low snow depth and hardness, such as windswept ridge tops or coastal areas (Tucker et al. 1991, Saperstein 1993). Caribou herds in Alaska are shown in Figure 4-10.

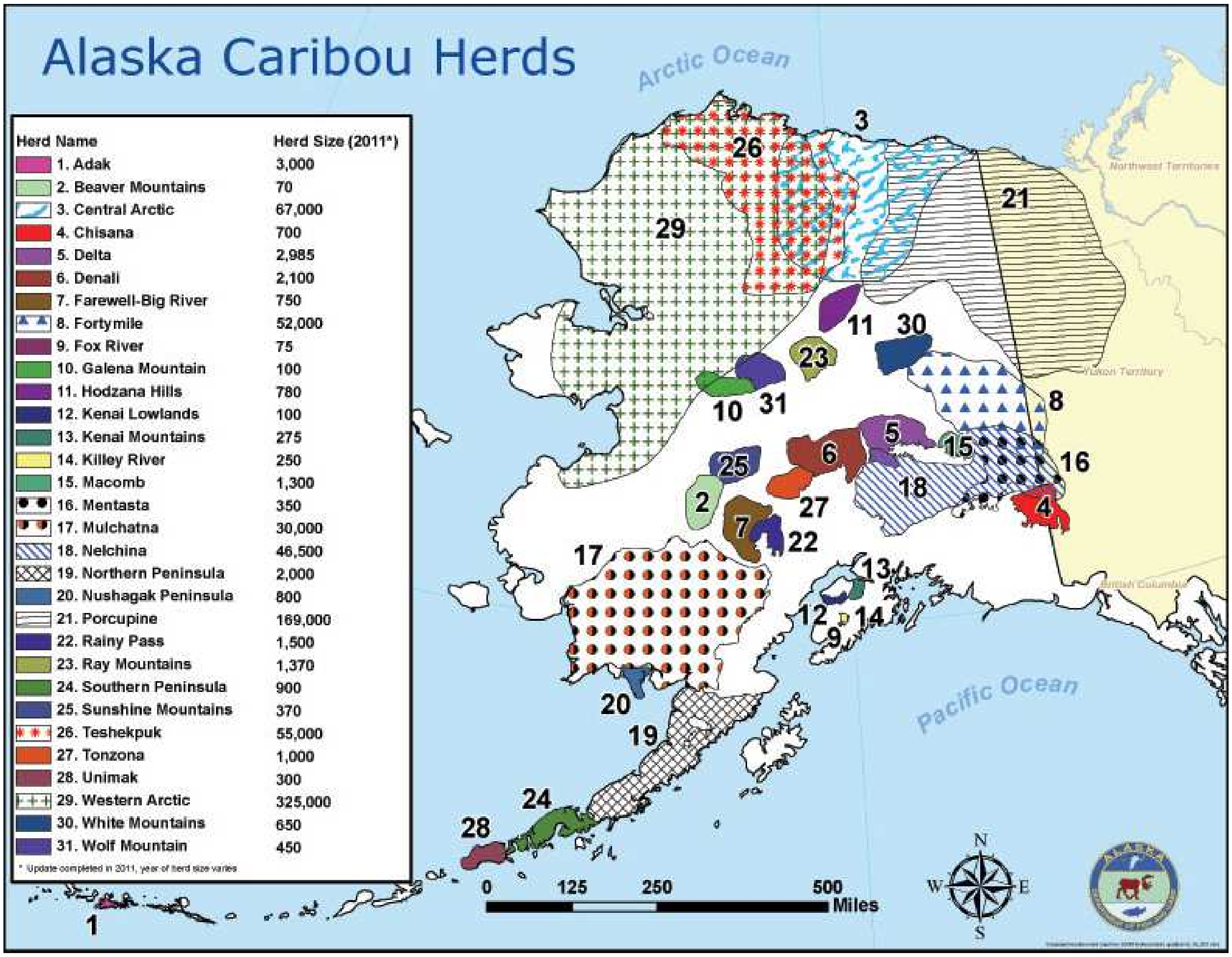

Figure 4-10. Alaska Caribou Herds (ADFG 2019c).

Caribou herds experience long-term population fluctuations and changing patterns of range use. A large number of caribou were present in southwest Alaska in the 1800s and was referred to as the Bering Seacoast Herd (Murie 1935, Skoog 1968, Hinkes et al. 2005). That herd apparently peaked in the 1860s and declined in the 1870s (Hinkes et al. 2005). Caribou were virtually absent from the Yukon–Kuskokwim Delta by 1880 but were still present in the Kilbuck Mountains (Petrof 1884, cited in Hinkes et al. 2005). Substantial numbers of caribou were reported in the Mulchatna River area in the early 1900s (Murie 1935).

According to ADFG’s caribou herd information, the caribou in the Project area most likely belong to the Mulchatna Herd (ADFG 2019c). Only 1,000 caribou were estimated to be in the Mulchatna Caribou Herd (MCH) in 1949 (Woolington 2003). The herd grew slowly over the next two decades, reaching about 5,000 animals by 1965 (Skoog 1968). Herd growth accelerated rapidly during the 1980s and early 1990s, however, peaking at approximately 200,000 animals in 1996 (Taylor 1989, Van Daele 1995, Woolington 2009a). Since then, the herd has declined steeply, and was estimated at just 30,000 caribou in July 2008, the most recent census (Woolington 2009a). Adult female survival rates increased in 2010 (Demma et al. 2011), raising the prospect that the herd may rebound.

Caribou are monitored by ADFG through the use of periodic population estimates, counts of sex and age composition, and tracking of harvest statistics. A collaborative study is being undertaken by researchers from the University of Alaska, ADFG, and USFWS on the linkages between climate, nutrient cycling, vegetation, and caribou for the five southwestern Alaska herds, focusing especially on the Unimak Herd (Spalinger et al. 2011). ADFG is studying MCH bull survival and recruitment, bull antler development and growth, and distribution of bulls (Demma et al. 2011). An ADFG calf survival study is estimating calf survival and recruitment rates and determining the cause of death for young calves. Preliminary results indicate that early calf mortality is largely due to an even mix of predation by wolves and bears (Demma et al. 2011). The number of caribou in the area likely varies annually and seasonally.

4.5.1.3 Brown Bear

Specific information regarding brown bear populations does not currently exist for the Project location, so information available for the region and GMU 17 is presented in this section. Brown bears occur throughout the region, although their preferred habitat occurs primarily in mountainous terrain. Brown bears are mobile generalist species that use large home ranges to exploit seasonally abundant resources. Brown bears will often feed on a variety of vegetation, berries, salmon, ungulates, and small mammals. They often feed on arctic ground squirrels in the spring. Vegetation in coastal sedge meadows and mudflats supports very high densities of bears in early summer (Rode et al. 2001). Bears will also feed on moose and caribou calves and berries during the summer. By mid and late summer, brown bears congregate at salmon streams, where available. Brown bears in alpine areas of Kodiak Island fed heavily in sedge–forb meadows (Atwell et al. 1980). Brown bears are often found in open areas, but riverine and forested areas commonly are used as travel corridors, for hunting moose calves, and for feeding on salmon.

Brown bears usually den at high elevations in winter. Female bear dens on the Kenai Peninsula were located in high-elevation areas with steep slopes and away from human disturbance (Goldstein et al. 2010). The vegetation at denning locations in the Talkeetna Mountains was alpine tundra (52 percent), shrubs (alder, willow, or birch; 35 percent), tussock grass and rocks (13 percent; Miller 1990). On Kodiak Island, brown bears denned most often in alder–willow thickets at elevations ranging from 100 to 3,300 ft above msl (Lentfer et al. 1972).

Grumman Ecosystems Corporation (1971) reported 17 sightings of brown bears during field work in 1970 in the area north of the proposed Project, with the majority occurring near Chauekuktuli, Chikuminuk, and Upnuk lakes. Several bear dens were noted on well drained slopes near Upnuk Lake. Important brown bear denning areas have been identified around Agenuk Mountain, north of Nishlik Lake, and in the upper Youth Creek valley (ADNR 2002). The brown bear habitat in GMU 17 is reported to be in excellent condition (Woolington 2009b). The brown bear harvest in GMU 17 has increased since the mid-1990s and 62 percent of reported brown bear harvest has come from GMU 17B in recent years (Woolington 2009b). Approximately 250 brown bears are estimated to inhabit the Kilbuck Mountains (Perry 2009). The density of brown bears in the Togiak NWR was estimated to be 40.4 bears/1,000 km^2 in 2003–2004 (Walsh et al. 2010), compared with 101 bears/1,000 km^2 in Katmai National Park and Preserve (Hamon et al. 2011), and 47.7–58.3 brown bears/1,000 km^2 in the area surrounding Iliamna Lake in 2009 (PLP 2011). Ruggerone et al. (2000) studied brown bear predation on spawning salmon in a tributary of Lake Aleknagik and found that bears could kill a large proportion of salmon (up to 92 percent) when the run was small.

A long-term brown bear study conducted in the Kuskokwim Mountains provides a great deal of information for southwest Alaska. During the period 1993–2003, Kovach et al. (2006) deployed radio-collars on 40 female brown bears in a study area including western Chikuminuk Lake and areas farther west, including much of the proposed transmission-line corridor. They reported a mean litter size of 2.0 cubs per female and survival rates of 90.1–97.2 percent for adult females, 48.2–61.7 percent for cubs of the year, and 73.3–83.8 percent for yearlings and two-year-olds. The population was estimated to be expanding during the first half of the study and declining during the second half of the study (Kovach et al. 2006). The home range of adult females ranged from 93 to 623 km² (Collins et al. 2005). During July, bears rested in alder and willow thickets when air temperatures were high (Van Daele et al. 2001). Bears occupied lower elevations in July and August when salmon were spawning and moved to higher elevations in September, probably reflecting selection for areas supporting arctic ground squirrels, berries, and caribou. Females with cubs were found at higher elevations than were females without cubs (Collins et al. 2005). Bears denned in areas of higher elevation (mean = 632 m): 71 percent in steep rocky areas and 13 percent in tundra habitats (Van Daele et al. 2001). Occupancy of winter dens generally began by mid-October and ended by mid-May (Collins et al. 2005). Individual bears showed fidelity to general denning areas, with an average distance between consecutively occupied dens of 4.5 km (SD = 3.1) between years. Bears were located farther from spawning streams when salmon escapement was low (Collins et al. 2005). Van Daele et al. (2001) also discuss some of the cultural barriers to brown bear management in the Kuskokwim Mountain area. No population estimate or habitat use data are available on brown bears in the immediate Project vicinity.

4.5.1.4 Black Bear

Specific information regarding black bear populations does not currently exist for the Project location, so information available for the region and GMU 17 is presented in this section. Black bears avoid open habitats and select closed forest and scrub habitats (Holm et al. 1999). In areas where brown and black bears occur together, black bears typically avoid areas used consistently by brown bears, such as salmon-spawning streams. In such areas, there is an inverse relationship between brown bear density and the proportion of salmon in black bear diets (Belant et al. 2006) and black bears are largely herbivorous and frugivorous (Jacoby et al. 1999, Belant et al. 2006, Fortin et al. 2007). In the spring, black bears seek out emerging green vegetation such as horsetails (*Equisetum* spp.), grasses, and sedges (*Carex* spp.), which are high in protein and easily digestible. Bears begin to eat berries and fruit as they begin to ripen in midsummer and continue feeding heavily on berries and fruit throughout the fall to store up energy for winter dormancy. They also feed on newborn ungulate calves, carrion, insects, and salmon (when brown bears are not present).

There have been no research activities by ADFG on black bears in GMU 17 but, based on incidental observations, they might be increasing in abundance (Woolington 2008). The greatest densities of black bear in GMU 17 are suspected to occur in spruce forest habitats along the upper Mulchatna, the upper Nushagak, and the Chichitnok rivers. Black bears are most frequently seen feeding on berries on open hillsides in the fall (ADFG 1973).

4.5.1.5 Wolf

Specific information regarding wolf populations does not currently exist for the Project location, so information available for the region and GMU 17 is presented in this section. The wolf is a generalist species that uses most habitats from alpine tundra to lowland coastal wetlands, depending on the distribution and abundance of prey. Wolves feed on a variety of prey species, including moose, caribou, beavers, hares, porcupines, small mammals, and salmon. Wolves are common throughout the northern Bristol Bay region but the population fluctuates due to periodic rabies epizootics and fluctuations in the availability of prey species, especially caribou (Woolington 2009c). Moose, caribou, and possibly beaver are thought to be the main prey for wolves in the northern Bristol Bay region, but wolf packs do not appear to follow the movements of the MCH (Woolington 2009c).

The gray wolf population in Alaska is estimated to be 7,000-10,000 wolves, with the highest densities on the islands in the southeastern panhandle. Wolf population numbers have not been well studied in the Nushagak watershed and are considered speculative (Brna and Verbrugge 2013). A trapper questionnaire conducted in 2000–2001 indicated that in GMU 17, wolves were abundant and their population was increasing (Scott and Kephart 2002). The wolf population in GMU 17 was also thought to be increasing from 2005–2008. Woolington (2009c) estimated that 280 to 320 wolves in 16 to 22 packs inhabited GMU 17B in 2008. With the recent decline in caribou numbers in the area, wolf numbers also may have declined. Walsh and Woolington (2008) deployed four radio-collars (two GPS and two VHF collars) on wolves from two packs near the Nushagak Peninsula to determine how much time they spent near caribou of the NPCH, and additional wolves have been collared in recent years (Walsh and Woolington 2011). A study of wolves in Lake Clark National Park and Preserve found that the main prey species in that location was moose, but some packs also fed heavily on salmon when available. The packs that had large components of salmon in their diet had smaller territories (Mangipane 2011).

4.5.1.6 Wolverine

Specific information regarding wolverine populations does not currently exist for the Project location, so information available for the region and GMU 17 is presented in this section. Wolverines have large home ranges and take a broad range of foods, consisting mostly of small mammals and birds, but also including carrion and, occasionally, larger mammals (Pasitschniak-Arts and Larivière, 1995). They occur at low densities and are sensitive to human disturbance (Pasitschniak-Arts and Larivière 1995, May et al. 2006). Wolverines in the middle Susitna River basin of south-central Alaska tended to use broad habitat categories (forest, scrub, rock/ice) in relation to availability but changed elevations seasonally. They moved to higher elevations where arctic ground squirrels and other small mammals were available during summer and lower elevations where moose carcasses were available in winter (Whitman et al. 1986).

Wolverine numbers in GMU 17 are thought to be stable (Woolington 2010b). A trapper questionnaire conducted in 2000–2001 indicated that wolverines were common in GMU 17 and their population was stable (Scott and Kephart 2002).

4.5.1.7 Beaver

Specific information regarding beaver populations does not currently exist for the Project location, so information available for the region and GMU 17 is presented in this section. The beaver is a keystone species of the regional ecosystem, meaning that their presence and activities profoundly affect the distribution of aquatic and riparian habitats and the abundance of fish and other wildlife species in those habitats (Johnston and Naiman 1987, Mitchell and Cunjak 2007). The only aquatic habitats unsuitable for beavers are fast-moving streams and rivers and those with widely varying levels of water flow. Beavers prefer to forage on aspen, balsam poplar (cottonwood), and willow but also eat birch and alder (Jenkins and Busher 1979).

Beavers are reported to be common in all major drainages and most of the smaller tributaries in GMU 17. Beavers were observed commonly along the Kisaralik River (Boyce and Fristensky 1984). A trapper questionnaire from 2000–2001 indicated that beaver populations were abundant and increasing in GMU 17 (Scott and Kephart 2002).

4.5.1.8 Snowshoe Hare

Specific information regarding snowshoe hare populations does not currently exist for the Project location, so information available for the region and GMU 17 is presented in this section. Snowshoe hares follow a roughly ten-year population cycle with peaks followed by a precipitous crash. Predators such as lynx, coyotes, Northern Goshawks, and Great Horned Owls will show a similar numerical response, often with a lag period. Other small mammals also show cyclical patterns, possibly due to food competition or as alternative prey for predators. Snowshoe hares can remove a large proportion of the standing shrub biomass (Hodges 1999) and in locations where they are abundant, snowshoe hares have a large effect on the ecosystem.

Snowshoe hares actively select habitats with dense understory cover in boreal coniferous forest, avoiding young regrowth, clearings, and other open areas (Hodges 1999). Dense understory is more important than canopy closure and interspersion of different stand types may be preferred. They are more likely to use deciduous forest types in summer than in winter due to the greater cover afforded by leaves and may occur in areas of sparse cover mainly during darkness. Open areas may be used more when hare densities are high (Wolff 1980). Dense understories provide escape cover and thermal protection and were correlated with spring densities and overwinter survival in Maine (Litvaitis et al. 1985).

In south-central Alaska, snowshoe hares preferred white spruce forest, alder, and willow plant communities during winter and early spring. Pellets contained predominately spruce, willow, Labrador tea, and dwarf birch with lesser amounts of blueberry, horsetail, and unidentified forbs and grasses. Alder was not an important forage species even though it was abundant (MacCracken et al. 1988). Areas used in winters when hare densities are low may be critical habitat to maintain remnant populations until the subsequent population increase (Wolff 1980). Snowshoe hare populations appeared to be moderate in GMU 17B from 2006–2009, although not quantified in ADFG reports (Woolington 2010b).

4.5.1.9 Other Furbearers

Specific information regarding other furbearer populations does not currently exist for the Project location, so information available for the region and GMU 17 is presented in this section. Other species of furbearers in the Wood–Tikchik area include coyote, red fox, lynx, river otter, marten, ermine, least weasel, mink, and muskrat. Grumman Ecosystems Corporation (1971) reported that the most common furbearers in the Wood–Tikchik areas were beaver, muskrat, river otter, red fox, and wolverine.

River otter populations increased in GMU 17 during the 1980s and appear to have been stable since the 1990s (Woolington 2010a). Muskrats are reported to be rare in GMU 17, although they have been more numerous in the past (Woolington 2010a). Coyotes have become common in GMU 17, with the highest densities occurring along the lower Nushagak River and on the Nushagak Peninsula (Woolington 2010a). Lynx have never been common in GMU 17, although their numbers increased in the early 1990s. Both lynx and snowshoe hare numbers were low during 2006–2009 (Woolington 2010a).

A trapper questionnaire conducted in 2000–2001 indicated that coyotes and muskrats were scarce but increasing in GMU 17; lynx were scarce and stable; ermine were common and stable; marten, mink, and hares were common and increasing; and red foxes and river otters were abundant and increasing (Scott and Kephart 2002). In the Kisaralik River drainage between Chikuminuk Lake and the Kuskokwim River, muskrats were recorded on the lower river, river otter tracks were common on the middle and lower river, mink tracks and red foxes were observed along the entire river (Boyce and Fristensky 1984, Brown et al. 1985).

4.5.1.10 Small Mammals

Specific information regarding small mammal populations does not currently exist for the Project location, so information available for the region and GMU 17 is presented in this section. Small mammals likely present in the Project study area include as many as five species of shrews, three species of squirrels and marmots, porcupines, and as many as nine species of mice, voles, and lemmings (Table 4-10).

Shrew distributions are related to invertebrate abundance, temperature, and moisture, and they appear to require adequate ground cover. Pygmy shrews prefer boreal habitats where both dry and wet habitats are found together in proximity to water (Long 1974). The cinereus shrew can be found in a wide variety of habitats but prefers moist areas within habitats, often near mosses (Whitaker 2004). The dusky shrew is found in montane and boreal habitats with dense ground cover—often in clearcuts with dense herbaceous ground cover (Smith and Belk 1996).

The Alaska tiny shrew, the smallest mammal in North America, was described as a new species (*Sorex yukonicus*) only in 1997, although Hope et al. (2010) have since concluded that it is conspecific with *S. minutissimus*, an Old World species. When he described the species, Dokuchaev (1997) listed only three locations where it had been recorded, but specimen records increased quickly as researchers looked for it elsewhere in the state. By the late 1990s and early 2000s, the species had been recorded over a broad area of interior, western, and northern Alaska. By 2007, the total number collected statewide had increased to 38 specimens from at least 22 locations (MacDonald and Cooke 2009), including the Togiak NWR (Peirce and Peirce 2000) and Lake Clark National Park and Preserve (Cook and MacDonald 2005). Early information on habitat affinities indicated that it occurred primarily in riparian habitats, but as trapping efforts expanded, it also was captured in scrub habitats. The Alaska Natural Heritage Program classifies the Alaska tiny shrew as “unrankable” globally (GU), presumably because little information is available; as “vulnerable” in the state (S3; AKNHP 2019c), probably due to restricted range and relatively few populations; and it was listed as a sensitive species by BLM (2010), presumably because of its S3 ranking by AKHNP. That ranking warrants further scrutiny, however, in view of the species' cryptic nature, the possibility of misidentification, the difficulty of capture, and the widespread distribution documented by inventory work in the relatively brief time since the species was described (MacDonald and Cook 2009).

Arctic ground squirrels live in arctic and alpine tundra, meadows, riverbanks, and lakeshore habitat. They prefer permafrost-free areas with loose soils, good visibility, and an adequate supply of low, early successional vegetation (MacDonald and Cook 2009). They survive the long winters by putting on large fat reserves during the summer and dropping their body temperature below the freezing point of water during winter hibernation (Barnes 1989, Buck and Barnes 1999). Arctic ground squirrels were reported to be common on the upper and middle Kisaralik River (Boyce and Fristensky 1984, Brown et al. 1985).

Red squirrels are abundant across much of boreal Canada and the northern and western United States but are largely restricted to coniferous forest, although they also may use mixed forest (Steele 1998). They prefer coniferous habitats for the abundant conifer seed, fungi, and interlocking canopies that allow for effective escape from predators and efficient foraging (Steele 1998).

Hoary marmots live in small colonies of 2 to 36 animals in areas above treeline with suitable vegetation for forage and rocky areas for escape cover. They feed on the leaves of herbaceous plants in early summer, flowers of herbaceous plants in midsummer, and herbs and forbs in late summer (Braun et al. 2011). In south-central Alaska, Carex species made up 78 to 91 percent of the total dry weight of the diet (Holmes et al. 1994). Juvenile survival is strongly affected by winter climate, especially snow depth (Patil 2010).

The northern red-backed vole is one of Alaska's most ubiquitous and common mammal species, inhabiting forest, scrub land, alpine tundra, and riparian areas throughout much of the state (MacDonald and Cook 2009). They feed on fungi, berries, succulent green plants, and lichens (Bangs 1984). Northern red-backed voles have large interannual fluctuations in density that are strongly influenced by climate. Overwinter survival was influenced by winter severity and snow depth; food availability was influenced by green-up date; and early summer precipitation influenced survival of the first litter (Rexstad and Debevec 2002).

Tundra, or root, voles inhabit a wide variety of open herbaceous habitats at various elevations. Although they can be found in scrub land, tundra, grassland, and riparian areas, they are most abundant in wet sedge and grass–forb meadows and bogs (MacDonald and Cook 2009). In northern Alaska, tundra voles reach their highest densities in swales and watercourses with dense, wet meadows dominated by sedges (*Carex* spp. and *Eriophorum* spp.), their primary food plants (Bee and Hall 1956, Batzli and Henttonen 1990).

Brown lemmings are usually associated with wet sedge-grass meadow but move to higher ground when preferred areas are flooded (McDonald and Cook 2009). Collared lemmings are usually associated with higher, drier, rockier tundra and often associated with cotton-grass sedges (Bee and Hall 1956, McDonald and Cook 2009).

Grumman Ecosystems Corporation (1971) reported that arctic ground squirrels and hoary marmots were abundant in the Wood–Tikchik region. Trappers responding to an ADFG questionnaire in 2000–2001 indicated that mouse and rodent populations were abundant and increasing in GMU 17 (Scott and Kephart 2002).

In their survey of small mammals in Wood–Tikchik State Park, Nolan and Peirce (1996) trapped meadow jumping mice, pygmy shrews, northern red-backed voles, cinereus shrews, dusky shrews, and ermines, and observed arctic ground squirrels and red squirrels. Peirce and Peirce (2000, 2005) captured eight species of small mammals in the Goodnews River drainage: four species of shrew (cinereus, pygmy, Alaska tiny shrew, and tundra shrew) and four microtine rodents (tundra vole, northern red-backed vole, collared lemming, and brown lemming).

In 2003, the University of Alaska Museum conducted field surveys of small mammals for the federal Bureau of Land Management (BLM) north and west of Iliamna Lake and in the Kvichak and Nushagak river valleys (Jacobsen 2004). Seventeen species were documented with vouchered specimens: four species of shrews (cinereus, pygmy, montane, and tundra), river otter, marten, hoary marmot, arctic ground squirrel, red squirrel, meadow jumping mouse, northern red-backed vole, collared lemming, brown lemming, root vole, meadow vole, northern bog lemming, and porcupine. The most frequently captured small mammals were cinereus shrew, montane shrew, and northern red-backed vole. Small mammals were most diverse and abundant in scrub and forest habitats (Jacobsen 2004).

4.5.1.11 Little Brown Bat

The little brown bat is the most widely distributed and common species of bat in Alaska and Canada, inhabiting areas with some degree of forest cover (van Zyll de Jong 1985, MacDonald and Cook 2009). During summer, little brown bats roost in natural cavities, under loose bark, in rock crevices, in dead or hollow trees, and in buildings; females with young roost in communal maternity colonies numbering from a few bats to more than a thousand (van Zyll de Jong 1985). Little brown bats generally occupy caves during winter hibernation. The species has been found hibernating in caves in southeastern Alaska and has been recorded on Kodiak Island in the winter months, but it is not known if bats in interior Alaska migrate to the south coast or hibernate elsewhere (Parker et al. 1997). The population of little brown bats in the eastern United States is experiencing a precipitous decline due to mass mortality caused by white-nose syndrome and the eastern population has a high probability of regional extinction in coming decades (Frick et al. 2010). Concern has been expressed about the possibility of white-nose syndrome being transported to Alaska (Wright and Moran 2011).

Grumman Ecosystems Corporation (1971) reported little brown bats in the Wood–Tikchik region but provided no supporting details. Nolan and Peirce (1996) observed a colony of little brown bats occupying a cabin in summer on the Agulukpak River in Wood–Tikchik State Park, but did not report whether it was a maternity colony. Specimens have been collected near Iliamna Lake, King Salmon, and Sleetmute, on the Kuskokwim River (Parker et al 1997).

4.5.1.12 Amphibians

The only amphibian expected to occur in the Project vicinity is the wood frog (*Rana sylvatica*). Wood frogs occur in a wide variety of habitats during the year. Mature adults congregate in wetland areas to breed in the spring (beginning in late April to early May) and then move into adjacent wetland and upland habitats, usually within a few hundred yards of the breeding areas, during the summer (MacDonald 2010). Beaver ponds provide high-value habitat for wood frogs (Stevens et al. 2006). Egg-laying occurs in small ponds or lakes in wooded or open habitats; wood frogs reportedly avoid egg predation by fish by selecting waterbodies that are free of fish (Gotthardt 2005). Birds, such as gulls, prey on frogs during the breeding season. Wood frog breeding populations may vary by a factor of ten and juvenile populations may vary by a factor of 100 among years (Berven 1990). Adult survival depends on rainfall, drought, and winter severity (Berven 1990, Anderson 2004). Wood frogs hibernate throughout the winter under snow cover in shallow depressions of compacted forest litter, entering hibernation as early as late August. The species is remarkable because of its ability to tolerate freezing during winter hibernation by producing cryoprotectant chemicals that act as a natural "antifreeze" to prevent cell disruption, allowing up to 65 percent of the water in their bodies to crystallize and their body temperature to drop as low as –12 °C (MacDonald 2010).

Wood frogs have been recorded northwest of Iliamna Lake (Jacobsen 2004, PLP 2011) and southwest of Iliamna Lake near Kaskanak Creek (Jacobsen 2004). They also have been reported in Lake Aleknagik in the Wood River system and along the lower Kuskokwim and Yukon rivers (MacDonald 2010). About 50 percent of the waterbodies mapped for the proposed Pebble Mine Project northwest of Iliamna hosted wood frogs in the spring; deep ponds with aquatic vegetation and with hibernation habitat nearby were most likely to contain frogs (PLP 2011).

4.5.1.13 Birds

The diverse landscape in the Bristol Bay watershed, the larger watershed which includes the Nushagak watershed where the Project is located, as well as the Kvichak watershed, provides habitat for a variety of avian species (Table 4-11). The lake and stream habitats in the Project vicinity are used by several species of waterfowl, shorebirds, and other waterbirds. Forest and scrub habitats are predominately occupied by landbirds and may support some tree-nesting raptors. Tundra habitats are predominantly occupied by shorebirds and some landbirds. Cliffs and bluffs along river corridors and rocky outcrops in the mountains are used by cliff-nesting raptors (Golden Eagles, Rough-legged Hawks, and falcons). All migratory species of birds are protected under the Migratory Bird Treaty Act (MBTA); eagles are also protected by federal law under the Bald and Golden Eagle Protection Act. Both species of eagles occur in the Project area.

Table 4-11. Bird species that may occur in the Bristol Bay watershed. An asterisk in the Breeder column indicates species that are known to breed in areas within or adjacent to the Bristol Bay watershed (Brna and Verbrugge 2013).

Common Name	Scientific Name	Breeder
Waterfowl		
Greater White-fronted Goose	*Anser albifrons*	*
Emperor Goose	*Chen canagica*	*
Snow Goose	*Chen caerulescens*	
Brant	*Branta bernicla*	*
Cackling Goose	*Branta hutchinsii*	

Common Name	Scientific Name	Breeder
Canada Goose	*Branta canadensis*	*
Trumpeter Swan	*Cygnus buccinator*	*
Tundra Swan	*Cygnus columbianus*	*
Gadwall	*Anas strepera*	*
Eurasian Wigeon	*Anas penelope*	
American Wigeon	*Anas americana*	*
Mallard	*Anas platyrhynchos*	*
Northern Shoveler	*Anas clypeata*	*
Northern Pintail	*Anas acuta*	*
Green-winged Teal	*Anas crecca*	*
Canvasback	*Aythya valisineria*	
Redhead	*Aythya americana*	
Ring-necked Duck	*Aythya collaris*	*
Greater Scaup	*Aythya marila*	*
Lesser Scaup	*Aythya affinis*	
Steller's Eider	*Polysticta stelleri*	
Spectacled Eider	*Somateria fischeri*	
King Eider	*Somateria spectabilis*	
Common Eider	*Somateria mollissima*	*
Harlequin Duck	*Histrionicus histrionicus*	*
Surf Scoter	*Melanitta perspicillata*	*
White-winged Scoter	*Melanitta fusca*	*
Black Scoter	*Melanitta americana*	*
Long-tailed Duck	*Clangula hyemalis*	*
Bufflehead	*Bucephala albeola*	*
Common Goldeneye	*Bucephala clangula*	*
Barrow’s Goldeneye	*Bucephala islandica*	
Common Merganser	*Mergus merganser*	*
Red-breasted Merganser	*Mergus serrator*	*
Gallinaceous Birds		
Spruce Grouse	*Falcipennis canadensis*	*
Willow Ptarmigan	*Lagopus lagopus*	*
Rock Ptarmigan	*Lagopus muta*	*
Rock Ptarmigan	*Lagopus leucura*	*

Common Name	Scientific Name	Breeder
Loons		
Red-throated Loon	*Gavia stellata*	*
Pacific Loon	*Gavia pacifica*	*
Common Loon	*Gavia immer*	*
Grebes		
Horned Grebe	*Podiceps auritus*	*
Red-necked Grebe	*Podiceps grisegena*	*
Tubenoses		
Northern Fulmar	*Fulmarus glacialis*	
Sooty Shearwater	*Puffinus griseus*	
Short-tailed Shearwater	*Puffinus tenuirostris*	
Fork-tailed Storm-Petrel	*Oceanodroma furcata*	
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	
Cormorants		
Double-crested Cormorant	*Phalacrocorax auritus*	*
Red-faced Cormorant	*Phalacrocorax urile*	*
Pelagic Cormorant	*Phalacrocorax pelagicus*	*
Hawks, Eagles, Falcons		
Osprey	*Pandion haliaetus*	*
Bald Eagle	*Haliaeetus leucocephalus*	*
Northern Harrier	*Circus cyaneus*	*
Sharp-shinned Hawk	*Accipiter striatus*	
Northern Goshawk	*Accipiter gentilis*	*
Red-tailed Hawk	*Buteo jamaicensis*	*
Rough-legged Hawk	*Buteo lagopus*	*
Golden Eagle	*Aquila chrysaetos*	*
American Kestrel	*Falco sparverius*	
Merlin	*Falco columbarius*	*
Gyrfalcon	*Falco rusticolus*	*
Peregrine Falcon	*Falco peregrinus*	*
Cranes		
Sandhill Crane	*Pluvialis squatarola*	
Shorebirds		
Black-bellied Plover	*Pluvialis squatarola*	*

Common Name	Scientific Name	Breeder
American Golden-Plover	*Pluvialis dominica*	*
Pacific Golden-Plover	*Pluvialis fulva*	*
Semipalmated Plover	*Charadrius semipalmatus*	*
Black Oystercatcher	*Haematopus bachmani*	*
Spotted Sandpiper	*Actitis macularius*	*
Solitary Sandpiper	*Tringa solitaria*	
Wandering Tattler	*Tringa incana*	*
Greater Yellowlegs	*Tringa melanoleuca*	*
Lesser Yellowlegs	*Tringa flavipes*	*
Whimbrel	*Numenius phaeopus*	*
Bristle-thighed Curlew	*Numenius tahitiensis*	
Hudsonian Godwit	*Limosa haemastica*	*
Bar-tailed Godwit	*Limosa lapponica*	*
Marbled Godwit	*Limosa fedoa*	*
Ruddy Turnstone	*Arenaria interpres*	
Black Turnstone	*Arenaria melanocephala*	*
Surfbird	*Aphriza virgata*	*
Red Knot	*Calidris canutus*	
Sanderling	*Calidris alba*	
Semipalmated Sandpiper	*Calidris pusilla*	
Western Sandpiper	*Calidris mauri*	*
Least Sandpiper	*Calidris minutilla*	*
Baird’s Sandpiper	*Calidris bairdii*	*
Pectoral Sandpiper	*Calidris melanotos*	*
Rock Sandpiper	*Calidris ptilocnemis*	*
Dunlin	*Calidris alpina*	*
Short-billed Dowitcher	*Limnodromus griseus*	*
Long-billed Dowitcher	*Limnodromus scolopaceus*	
Wilson’s Snipe	*Gallinago delicata*	*
Red-necked Phalarope	*Phalaropus lobatus*	*
Red Phalarope	*Phalaropus fulicarius*	
Gulls and Terns		
Black-legged Kittiwake	*Rissa tridactyla*	*
Sabine’s Gull	*Xema sabini*	*

Common Name	Scientific Name	Breeder
Bonaparte's Gull	*Chroicocephalus philadelphia*	*
Mew Gull	*Larus canus*	*
Herring Gull	*Larus argentatus*	
Slaty-backed Gull	*Larus schistisagus*	
Glaucous-winged Gull	*Larus glaucescens*	*
Glaucous Gull	*Larus hyperboreus*	*
Aleutian Tern	*Onychoprion aleuticus*	*
Arctic Tern	*Sterna paradisaea*	*
	Jaegers	
Pomarine Jaeger	*Stercorarius pomarinus*	
Parasitic Jaeger	*Stercorarius parasiticus*	*
Long-tailed Jaeger	*Stercorarius longicaudus*	*
	Alcids	
Common Murre	*Uria aalge*	*
Thick-billed Murre	*Uria lomvia*	*
Pigeon Guillemot	*Cepphus columba*	*
Marbled Murrelet	*Brachyramphus marmoratus*	*
Kittlitz's Murrelet	*Brachyramphus brevirostris*	*
Ancient Murrelet	*Synthliboramphus antiquus*	
Parakeet Auklet	*Aethia psittacula*	*
Rhinoceros Auklet	*Cerorhinca monocerata*	
Horned Puffin	*Fratercula corniculata*	*
Tufted Puffin	*Fratercula cirrhata*	*
	Owls	
Great Horned Owl	*Bubo virginianus*	*
Snowy Owl	*Bubo scandiacus*	
Northern Hawk Owl	*Surnia ulula*	*
Great Gray Owl	*Strix nebulosa*	*
Short-eared Owl	*Asio flammeus*	*
Boreal Owl	*Aegolius funereus*	*
Northern Saw-whet Owl	*Aegolius acadicus*	*
	Hummingbirds	
Rufous Hummingbird	*Selasphorus rufus*	
	Kingfishers	

Common Name	Scientific Name	Breeder
Belted Kingfisher	*Megaceryle alcyon*	*
Woodpeckers		
Downy Woodpecker	*Picoides pubescens*	*
Hairy Woodpecker	*Picoides villosus*	
American Three-toed Woodpecker	*Picoides dorsalis*	*
Black-backed Woodpecker	*Picoides arcticus*	*
Northern Flicker	*Colaptes auratus*	*
Flycatchers		
Olive-sided Flycatcher	*Contopus cooperi*	*
Alder Flycatcher	*Empidonax alnorum*	*
Say's Phoebe	*Sayornis saya*	*
Shrikes		
Northern Shrike	*Lanius excubitor*	*
Crows, Jays, Magpies		
Gray Jay	*Perisoreus canadensis*	*
Steller's Jay	*Cyanocitta stelleri*	
Black-billed Magpie	*Pica hudsonia*	*
Northwestern Crow	*Corvus caurinus*	*
Common Raven	*Corvus corax*	*
Larks		
Horned Lark	*Eremophila alpestris*	*
Swallows		
Tree Swallow	*Tachycineta bicolor*	*
Violet-green Swallow	*Tachycineta thalassina*	*
Bank Swallow	*Riparia riparia*	*
Cliff Swallow	*Petrochelidon pyrrhonota*	*
Barn Swallow	*Hirundo rustica*	*
Chickadees		
Black-capped Chickadee	*Poecile atricapillus*	*
Boreal Chickadee	*Poecile hudsonicus*	*
Nuthatches		
Red-breasted Nuthatch	*Sitta canadensis*	*
Creepers		
Brown Creeper	*Certhia americana*	*

Common Name	Scientific Name	Breeder
Wrens		
Pacific Wren	*Troglodytes pacificus*	*
Dippers		
American Dipper	*Cinclus mexicanus*	*
Kinglets		
Golden-crowned Kinglet	*Regulus satrapa*	*
Ruby-crowned Kinglet	*Regulus calendula*	*
Old World Warblers		
Arctic Warbler	*Phylloscopus borealis*	*
Thrushes		
Northern Wheatear	*Oenanthe oenanthe*	
Gray-cheeked Thrush	*Catharus minimus*	*
Swainson's Thrush	*Catharus ustulatus*	*
Hermit Thrush	*Catharus guttatus*	*
American Robin	*Turdus migratorius*	*
Varied Thrush	*Ixoreus naevius*	*
Wagtails and Pipits		
Eastern Yellow Wagtail	*Motacilla tschutschensis*	*
American Pipit	*Anthus rubescens*	*
Waxwings		
Bohemian Waxwing	*Bombycilla garrulus*	*
Longspurs and Buntings		
Lapland Longspur	*Calcarius lapponicus*	*
Snow Bunting	*Plectrophenax nivalis*	*
McKay's Bunting	*Plectrophenax hyperboreus*	
Wood Warblers		
Northern Waterthrush	*Parkesia noveboracensis*	*
Orange-crowned Warbler	*Oreothlypis celata*	*
Yellow Warbler	*Setophaga petechia*	*
Blackpoll Warbler	*Setophaga striata*	*
Yellow-rumped Warbler	*Setophaga coronata*	*
Wilson's Warbler	*Cardellina pusilla*	*
Sparrows		
American Tree Sparrow	*Spizella arborea*	*

Common Name	Scientific Name	Breeder
Savannah Sparrow	*Passerculus sandwichensis*	*
Fox Sparrow	*Passerella iliaca*	*
Song Sparrow	*Melospiza melodia*	*
Lincoln's Sparrow	*Melospiza lincolnii*	*
White-crowned Sparrow	*Zonotrichia leucophrys*	*
Golden-crowned Sparrow	*Zonotrichia atricapilla*	*
Dark-eyed Junco	*Junco hyemalis*	*
Blackbirds		
Rusty Blackbird	*Euphagus carolinus*	*
Finches		
Gray-crowned Rosy-Finch	*Leucosticte tephrocotis*	*
Pine Grosbeak	*Pinicola enucleator*	*
Red Crossbill	*Loxia curvirostra*	
White-winged Crossbill	*Loxia leucoptera*	*
Common Redpoll	*Acanthis flammea*	*
Hoary Redpoll	*Acanthis hornemanni*	*
Pine Siskin	*Spinus pinus*	

4.5.2 Botanical Resources and Habitat Types

Terrestrial vegetation in the Project vicinity is typically maritime tundra, lowland spruce/hardwood forest, deciduous hardwood forest, or alpine tundra and barren ground (NMWC 2007, BBNA 2014). To the west of the Project, the high elevation areas in the Wood River mountain range are typically a mix of barren ground and alpine tundra. As the elevation decreases to the east, vegetation cover transitions to upland spruce-hardwood forest and then to lowland spruce-hardwood forest (BBNA 2014). White and black spruce (*Picea glauca* and *P. mariana*) are common in the region, and hardwood species consist of paper birch (*Betula papyrifera*), cottonwood (*Populus* spp.), alder (*Alnus* spp.), and willow (*Salix* spp.) (BBNA 2014). Maritime tundra habitat is described in further detail as wetland habitat in Section 4.6. In the Nushagak Sub-region of the Bristol Bay Region of Alaska, it is estimated that of 7,280 acres total, 48.6 percent is forested, shrublands are 37.6 percent, and wetlands comprise 9.4 percent (BBNA 2014). Vegetation cover types in the Bristol Bay Region of Alaska are shown in Figure 4-11.

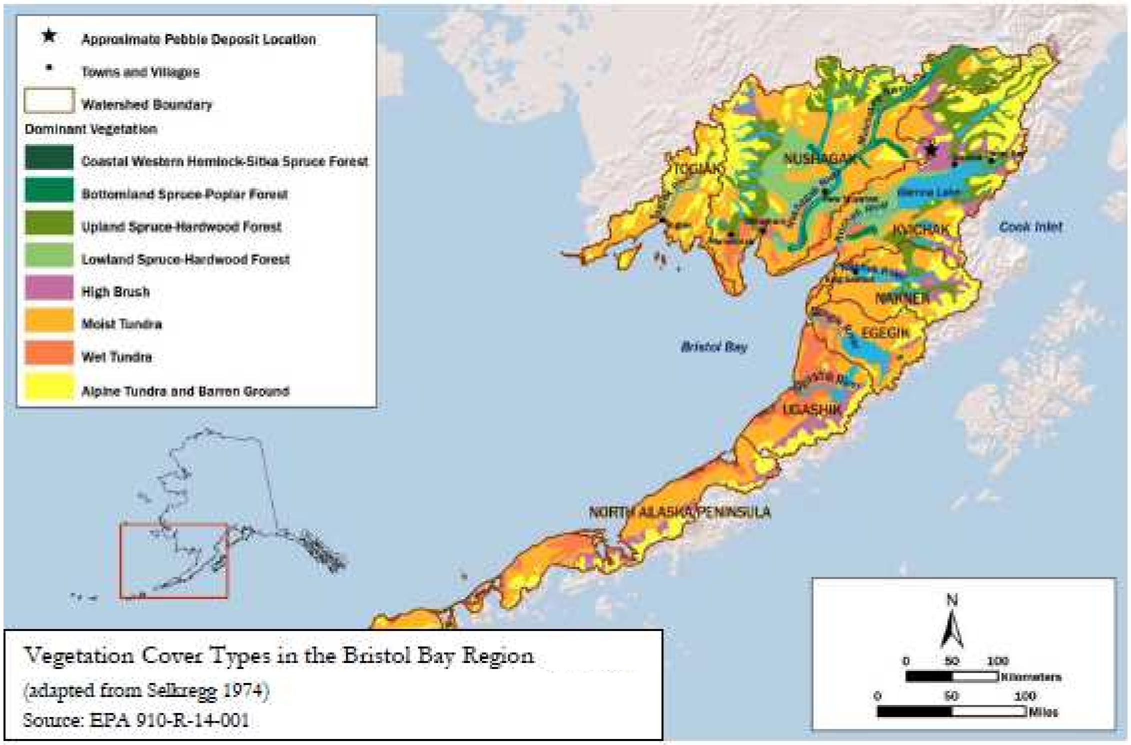

Figure 4-11. Vegetation Cover Types in the Bristol Bay Region (BBNA 2014).

4.5.2.1 Invasive Plants

The Alaska Exotic Plants Information Clearinghouse (AKEPIC), maintained by the Alaska Natural Heritage Program (AKNHP), provides geospatial information for non-native plant occurrences in the State of Alaska. The database does not contain any information near the Project vicinity on the Nuyakuk River, but downstream near the Nushagak River (approximately 84 miles from the Project site), four occurrences of non-native plants are identified at a single location: splitlip hempnettle (*Galeopsis bifida*), pineappleweed (*Matricaria discoidea*), common sheep sorrel (*Rumex acetosella*), and common dandelion (*Taraxacum officinale* ssp. *officinale*) (AKNHP 2019a). The location of these exotic plant occurrences is shown in Figure 4-12. A USFS study ranking non-native plants in Alaska according to invasiveness reported that both common sheep sorrel and common dandelion are “Modestly Invasive”, splitlip hempnettle is “Weakly Invasive” and pineappleweed is “Very Weakly Invasive” (USFS 2008).

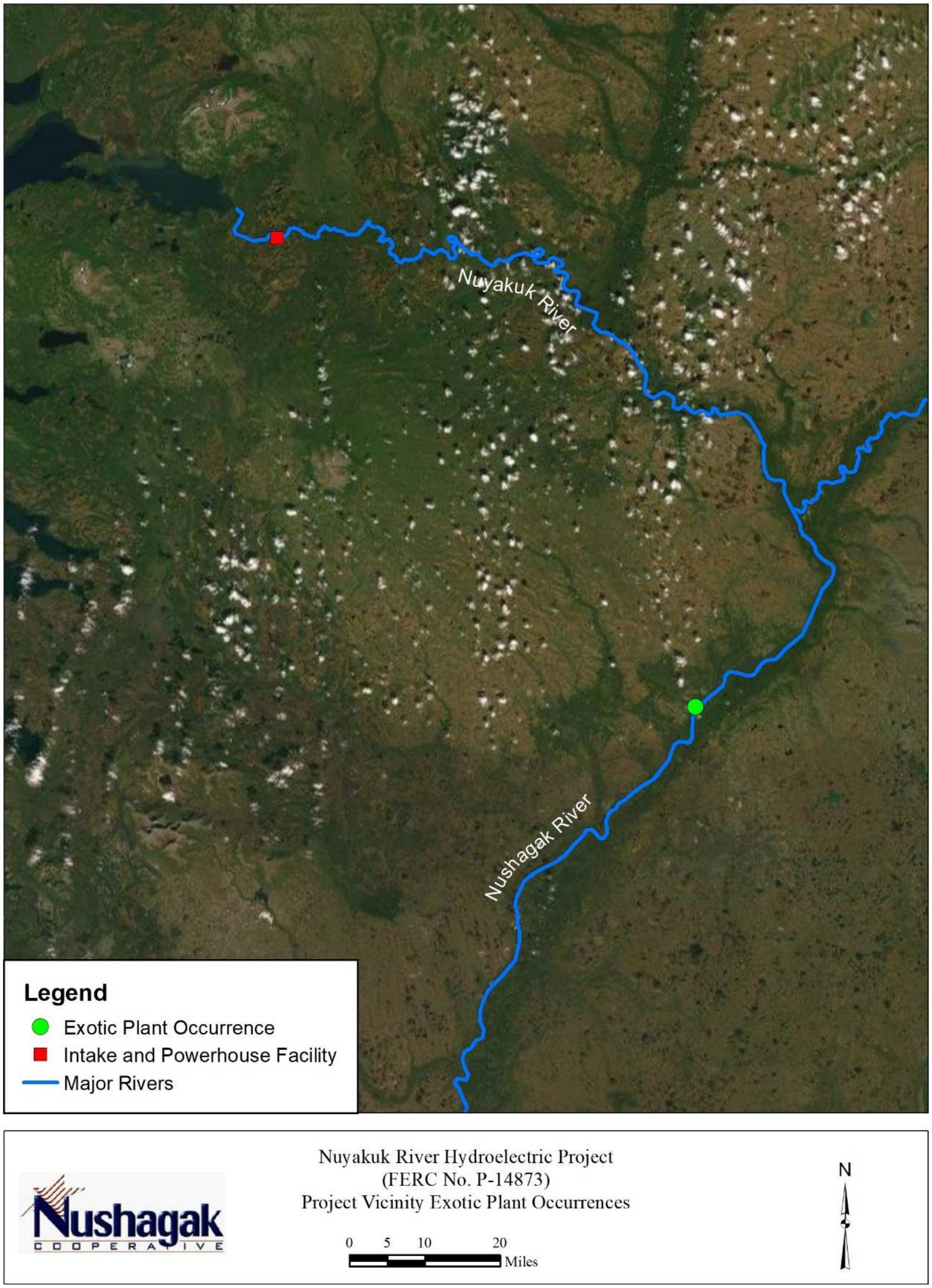

Figure 4-12. Location of exotic plant occurrences in the Project vicinity (AKNHP 2019a).

4.5.2.2 Rare Plants

AKNHP tracks the status of rare plant taxa in Alaska. The AKNHP maintains a database with collection locality and habitat information for rare and/or endemic vascular plants in the state. To determine which of these rare plant taxa have the potential to occur in the Project vicinity, data were requested from AKNHP's spatially explicit database of rare species (AKNHP 2019b) for collections of rare plants that have been made in a broad region surrounding the proposed Project. It is anticipated that rare plant surveys near the Project area will occur as a part of the overall Project licensing study program. The rare plant occurrence search area is shown in Figure 4-13. The query returned 32 occurrences of 13 species in the search area, and these species are listed in Table 4-12 along with their state and global ranking. It is unknown at this time if any of these species occur in the Project vicinity.

Figure 4-13. Rare plant search area (AKNHP 2019b).

Table 4-12. Rare plants that may occur in the Project vicinity (AKNHP 2019b).

Common Name	Scientific Name	Number of Occurrences	State Rank	Global Rank	Federal Listings
Cape Thompson draba	*Draba chamissonis*	1	S1Q	GNR	
Pear-shaped smelowskia	*Smelowskia pyriformis*	3	S3	G2	BLM Sensitive

Common Name	Scientific Name	Number of Occurrences	State Rank	Global Rank	Federal Listings
Wheat sedge	*Carex atherodes*	1	S3S4	G5	
Water mudwort	*Limosella aquatica*	1	S3	G5	
Northern fescue	*Festuca viviparoidea*	4	SU	G4G5	
Yenisei River pondweed	*Potamogeton subsibiricus*	1	S3S4	G3G4	BLM Watch
Horned pondweed	*Zannichellia palustris*	1	S3S4	G5	
Chukchi primrose	*Primula tschuktschorum*	11	S3	G2G3	BLM Sensitive
Pacific buttercup	*Ranunculus pacificus*	1	S3S4	G3	
Lesser meadow-rue	*Thalictrum minus*	2	S2	GNR	
Yellow avens	*Geum aleppicum*	3	S3	G5T5	
Wedgeleaf saxifrage	*Saxifraga adscendens*	2	S2S3	G5T4T5	
Selkirk's violet	*Viola selkirkii*	1	S3S4	G5	

State and Global Rank Definitions (Nawrocki et. al 2013):

S1: Critically imperiled within the state; at very high risk of extirpation because of very few occurrences, declining populations, or extremely limited range and/or habitat.

S2: Imperiled within the state; at high risk of extirpation because of few occurrences, declining populations, or limited range and/or habitat.

S3: Rare within the state; at moderate risk of extirpation because of restricted range, narrow habitat specificity, recent population decline, small population sizes, or a moderate number of occurrences.

S4: Apparently secure, but uncommon, within the state; may be a long-term conservation concern.

S#S#: Status of species within a region is best described as a range between two ranks.

S#Q: Taxon is questionable or uncertain as currently defined, but records assigned to that taxon are not questionable.

G2: Imperiled; at high risk of extirpation because of very restricted range, few occurrences, small populations, steep declines, or other factors.

G3: Vulnerable; at moderate risk of extinction because of restricted range, relatively few occurrences, small populations, recent and widespread declines, or other factors.

G4: Apparently secure, but uncommon; some cause for long-term concern because of declines or other factors.

G5: Secure; common, widespread, and abundant.

G#G#: Global status of species is best described as a range between two ranks.

T: Indicates the global rank of a subspecies or variety and is appended to the end of the G rank for the species.

GNR: Global rank not yet assessed.

4.5.3 Potential Adverse Effects

Potential adverse impacts will be discussed with stakeholders during study planning and ultimately assessed during the licensing study process. Based on the current conceptual layout and operational regime identified for the Project, Table 4-13 below identifies potential adverse impacts related to wildlife and botanical resources.

Table 4-13. Potential adverse impacts related to wildlife and botanical resources.

Potential Adverse Impact	Associated Resource Effect
Impacts to local native botanical populations as a result of Project construction and operations	Potential short and long-term impacts to local native botanical populations due to land clearing, construction of infrastructure and the potential for introduction of non-native species
Impacts to wildlife species migratory corridors	Potential for impacts to migration timing and routes of a variety of wildlife species associated with construction, maintenance and operation of transmission line corridor
Impacts to avian populations associated with the transmission corridor	Potential for bird strikes and mortality related to placement and operation of the transmission line corridor primarily, specific to the poles and lines.
Impact to terrestrial habitat character and quality along the transmission line corridor	Potential for impacts to key terrestrial habitat types for a variety of species and life stages associated with construction, maintenance and operation of the transmission line corridor

4.6 Wetlands, Riparian and Littoral Habitat

Wetlands in Alaska are classified using the three-parameter approach described in the U.S. Army Corps of Engineers Wetlands Delineation Manual (USACE 1987) and the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Alaska Region Version 2.0 (USACE 2007). To be classified as a wetland, a site must be dominated by hydrophytic plants, have hydric soils, and show evidence of wetland hydrologic conditions (saturation or inundation of sufficient duration during the growing season). Wetlands, riparian, and littoral habitat have not been formally mapped or studied in the Project vicinity. However, descriptions of the Nushagak-Mulchatna drainage basin mention riparian corridors consisting of willow, cottonwood, and alder that exist in some locations along the rivers in the basin (NMWC 2007, ADFG 2006). Tundra wetlands are also a common feature of the low-lying areas of the drainage basin a short distance away from rivers and may occur in the Project vicinity. These tundra wetlands are often connected by lakes and meandering sloughs and provide important habitat for migratory waterfowl (NMWC 2007). A 1982 literature survey of wetlands in Alaska describes the Nushagak-Bristol Bay lowlands as having abundant thaw, oxbow, and kettle lakes (Batten and Murray 1982). The National Wetland Inventory (NWI) does not contain any mapped wetlands data for the Project vicinity, and it is anticipated that wetland mapping associated with the Project area and specific locations for Project infrastructure will occur during the natural resource study program associated with the licensing process (USFS 2019). Due to the lack of wetland mapping data in the Project vicinity, the acreage of specific wetland types potentially impacted by Project operations is currently unknown.

Plant species composing the tundra wetlands in the Nushagak-Mulchatna drainage basin have not been described or formally studied. However, maritime tundra in southwestern Alaska is generally characterized as "prostrate heath-scrub type communities interspersed with grass and forb meadows, with willows and alders present in the protected swales" (ADFG 2006). Common vegetation in maritime tundra that may be present in the proposed Project vicinity is listed in Table 4-14.

Table 4-14. Common maritime tundra plant species in Alaska (ADFG 2006).

Common Name	Scientific Name
Alpine azalea	*Loiseleuria procumbens*
American green alder	*Alnus crispa*
Bearberry	*Arctostaphylos* spp.
Bluejoint	*Calamagrostis canadensis*
Bog blueberry	*Vaccinium uliginosum*
Cottongrasses	*Eriophorum* spp.
Crowberry	*Empetrum nigrum*
Diamondleaf willow	*Salix planifolia*
Dwarf arctic birch	*Betula nana*
Feltleaf willow	*Salix alaxensis*
Fireweed	*Epilobium angustifolium*
Four-angled cassiope	*Cassiope tetragona*
Grayleaf willow	*Salix glauca*
Lichens	*Alectoria* spp., *Cetraria* spp., *Cladonia* spp., *Clandina* spp., *Thamnolia subuliformis*
Mosses	*Aulacomnium* spp., *Dicranum* spp., *Drepanocladus uncinatus*, *Hylocomium splendens*, *Hypnum* spp., *Pleurozinum schreberi*, *Polytrichum* spp., *Rhacomitrium* spp., *Rhytidium rugosum*, *Sphagnum* spp., *Tomethypnum nitens*
Mountain-avens	*Dryas integrifolia*, *D. octopetala*
Mountain cranberry	*Vaccinium vitisidaea*
Narrow-leaf Labrador tea	*Ledum decumbens*
Netleaf willow	*Salix reticulata*
Oxytrope	*Oxytropis* spp.
Saxifrage	*Saxifraga* spp.
Sedges	*Carex* spp.
Sitka alder	*Alnus sinuata*
Skeletonleaf willow	*Salix phlebophylla*
Vetch	*Astragalus* spp.

Maritime tundra in Alaska provides important nesting area for migratory waterfowl. Other avian species, including raptors, terns, falcons, ptarmigan, and grouse may also utilize maritime tundra habitat for nesting and foraging (ADFG 2006). Table 4-15 lists avian species that may be associated with maritime tundra habitat in the Project vicinity (ADFG 2006). Additionally, mammalian species including muskox, caribou, foxes, wolves, bears, arctic ground squirrels, and a variety of small rodents may utilize maritime tundra habitat near the proposed Project (ADFG 2006).

Table 4-15. Maritime tundra-associated avian species (ADFG 2006).

Common Name	Scientific Name
Arctic Loon	*Gavia arctica*
Blue Grouse	*Dendragapus obscurus*
Bristle-thighed Curlew	*Numnius tahitiensis*
Buff-breasted Sandpiper	*Calidris subruficollis*
Gray-crowned Rosy Finch	*Leucosticte tephrocotis*
Gyrfalcon	*Falco rusticolus*
King Eider	*Somateria spectabilis*
Pacific Loon	*Gavia pacifica*
Peregrine Falcon	*Falco peregrinus*
Rock Ptarmigan	*Lagopus muta*
Rock Sandpiper	*Calidris ptilocnemis*
Rock Sandpiper subsp. Pribilof Sandpiper	*Calidris ptilocnemis ptilocnemis*
Rock Sandpiper subsp. Aleutian Sandpiper	*Calidris ptilocnemis couesi*
Rock Sandpiper subsp. Northern Rock Sandpiper	*Calidris ptilocnemis tschuktschorum*
Rough-legged Hawk	*Buteo lagopus*
Sandhill Crane	*Antigone canadensis*
Short-eared Owl	*Asio flammeus*
Smith's Longspur	*Calcarius pictus*
Snowy Owl	*Bubo scandiacus*
Spectacled Eider	*Somateria fischeri*
Steller's Eider	*Polysticta stelleri*
Tule White-fronted Goose	*Anser albifrons gambeli*
Tundra Swan	*Cygnus columbianus*
Yellow-billed Loon	*Gavia adamsii*

4.6.1 Potential Adverse Effects

Potential adverse impacts will be discussed with stakeholders during study planning and ultimately assessed during the licensing study process. Based on the current conceptual layout and operational regime identified for the Project, Table 4-16 below identifies potential adverse impacts related to wetlands, riparian and littoral habitat.

Table 4-16. Potential adverse impacts related to wetland, riparian, and littoral habitat.

Potential Adverse Impact	Associated Resource Effect
Construction of Project infrastructure in or immediately adjacent to the Nuyakuk River	In-water work has the potential to have a short-term impact to spawning and rearing habitat immediately upstream of Nuyakuk falls
Bypass of a portion of the river flow around Nuyakuk Falls during operations	Potential for periodic delayed or prohibited migratory upstream passage of certain resident and anadromous fish species
False attraction flow from the Project tailrace during operations	Potential for delayed migration or mortality to upstream migrating resident and anadromous salmonids associated with tailrace outflow
Increased sediment load during construction of infrastructure in adjacent to the Nuyakuk River	Potential for short-term increases in sediment load during construction may have limited impact on fish habitat downstream of the Project area

4.7 Threatened, and Endangered Species

Two avian species that may be associated with maritime tundra habitat (Steller's eider and Spectacled eider) are listed as threatened by the U.S. Fish and Wildlife Service under the Endangered Species Act (USFWS 2012, USFWS 2016). However, neither of these species' ranges overlaps with the proposed Project area and therefore it is unlikely that either species would be found near the proposed Project. Critical habitat for both species has been designated within Alaska but is not located near the proposed Project (USFWS 2012, USFWS 2016). No other threatened or endangered species listed by state or federal agencies have been identified in the Project vicinity. It is anticipated that threatened and endangered species that may exist in the proposed Project vicinity will be investigated as part of the overall Project licensing study program.

4.7.1 Potential Adverse Effects

No potential adverse impacts related to Project construction and operations have been identified for threatened and endangered species.

4.8 Recreation and Land Use

Southwestern Alaska contains a diverse variety of outdoor recreational opportunities. The National Park Service (NPS) manages two large parks in the region: Katmai National Park and Preserve and Lake Clark National Park and Preserve. Both Katmai and Lake Clark offer world-renowned sports fishing, bear viewing, and remote wilderness experiences in striking, largely undeveloped landscapes (NPS 2019a, NPS 2019c). USFWS manages a number of refuges in the region as well, including the 19 million-acre Yukon Delta NWR and the slightly smaller Togiak NWR (USFWS 2019a, 2019b). Figure 4-14 shows the location of recreational areas in southwestern Alaska. It is anticipated that Project vicinity recreation and land use will be investigated as part of the overall Project licensing study program.

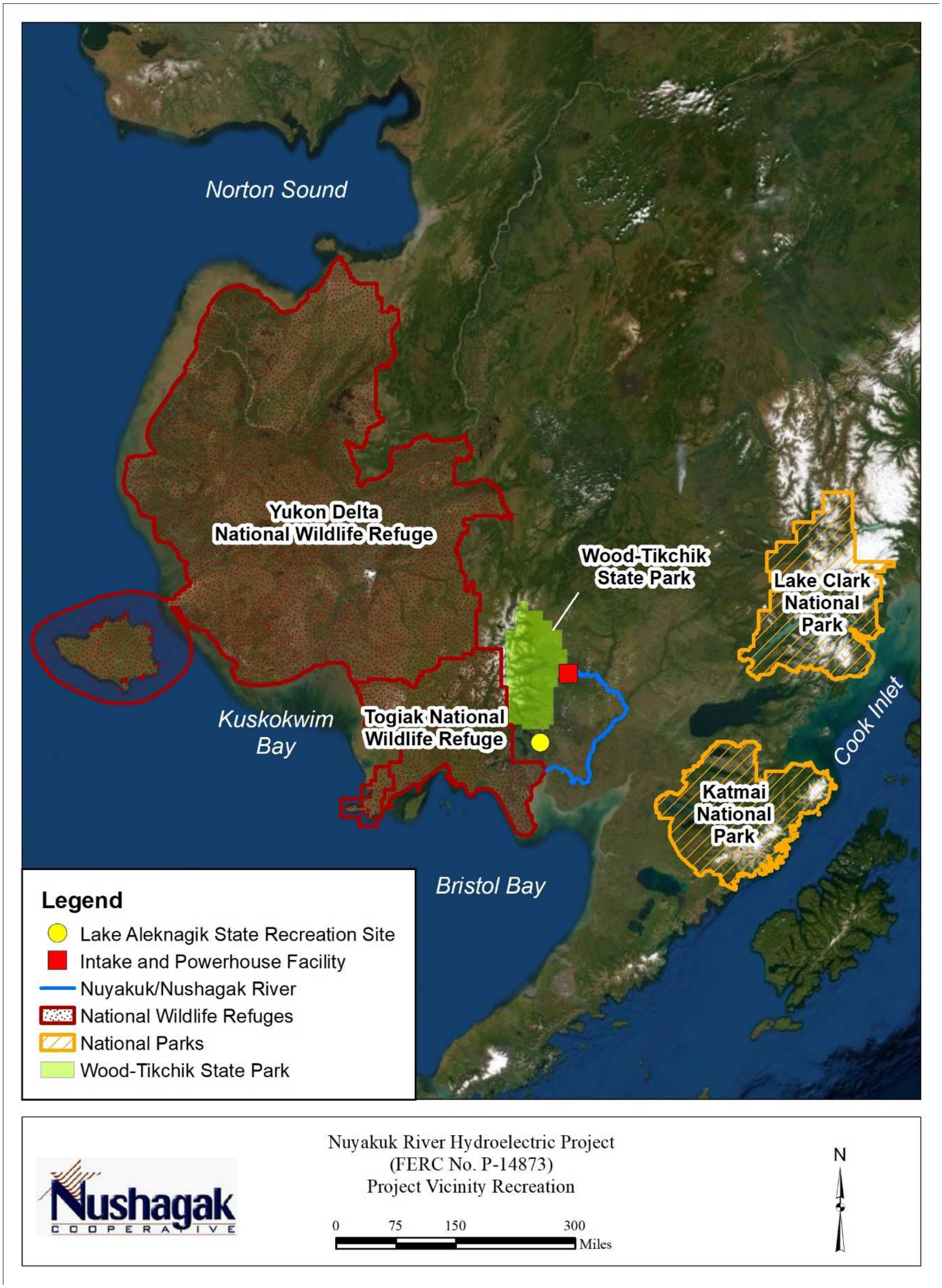

Figure 4-14. Recreation areas in the proposed Project vicinity.

The proposed Project is located within Wood-Tikchik State Park managed by ADNR. The Wood River-Tikchik Lakes area was originally considered by the NPS for addition to the National Park System in the 1960s. However, the State of Alaska preemptively selected lands in the area and proposed a state park designation, largely due to concerns that federal action could diminish future opportunities for commercial, recreational, and resource development (including hydroelectric potential). After a variety of interagency studies examining the area's recreation and commercial fishery potential, Wood-Tikchik State Park was established in 1978 and became the largest state park in the country at approximately 1.6 million acres. The enabling legislation for the establishment of the Park states that "the primary purposes of creating the Wood-Tikchik State Park are to protect the area's fish and wildlife breeding and support systems and to preserve the continued use of the area for subsistence and recreational activities" (ADNR 2002).

4.8.1 Current Recreational Use of the Project Vicinity and Region

Wood-Tikchik State Park contains very few facilities or developed trails within the park. The only official public access point is at Lake Aleknagik State Recreation Site (SRS) which offers a ranger station, parking area, boat launch ramp and other facilities. The SRS is located at the southern end of the Park in the City of Aleknagik. However, visitors are welcome to fly, hike, or boat into more remote areas (ADNR 2002).

The primary recreational activity in Wood-Tikchik State Park is sport fishing for trout, char, arctic grayling, and salmon. Eight commercial fishing lodges operate within the park generating a substantial amount of aircraft and boat travel (ADNR 2002). The Royal Coachman Lodge is located approximately 4 river miles upstream from the proposed Project near the outlet of Tikchik Lake. The lodge can host 10-12 guests per week and offers guided fishing tours via floatplane to various locations within the Park as well as within Togiak NWR and Katmai National Park. In addition to fishing, they also offer bear viewing, hiking, and kayaking options (RCL 2019).

While sport fishing occurs throughout Wood-Tikchik State Park, the Wood River Lakes System in the southern half of the Park receives the heaviest fishing pressure because of easier access (ADNR 2002). There is also significant fishing pressure outside the Park, especially in the Lower Nushagak River from Black Point to the mouth of the Mulchatna River (ADNR 2005). ADFG performs a census of sport fishing effort in the area each year. Table 4-17 summarizes the number of angler-days reported for multiple areas both inside and outside the park. Note that results were only reported for study years where twelve or more responses were received (ADFG 2019).

Table 4-17. Number of angler-days reported in the proposed Project vicinity and surrounding areas (ADFG 2019).

Year	Wood River Lakes System	Lower Nushagak River	Upper Nushagak River	Mulchatna River Drainage	Nuyakuk River Drainage	Tikchik-Nuyakuk Lake System
2017	6,440	12,369	930	1,806	3,030	NR
2016	4,500	13,436	3,315	1,169	636	NR
2015	5,707	10,404	1,987	2,949	1,624	NR
2014	9,452	13,161	3,019	1,338	2,427	531

2013	9,853	12,998	1,743	1,415	1,485	NR
2012	4,827	11,033	1,477	1,573	1,353	NR
Average	**6,797**	**12,234**	**2,079**	**1,708**	**1,759**	**89**

NR – Not Reported

Another popular recreational activity in the park is river floating. The most popular river trip in the park is the Tikchik River, which can begin on either Nishlik or Upnuk lakes and ends 60 miles downriver at the river's mouth on Tikchik Lake. The trip takes approximately four to five days. Most floaters take out at Pick-up Island on Tikchik Lake. The remainder continue westward to explore Tikchik, Nuyakuk, and Chauekuktuli lakes or continue on down the Nuyakuk River to exit the Park. For those that float down the Nuyakuk River, there is an existing trail that provides safe portage around Nuyakuk Falls (ADNR 2002).

While a select number of local residents use the park year-round, the park sees its heaviest use between June 15 and the end of September. The heavier use in the summer reflects the influx of visitors for the prime fishing and hunting seasons (ADNR 2002). ADNR collects annual use information from permitted commercial recreation operators through a registration system used to make informed land management decisions for state land. The information collected includes where such uses are occurring, how many clients are recreating on state land, and the types of activity that are occurring. Table 4-18 summarizes the registration information for 2012 through 2018 for GMU 17B, which includes the Project location and the surrounding area (ADNR 2019).

Table 4-18. Commercial Recreation Use in GMU 17B (ADNR 2019).

Year	Number of Registered Operators	Visitor Days	Activity Types	Types of Access
2018	12	3210	Skiing, snowshoe, snowboard, Hunting, Off-road Vehicle Use, Motorized Boating, General Tour (sightseeing, wildlife, nature), Hiking Rock/Mountain Climbing, Drop-off Comm. Recreation Uses, Rafting, Kayaking, Canoeing, Fishing	Ski Plane, Off-road Vehicle, Motorized Boat, Float Plane*, Helicopter*
2017	13	8078	Skiing, snowshoe, snowboard, Dogsledding, Bicycling, Hunting, Off-road Vehicle Use, Motorized Boating, Scuba Diving, General Tour (sightseeing, wildlife, nature), Hiking Rock/Mountain Climbing, Drop-off Comm. Recreation Uses, Rafting, Kayaking, Canoeing, Horseback Riding, Fishing	Ski Plane, Off-road Vehicle, Horse/Beast of Burden, Motorized Boat, Float Plane*, Helicopter*
2016	10	6261	Skiing, snowshoe, snowboard, Hunting, Off-road Vehicle Use, Motorized Boating, General Tour (sightseeing, wildlife, nature), Hiking Rock/Mountain Climbing, Drop-off Comm. Recreation Uses, Rafting, Kayaking, Canoeing, Fishing	Ski Plane, Off-road Vehicle, Motorized Boat, Float Plane*, Helicopter*

2015	18	9529	Skiing, snowshoe, snowboard, Dogsledding, Bicycling, Hunting, Off-road Vehicle Use, Motorized Boating, Scuba Diving, General Tour (sightseeing, wildlife, nature), Hiking Rock/Mountain Climbing, Drop-off Comm. Recreation Uses, Rafting, Kayaking, Canoeing, Horseback Riding, Fishing, Big Game Guiding for Hunting	Ski Plane, Off-road Vehicle, Horse/Beast of Burden, Motorized Boat, Float Plane*, Helicopter*
2014	12	9012	Skiing, snowshoe, snowboard, Hunting, Off-road Vehicle Use, Motorized Boating, General Tour (sightseeing, wildlife, nature), Hiking Rock/Mountain Climbing, Drop-off Comm. Recreation Uses, Rafting, Kayaking, Canoeing, Fishing	Ski Plane, Off-road Vehicle, Motorized Boat, Float Plane*, Helicopter*
2013	17	6692	Skiing, snowshoe, snowboard, Hunting, Off-road Vehicle Use, Motorized Boating, General Tour (sightseeing, wildlife, nature), Hiking Rock/Mountain Climbing, Drop-off Comm. Recreation Uses, Rafting, Kayaking, Canoeing, Fishing, Big Game Guiding for Hunting	Ski Plane, Off-road Vehicle, Motorized Boat, Float Plane*, Helicopter*
2012	15	1753	Skiing, snowshoe, snowboard, Hunting, Off-road Vehicle Use, Motorized Boating, General Tour (sightseeing, wildlife, nature), Hiking Rock/Mountain Climbing, Drop-off Comm. Recreation Uses, Rafting, Kayaking, Canoeing, Fishing, Big Game Guiding for Hunting	Ski Plane, Off-road Vehicle, Motorized Boat, Float Plane*, Helicopter*

** Float plane and helicopter were not documented in the ADNR report but are commonly used to access recreational sites in the region.*

4.8.2 Recreation Needs and Management Goals

Relevant local, state, and regional recreation and land use management plans include Alaska's North to the Future Statewide Comprehensive Outdoor Recreation Plan (SCORP) 2016-2021, the Bristol Bay Area Plan, and the Wood-Tikchik State Park Management Plan.

4.8.2.1 Alaska's North to the Future Statewide Comprehensive Outdoor Recreation Plan (SCORP) 2016-2021

States are required to develop and update a SCORP to be eligible for participation in the federal Land and Water Conservation Fund (LWCF) State & Local Assistance matching grant program which provides capital project funding for close-to-home recreation per the LWCF Act of 1965 as amended. Alaska's SCORP is a tool that:

- Provides government agencies, communities, and non-profits with a reference for outdoor recreation preferences, use trends, and issues relevant to Alaska through 2021,
- Identifies statewide capital investment priorities for acquiring, developing, and protecting outdoor recreation resources,
- Identifies the state's priorities and strategies for LWCF funding, and

- Provides information that agencies and communities need to ensure their project proposals are eligible for LWCF assistance.

Based on an evaluation of supply and demand for outdoor recreation, the SCORP identifies the following three recreation goals and strategies to meet these goals.

- Increase participation in outdoor recreation by introducing new users to Alaska's parks and green spaces, improving/increasing accessibility to outdoor recreation facilities and areas, and coordinating with health care providers for "Prescriptions to Parks".
- Maintain sustainable outdoor recreation infrastructure by designing, building, and refurbishing infrastructure using sustainable materials and by promoting a safe and healthy environment for recreation.
- Ensure future funding and support for outdoor recreation by educating decision-makers on the economic benefits of funding outdoor recreation, supporting re-authorization of LWCF, and partnering with local groups for grassroots support (ADNR 2016).

4.8.2.2 Bristol Bay Area Plan

The Bristol Bay Area Plan (BBAP) directs how ADNR will manage state uplands, tidelands, and submerged lands within the planning boundary, which includes the Project area. The plan determines management intent, land-use designations, and management guidelines that apply to all state lands in the planning area. Goals in the Bristol Bay planning area include:

- Economic Development – Provide opportunities for jobs and income by managing state land and resources to support a vital, self-sustaining local economy.
- Fiscal Costs – Minimize the needs for, and the fiscal cost of, providing government services and facilities such as schools and roads.
- Public Health and Safety – Maintain or enhance public health and safety for users of state lands and resources.
- Public Use – Provide and enhance diverse opportunities for public use of state lands, including uses such as hunting, fishing, boating, and other types of recreation.
- Quality of Life – Maintain or enhance the quality of the natural environment including air, land and water, and fish and wildlife habitat and harvest opportunities; protect heritage resources and the character and lifestyle of the community.
- Settlement – Provide opportunities for private ownership and leasing of land currently owned by the state.
- Sustained Yield – Maintain the long-term productivity and quality of renewable resources including fish and wildlife, and timber.

Specific to public recreation, the goals of the plan include providing lands for accessible outdoor recreational opportunities with recreational facilities where the demand warrants such facilities and providing undeveloped lands for recreation pursuits that do not require developed facilities. These opportunities would be realized by:

- providing recreation opportunities on less developed land and water areas that serve multiple purposes such as habitat protection or mineral resource extraction;
- assisting communities through cooperative planning, conveyance of state lands, and grants-in-aid for parks and trails within population centers;
- encouraging commercial development of recreational facilities and services through concession contracts, land sales, leases, and permits where public recreation needs can most effectively be provided by private enterprise, while minimizing environmental impacts and conflicts with the existing users of an area; and
- protecting recreation resources including public access, viewsheds, quiet, fish and wildlife important for recreation, and the unique natural characteristics of the planning area (ADNR 2013).

4.8.2.3 Wood-Tikchik State Park Management Plan

This management plan constitutes the primary policy of ADNR for the management and development of Wood-Tikchik State Park and the Lake Aleknagik State Recreation Site. The enabling legislation for the Park and the management philosophy of the Division of Parks and Outdoor Recreation are summarized by the following goal statements:

- Protect the fish and wildlife resources of the park, including management of natural habitats and support systems;
- Protect and manage park resources to ensure continued traditional subsistence use activities;
- Provide for the outdoor recreation needs of visitors to the park, appropriate to the park's values and regional setting;
- Protect, document, interpret and manage areas of significant scientific or educational value, visual quality, cultural or historic value, and areas of special significance; and
- Establish management practices which respond to regional and statewide recreation and tourism demands.

Specific to public recreation, the plan discusses facility development as a positive park management tool. Because facilities attract visitation, they can be used to draw visitors away from sensitive areas that might otherwise be impacted. However, the plan also states that if improperly employed, facility development could create new recreational demand rather than simply responding to existing demand. If not planned carefully, this type of development could result in increased competition for limited campsites, fishing holes, and fish and game resources.

New visitors could also disturb the natural experience favored by many park users. These concerns are reflected in specific plan objectives which include:

- Defining an acceptable level of tourism development and marketing, promotion of the park's tourism potential, commercial operations, concession activities, and visitor accommodations and services within the park;
- Establishing developments and facilities in a scale and manner appropriate to the park's natural setting, scenic character, and resource values; and
- Developing facilities as a means of meeting public needs for safety, visitor services, visitor information, resource protection, behavior control, and minimizing impacts;

The plan proposes several areas for addition to the park totaling approximately 290,000 acres which includes 11,000 acres of state land located at the northwestern end of Lake Aleknagik, 46,000 acres of state land located along the Park's western boundary that drains into Lake Chauekuktuli and Nuyakuk Lake, 35,000 acres of state land that drains into Lake Chikuminuk, and approximately 150,000 acres of state land between the northwestern park boundary and the Yukon Delta NWR (ADNR 2002).

Per Table 1-1, the Cooperative invested significant time and effort working collaboratively with the State of Alaska in 2019 to enact legislation allowing for the evaluation of the Project within the State Park boundary. Senate Bill 91, passed both houses of the Alaska legislature unanimously and has recently been signed into law by Governor Dunleavy.

4.8.3 Non-Recreational Land Use and Management

4.8.3.1 Subsistence Uses

A subsistence lifestyle plays an important part in the lives of the region’s residents. Almost all local residents partake in traditional harvests for a portion of their annual needs. The most important fish and game resource in Wood-Tikchik State Park is salmon, although moose, caribou, and resident fish are also important. In addition, the park is used for gathering firewood, picking berries, trapping and providing other renewable resources for food, clothing, shelter, transportation and handicrafts. These activities are an integral part of the culture in this region and provide not only food, but a cultural tie to the land and between generations.

Subsistence use in the Project area is concentrated in the lower Tikchik River and Tikchik Lakes system, although it is thought to be quite limited. Most village residents who use the Tikchik River are from Koliganek, New Stuyahok, and Ekwok. To get to the river, they must first ascend the Nuyakuk River which requires portaging or, under certain low-water conditions, skirting around Nuyakuk Falls. Upriver of the falls, boaters must also navigate Outlet Rapids, which can be quite treacherous. The primary reason for villagers to travel up river is to harvest whitefish, which are not readily available by their villages downriver. They also harvest moose, caribou, trout, black bear, brown bear, and furbearers, although these species are much more readily accessible along the Nushagak River and lower Nuyakuk River. Villagers also travel to the lower Tikchik River by snowmachine in winter to harvest whitefish by nets and by hook and line.

When subsistence patterns are compared with recreational patterns in the park, the areas where conflicts are emerging include the eastern end of Tikchik Lake, the lower Tikchik River, and the Nuyakuk River. Subsistence and recreational users visit those areas during the same times and often for similar purposes. In some of these areas, subsistence users have been displaced because of the high concentrations of sport anglers (ADNR 2002).

4.8.3.2 Hydroelectric Development

When Wood-Tikchik State Park was established, all state-owned lands and waters within the park were designated for special purpose management. The enabling legislation gives the Division of Parks and Outdoor Recreation a clearly defined management purpose, which it cannot exceed without specific legislative action.

The Legislature made a special finding that two potential hydroelectric projects, at Lake Elva and Grant Lake, were compatible with park purposes. Both projects have since been determined unfeasible and dismissed from further consideration. Hydroelectric development anywhere other than at Lake Elva or Grant Lake is prohibited. Therefore, to construct the proposed Project, the park enabling legislation needed to be amended to specifically allow hydroelectric development on the Nuyakuk River (ADNR 2002). Per Table 1-1, the Cooperative invested significant time and effort working collaboratively with the State of Alaska in 2019 to enact legislation allowing for the evaluation of the Project within the State Park boundary. Senate Bill 91, passed both houses of the Alaska legislature unanimously and has recently been signed into law by Governor Dunleavy.

4.8.4 Protected River Segments

The Project is not located within or adjacent to any river segments designated as part of, or under study for inclusion in, the National Wild and Scenic River System. There are no known state-protected river segments in the Project area (NWSRS 2019).

4.8.5 National Trails System and Wilderness Areas

There are no Project lands designated as part of, or under study for inclusion in, the National Trails System (NPS 2019b). The northern and middle portions of Wood-Tikchik State Park (Management Units 2 and 4) have been designated as Wilderness areas. However, the proposed Project location is not within either of these areas (ADNR 2002).

4.8.6 Shoreline Buffer Zones

The shoreline of the upper Nuyakuk River is managed by the State of Alaska. Majority of the upper river is undeveloped except for one fishing lodge located approximately 4 river miles upstream from the proposed Project location near the outlet of Tikchik Lake (ADNR 2002).

4.8.7 Potential Adverse Effects

No potential adverse impacts related to Project construction and operations have been identified for recreation and land-use.

4.9 Aesthetics and Visual Resources

The Bristol Bay region consists of vast, diverse, largely roadless wilderness. The majority of the regional landscape is visually intact and has no apparent signs of human activity, primarily because it is extremely remote. Visual disturbances and human development are generally limited to the rural communities dotted throughout the region (City of Dillingham 2010).

One of the primary purposes for the establishment of Wood-Tikchik State Park was to protect the area's scenic resources. The *Wood-Tikchik State Park Management Plan* directs park managers to "Define the park's landscape character and apply visual quality criteria to the park's management programs, developments and land use practices" (ADNR 2002). The proposed Project location is within Management Unit 3 of the Park, which is designated as a Natural area. The management plan defines Natural areas as relatively undeveloped and undisturbed areas that are managed to maintain high scenic qualities and provide visitors with the opportunity for a significant natural outdoor experience. The area's natural landscape character is the dominant feature (ADNR 2002).

The proposed Project would be located on the Nuyakuk River near Nuyakuk Falls. Project features would be visible to both recreational users that float the river and subsistence users that navigate upriver to access Tikchik Lake and the lower Tikchik River. The proposed transmission lines may also be visible from various viewpoints in the surrounding area, such as some of the public use sites identified in the *Nushagak & Mulchatna Rivers Recreation Management Plan*. It is anticipated that Project vicinity aesthetic resources will be investigated as part of the overall Project licensing study program. Figures 3-8 and 3-9 are photographs of the proposed Project location.

4.9.1 Potential Adverse Effects

Potential adverse impacts will be discussed with stakeholders during study planning and ultimately assessed during the licensing study process. Based on the current conceptual layout and operational regime identified for the Project, Table 4-19 below identifies potential adverse impacts related to aesthetics and visual resources.

Table 4-19. Potential adverse impacts related to aesthetics and visual resources.

Potential Adverse Impact	Associated Resource Effect
Visual anomaly from natural conditions near Nuyakuk Falls	Recreationalists (hikers, people floating the river, hunters and flightseers) may potentially notice a short-term visual impact associated with the Project infrastructure near the falls
Visual anomaly from natural conditions near along the transmission line corridor	Recreationalists (hikers, hunters and flightseers) may potentially notice a short-term visual impact associated with the Project infrastructure near the falls

4.10 Cultural and Tribal Resources

This section contains a brief overview of cultural and Tribal resources in the proposed Project vicinity. A formal Area of Potential Effects (APE) for the Project will be established once the transmission alternative(s) are further evaluated, which will comprise the study area for any cultural resources studies conducted as part of the licensing process. For hydroelectric projects, the size and scope of cultural resources research is typically guided by a Historic Properties Management Plan (HPMP) developed as part of a Programmatic Agreement (PA) or Memorandum of Agreement (MOA) for the project.

The term "cultural resources" is often used as a synonym for the legal term "historic properties" defined in the National Historic Preservation Act (NHPA) and its accompanying regulations (36 CFR 800). Historic properties include prehistoric or historic sites, buildings, structures, objects or districts eligible for listing on the National Register of Historic Places (NRHP) (36 CFR 800, 36 CFR 60). These may be resources such as archaeological sites, cultural landscapes, traditional cultural properties (TCPs), sacred sites, and paleontological sites.

Section 106 of the National Historic Preservation Act (16 USC § 470), as amended, requires that any federally funded, licensed, or permitted project consider the undertaking's effects on historic properties. The Section 106 process provides for identification and evaluation of historic properties, determination of effect, and a mechanism for resolution of any adverse effects (mitigation).

In order for a property to be eligible for the NRHP, it must possess integrity of location, design, setting, materials, workmanship, feeling, and association, and significance under one or more of the following criteria:

A. Be associated with events that have made a significant contribution to the broad patterns of our history; or

B. Be associated with the lives of persons significant in our past; or

C. Embody the distinctive characteristics of a type, period, or method of construction, or represent the work of a master, or possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction; or

D. Have yielded, or may be likely to yield, information important in prehistory or history.

There are some exceptions to these four criteria such as properties achieving significance in the last fifty years, certain cemeteries or religious properties and other property types. TCPs are places that are eligible for inclusion on the NHRP because of their association with the cultural practices and beliefs that are (1) rooted in the history of a community, and (2) are important for maintaining the continuity of that community's traditional beliefs and practices (Parker and King 1995).

Consultation is essential for completing the Section 106 review process. Consultation is required by the NHPA, as amended, and implementing regulations for the Advisory Council on Historic Preservation (ACHP), 36 CFR 800. Tribal consultation is required in all steps of the Section 106 process when a federal agency undertaking may affect historic properties that are located on Tribal lands, or when any Tribe attaches religious or cultural significance to the historic property, regardless of the property's location.

In Alaska, consultation occurs with 229 federally recognized Tribes, thirteen Alaska Native Regional Corporations and approximately 200 Alaska Native Village Corporations created by the Alaska Native Claims Settlement Act (ANCSA). The Regional and Village Corporations are recognized as "Indian tribes" for some NHPA purposes.

Tribes and Tribal entities that have cultural and subsistence ties to the area of proposed development, including transmission facilities include:

- Bristol Bay Native Association
  1500 Kanakanak Road, Dillingham, AK. 99576
  907.842.5257
- New Koliganek Village Council
  PO Box 5057 Koliganek, AK. 99576
  newkoliganekadmin@bbna.com
  907.596.3434
- New Stuyahok Traditional Council
  PO Box 49 New Stuyahok, AK. 99636
  newstuyahokadmin@bbna.com
  907.693.3173
- Ekwok Village Council
  PO Box 70 Ekwok, AK. 99580
  king2rick@yahoo.com
  907.464.3336
- Levelock Village Council
  PO Box 70 Levelock, Ak. 99625
  levelockadmin@bbna.com / levelockasstmgr@gmail.com
  907.287.3030 / 907.287.3031
- Aleknagik Traditional Council
  PO Box 115 Aleknagik, AK. 99555
  aleknagiktraditional@yahoo.com / aleknagikadmin@bbna.com
  907.842.2080
- Curyung Tribal Council
  PO Box 216 Dillingham, AK. 99576
  Courtenay@curyungtribe.com
  907.842.2384 / 907.842.3578

Given the small footprint of the Project and short stretch of river that will serve as the bypass reach (less than 0.5 mile) over Nuyakuk Falls, priority aquatic Tribal resources are not anticipated to impacted as a result of Project construction and operations. Key Tribal terrestrial and botanical resources may have the potential to be impacted from a migratory and/or an overall population perspective as a result of the construction, operation and maintenance of the transmission line. A robust set of aquatic and terrestrial studies associated with the licensing process are anticipated and will ultimately define the potential amount of impact (positive and negative), if any, to the aquatic and terrestrial environment.

4.10.1 Applicable Laws and Regulations

The following federal laws, regulations, executive orders and state legislation apply to the treatment of historic properties in the Project study area.

Federal legislation includes:

- Historic Sites Act of 1935 (16 U.S.C. § 1982)
- National Historic Preservation Act of 1966 (as amended in 2006) (16 U.S.C. § 470)
- National Environmental Policy Act of 1969 (42 U.S.C. § 4321-4347)
- Archaeological Data Preservation Act of 1974 (16 U.S.C. § 469)
- American Indian Religious Freedom Act of 1978 (42 U.S.C. § 1996)
- Archaeological Resources Protection Act of 1979 (16 U.S.C. § 470aa-470ll)
- Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. § 3001 et seq.)
- Paleontological Resources Preservation Act of 2009 (16 U.S.C § 470aaa)

Federal regulations include:

- 18 CFR 4: FERC Licensing, Permits, Exemptions, and Determination of Project Costs
- 18 CFR 380: Regulations Implementing the National Environmental Policy Act
- 36 CFR 60: National Register of Historic Places
- 36 CFR 79: Curation of Federally Owned and Administered Archaeological Collections
- 36 CFR 800: Protection of Historic Properties
- 43 CFR 7: Protection of Archaeological Resources
- 43 CFR 10: Native American Graves and Repatriation Act

Federal Executive Orders (E.O.) include:

- E.O. 11593: Protection and Enhancement of the Cultural Environment (1971)
- E.O. 12898: Environmental Justice (1994)
- E.O. 13007: Indian Sacred Sites (1996)

State legislation includes:

- Alaska Historic Preservation Act (Alaska Statute 41.35)

Private lands are directly affected by federal cultural resources legislation, especially the NHPA and implementing regulations (36 CFR 800), as long as any aspect of the proposed action has federal involvement. If any aspect of a project is affected by a federal undertaking (permit, license, or funding), then the federal review process applies to the entire Project area. Thus, the Project is subject to the Section 106 review process regardless of land status (federal, state, municipal, or private).

Local or Tribal ordinances, resolutions, and preservation plans may affect cultural resources at the local level; no such documents are known for this Project.

- Several publications provide guidance on cultural resources investigations, in relation to federal and state laws and regulations including:
- Guidelines for the Development of Historic Properties Management Plans for FERC Hydroelectric Projects. Federal Energy Regulatory Commission, Washington D.C. (Wood and Lau 2002).
- National Register Bulletin Series, National Park Service, U.S. Department of Interior. Website at: http://www.nps.gov/history/nr/publications/#bulletins
- Historic Preservation Series, Alaska Office of History and Archaeology, Division of Parks and Outdoor Recreation, Alaska Department of Natural Resources. Website at: http://dnr.alaska.gov/parks/oha/hpseries/hpseries.htm
- Human Remains and Cultural Resource Management in Alaska: State Laws and Guidelines (Dale and McMahan 2007).

4.10.2 Ethnographic and Historical Overview

4.10.2.1 Geochronology

The geochronology of the Wood-Tikchik lakes region is relatively undeveloped. Two major tephra deposits, the ODLF Tephra (3,800-4,000 ^{14}C years B.P.) and the Aniakchak Tephra (3,430 ± 70 B.P.) are likely to be encountered in the Project study area (Begét et al. 1992, Fierstein 2007). VanderHoek (2009) asserts that the Aniakchak eruption would have had a significant impact on the ecological productivity in western Alaska and either killed or caused the relocation of Arctic Small Tool tradition (ASTt) populations living in western Alaska, leaving a cultural and ecological dead zone between Bering Sea Eskimos and Aleutian populations for more than 1,000 years.

4.10.2.2 Prehistory

The prehistory of southwest Alaska is poorly understood. Most of the known archaeological sites in the region are situated in or near coastal environments (Dumond 1962, 1981; Henn 1978; Larsen 1950, Oswalt 1952, Shaw 1983). As a result, only an incomplete regional cultural chronology for southwest Alaska is possible at this point.

Paleoindian Tradition (10,000 to 8,000 years ago)

The earliest Paleoindian Tradition sites with unequivocal artifacts are dated to ca. 10,000 years ago and are typified by the assemblage at Spein Mountain (10,050±90 B.P.) (BTH-00062 through BTH-00065), which is located within the Project study area (Ackerman 1996a, b, 2001). The Paleoindian Tradition in southwest Alaska is a non-microblade complex consisting of lanceolate and leaf shaped projectile points, bifacial knives, gravers, notches, various scrapers (including some on bifacial blanks), and flake knives (Ackerman 2001).

American Paleoarctic Tradition (10,000 to 7,000 years ago)

The American Paleoarctic Tradition appears to overlap the Paleoindian Tradition temporally (Anderson 1970; cf. West 1967 for an interior variant, the Denali Complex). American Paleoarctic tool kits include composite antler and stone projectiles, generally thought to have been used to hunt late Pleistocene-early Holocene fauna.

Northern Archaic Tradition (6,000 to 2,000 years ago)

The Northern Archaic tradition appears to represent the spread of a new boreal-forest oriented culture (Anderson 1988), although the presence of numerous sites in tundra areas may complicate this interpretation (Lobdell 1986, Schoenberg 1995). The defining artifact-type of the Northern Archaic is a somewhat asymmetrical side-notched biface reminiscent of projectile point styles from mid-latitude North America (Anderson 1968,1988).

Arctic Small Tool Tradition (4,500 years ago to A.D. 900)

ASTt sites occur in an extensive zone stretching from the Bering Sea side of the Alaska Peninsula northward around Alaska, and through the Arctic Archipelago to Greenland. The Arctic Small Tool tradition (ASTt) is known for the presence of tiny, finely-flaked stone tools, which may be associated with the introduction of the bow and arrow. Many archaeologists believe ASTt is the direct ancestor to modern Eskimo people in Alaska, the arctic regions of Canada, and Greenland (Dumond 1987, Giddings 1967, Irving 1964); for another view see Gerlach and Mason (1992). The original ASTt definition has been expanded to include later cultures such as Choris, Norton, and Ipiutak (Gerlach and Hall 1988).

Norton Tradition (3,000 years ago to A.D. 1000)

The Norton tradition includes all post-Small Tool archaeological manifestations of Alaska usually termed Paleo-Eskimo, dating from ca. 1000 B.C. to 1000 A.D (Dumond 1982, 1987, 2000). Norton subsistence strategies were varied. Dumond (2000) sees Norton people as predominantly river fishing folk who also engaged actively in the terrestrial hunting of caribou as well as in the coastal hunting of sea mammals.

Western Thule and Late Prehistoric/Protohistoric Eskimo (A.D. 900 to 1790)

The direct ancestors of the southwest Alaskan Yup'ik Eskimos were likely people of the Western Thule tradition. Typical artifacts include ground slate, chipped stone technology, heavy gravel-tempered pottery, snowshoes, hafted beaver-tooth knives, and birch bark baskets. Late prehistoric and protohistoric Eskimo subsistence was broad-based, with both interior and coastal resource exploitation. Data from the Naknek drainage suggests reliance on salmon and caribou, though some sea mammal remains occur (Dumond 1984).

Athabascan Tradition (2,000 years ago to present)

The Athabascan tradition is a prehistoric culture attributed to ancestors of the northern Athabascan Indians of Alaska, whose archaeological history precedes Euro-American contact (Cook 1968, Cook and McKennan 1970, Dixon 1985). It is important to note that the "Athabascan Tradition," in its archaeological denotation, refers to the archaeological culture. In common usage, the Athabascan Tradition continues to the present.

Early prehistoric Athabascan sites are characterized by subsurface housepit and cache features associated with a variety of flaked and ground stone, bone, and antler artifacts. Proto-historic (or late prehistoric) Athabascan sites include artifact assemblages predominately characterized by Native-made items with a small amount of non-Native trade goods (e.g. iron and glass beads) obtained through trade. Historic Athabascan sites (post-1850) generally have a mixture of log cabin and house pit dwellings affiliated with a greater percentage of Euro-American artifacts, and possible changes in site location in order to obtain these goods.

4.10.2.3 Ethnohistory

The Project is located in a region traditionally occupied by the Yup'ik Eskimo. The early cultural center of the Central Alaskan Yup'ik speaking peoples of southwest Alaska was the Bering Sea coast. This was primarily a maritime economy based on seal hunting, with some caribou hunting in the adjacent tundra. Approximately 3,800 radiocarbon years before present (B.P), ancestral Eskimos (ASTt) moved south to occupy the Alaska Peninsula northwest of the Aleutian Range, displacing the previous Paleoindian occupants. Relatively little is known about this process (VanStone 1984).

Before contact, Yup'ik peoples in the region practiced a central based seasonal mobility subsistence strategy. In this system, people spend part of each year wandering and the rest in a settlement of central base to which they may or may not return in subsequent years (VanStone 1971).

According to Van Stone (1984b), several Yup'ik groups inhabited the region at the time of contact. The Aglurmiut resided along the coast around Nushagak Bay and throughout much of the Alaska Peninsula (Dumond et al. 1975, VanStone 1967). The Kiatagmiut occupied the entire Nushagak River, the lower Mulchatna River, and the area to the north, possibly including the Wood River Lake. The more northern Tikchik Lakes were within the territory of the Kusquqvagmiut, who also inhabited the Kuskokwim River as far inland as the modern village of Aniak. The Kusquqvagmiut occupied the village of Tikchik on Tikchik Lake. They may have controlled the lakes to the north, but it is doubtful they utilized this area extensively. The Tuyuryarmiut occupied the banks of the Togiak River, its tributaries and the adjacent coast, between the Kusquqvagmiut and the Kiatagmiut (VanStone 1984).

4.10.2.4 History

Explorations of Bristol Bay and the Nushagak River were undertaken by the Russian-American Company in the early nineteenth century in an effort to open the Alaskan interior to the fur trade. Between 1818 and 1836, the Russians established trading posts at the mouth of the Nushagak, on the middle Kuskokwim and the lower Yukon (VanStone 1959, 1967). Following the establishment of a Russian Orthodox Church at the Aleksandrovski Redoubt in 1841, missionaries began to penetrate the Nushagak and Kuskokwim region. Little is known about the interaction between the interior Yup'ik and missionaries, but it was apparently extremely effective. By the end of the Russian era (1867), it is probable that most of the Yup'ik peoples in southwestern Alaska considered themselves to be Christians (VanStone 1964, 1984).

Between 1818 and 1867, the fur trade with the Russian-American Company led Native peoples in western Alaska to alter their hunting efforts towards beaver, which had little or no food value, and away from subsistence game. As a result, Natives became dependant on the trading posts for the necessities of life. However, the process was slow among the Yup'ik, who did not become totally dependent on the global market until after the Americans purchased Alaska in 1867 (VanStone 1984). The impact of the Russian fur trade was most prevalent on the Nushagak and the middle Kuskokwim, where beaver were plentiful. It was not until the turn of the twentieth century, when mink became a major trade item, that intensive fur trapping was undertaken in the Yukon delta region (Oswalt 1963).

With the sale of Alaska to the United States in 1867, an American firm, the Alaska Commercial Company, continued to operate the Russian trading centers. During this period, the variety of goods offered for trade increased considerably but, from an economic standpoint the economic system of southwestern Alaska did not change significantly from the model established by the Russian trading posts until the commercial development of the Bristol Bay salmon fisheries in the 1880s (VanStone 1984).

During the American period, the Russian Orthodox Church experienced competition from other churches including the Moravians, Episcopalians, Catholics and various evangelical protestant denominations (VanStone 1984).

Despite the Klondike and Nome gold rushes, Natives in the Kuskokwim and Nushagak regions had little contact with miners during the late nineteenth and early twentieth centuries (VanStone 1984). One significant technology introduced to southwest Alaska by miners was the fish wheel, which was widely adopted along the Kuskokwim and Yukon Rivers and is still in use today (Oswalt 1978).

Beginning in Bristol Bay during the 1880s, commercial fishing came to have a significant impact on Native life. During the early years, most of the actual fishing was done by whites and the cannery work by imported Chinese and other laborers; Native peoples were considered to be poor workers due to prevailing ethnocentric attitudes. Gradually, some Natives were able to overcome this prejudice and get work in the canneries but, it was not until after WWII that Natives were allowed to participate fully in the industry. The Nushagak region was most directly affected by the development of the fishing industry, but residents from villages throughout southwest Alaska were attracted to Bristol Bay during the summer months when the canneries were opened. The canneries were important acculturation sites where Native peoples interacted not only with people from other Yup'ik groups, but also with people from different races and nationalities (VanStone 1984).

4.10.3 Cultural Resources in the Project Vicinity

Cultural resources located in the proposed Project vicinity are currently unknown and will be evaluated during the overall Project licensing study program (see Section 5.0).

4.10.4 Potential Adverse Effects

No potential adverse impacts related to Project construction and operations have been identified for cultural and Tribal resources.

4.11 Socioeconomic Resources

The proposed Project location is within the Dillingham Census Area approximately 60 miles northeast of the City of Dillingham. Located at the mouth of the Nushagak River, Dillingham is the largest community in the Bristol Bay area, and is the government, service and transportation hub for the region (City of Dillingham 2010). The proposed Project includes a new power distribution system that would link the nearby native communities of Aleknagik, Koliganek, New Stuyahok, Ekwok, and Levelock.

Dillingham is accessible only by air or ocean (Nushagak Bay). Most cargo such as food, fuel and other items to and within the region comes by air or by oceangoing vessel, which then transfers cargo for barging up the river systems. The Dillingham-Aleknagik communities have a small road network, but the roadway system is localized and does not connect with other regional communities. Routine travel between hub communities and regional villages is customarily by air, snowmachine, ATV or skiff, depending on the season. (City of Dillingham 2010). It is anticipated that Project vicinity socioeconomic resources will be investigated as part of the overall Project licensing study program.

4.11.1 General Land Use Patterns

Much of the land in the Bristol Bay region is sparsely populated or uninhabited. Population centers tend to be concentrated along important rivers and lakes, or along the more sheltered portions of the coastline. Large tracts of land in the region are owned and managed by federal agencies or the State of Alaska, including Lake Clark and Katmai National Parks, Togiak NWR, and Wood-Tikchik State Park. Most of this land is managed to preserve its natural condition.

Significant portions of the region are owned by Alaska Native Corporations (ANCs) established by the Alaska Native Claims Settlement Act (ANCSA) in 1971. ANCSA conferred land to 13 for-profit regional corporations and approximately 200 village corporations. The Bristol Bay Native Corporation is the ANSCA corporation for the Bristol Bay region. ANC land is private land that is available for development, preservation, or other activities as directed by the ANC so long as those activities are in alignment with local, state, and federal land use controls (GAO 2012).

Many Alaska Natives hold title to individual parcels called Alaska Native allotments that were legally transferred prior to ANCSA. Allotments are typically located near villages and local communities, but they can also be found within national and state parks. In 1978, there were 104 inholdings in Wood-Tikchik State Park claimed by Native residents of Bristol Bay under the 1906 Native Alaska Allotment Act. Because these inholdings were also claimed by the state, the Bureau of Land Management (BLM) was required to adjudicate land title. The issue was settled with a combination of relocation and conservation easements. Some applicants swapped their inholdings for State lands outside the Park boundary. The remaining 77 pressed their land claims but agreed to conservation easements based on the strength of the original claim, the age of the applicant and the location of the parcel. A three-tier system was created:

- Tier 1 – The least restrictive, established a 25-foot-wide pedestrian easement on land bordering lakes and rivers with no other restrictions.
- Tier 2 – Allows the subdivision of parcels into ten-acre lots, with no more than one five-acre commercial development site.
- Tier 3 – Similar to Tier 2, but with no commercial development.

Most of the Wood-Tikchik parcels affected were classified as Tier 2. This solution limited large scale commercial development within the Park and ensured public access while protecting Native land claims. (Sherwonit 2005). There is a native allotment adjacent to the proposed Project location with a Tier 2 conservation easement (ADNR 2002). Figure 4-15 depicts private land within the Park, including native allotments.

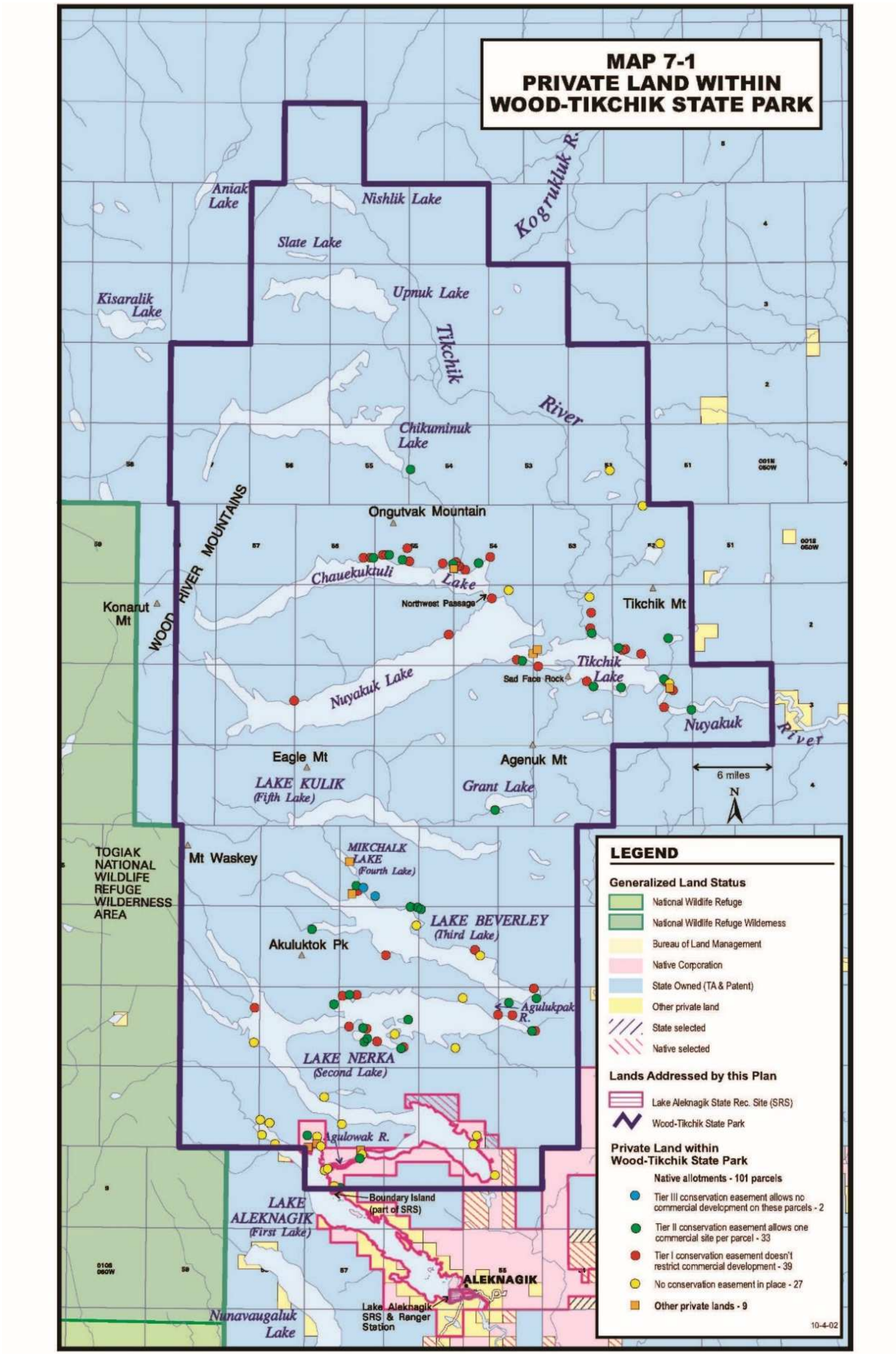

Figure 4-15. Private land within Wood-Tikchik State Park (ADNR 2002).

4.11.2 Demographics

Table 4-20 presents population data for the areas that would be impacted by the proposed Project. Between 2000 and 2010 the State of Alaska's population increased by approximately 12.7 percent. During this same time, the population of the Dillingham Census Area decreased by 1.5 percent (U.S. Census 2010a). In 2017 it was estimated that approximately 2,360 people lived in the City of Dillingham, almost half the population of the entire Dillingham Census Area. The average population of the 5 communities that would be connected to the Project by the proposed transmission lines is 224 people, ranging in size from 69 to just over 500 people (U.S. Census 2000, 2010, 2017).

Table 4-20. Population of the Project area from 2000-2017 (U.S. Census 2000, 2010, 2017).

Location	2000	2010	2017 (estimated)
State of Alaska	629,932	710,231	739,795
Dillingham Census Area	4,922	4,847	4,932
City of Dillingham	2,466	2,329	2,360
Aleknagik	221	219	221
Koliganek (CDP)	182	209	Not Available
New Stuyahok	471	510	513
Ekwok	130	115	131
Levelock (CDP)	122	69	Not Available

Although the racial composition of the State of Alaska is predominantly white, the majority of the population within the Dillingham Census Area (71.6 percent) is Alaska Native or Native American. Most of the surrounding communities are Yup'ik villages with even higher concentrations of Alaska Natives: 95.7 percent in Koliganek, 93.5 percent in New Stuyahok, 90.4 percent in Ekwok, and 84.1 percent in Levelock. The Alaska Native population makes up only 14.8 percent of the overall State population (U.S. Census 2010). Table 4-21 presents racial/ethnic data for the Project area.

Table 4-21. Racial/Ethnic Data for the Project Area (U.S. Census 2010).

Location	Alaska Native	White	African American	Asian	Pacific Islander	Other	2 or More Races	Hispanic (any race)
State of Alaska	104,871	473,576	23,263	38,135	7,409	11,102	51,875	39,249
Dillingham Census Area	3,470	878	11	32	6	12	438	101
City of Dillingham	1,301	716	9	30	4	9	260	68
Aleknagik	166	33	0	0	0	0	20	0

Koliganek (CDP)	200	7	0	0	0	0	2	0
New Stuyahok	477	18	0	0	1	0	14	6
Ekwok	104	6	0	0	0	0	5	3
Levelock (CDP)	58	7	0	0	0	0	4	0

4.11.3 Industry and Employment

Alaska's economy is heavily dependent on the extraction and transportation of the state's vast natural resources: oil, natural gas, coal and minerals, as well as salmon, halibut, crab and other sea life. The need to manage these resources has resulted in a very large government sector in Alaska. Almost half of the residents within the Dillingham Census Area (40.5 percent in 2017) are government employees (Table 4-22). Education and healthcare facilities are also large employers in Dillingham (e.g., Bristol Bay Area Health Corporation, Dillingham City School District, and University of Alaska Bristol Bay Campus) (U.S. Census 2017).

Table 4-22. Dillingham Census Area Employment by Industry (2017 estimates) (U.S. Census 2017).

Industry	Number of Employees	Percent
Government Workers	806	40.5
Agriculture, Forestry, Fishing & Hunting, Mining	106	5.3
Construction	59	3.0
Manufacturing	62	3.1
Wholesale Trade	9	0.5
Retail Trade	193	9.7
Transportation, Warehousing & Utilities	152	7.6
Information	27	1.4
Finance, Insurance, Real Estate, Rental & Leasing	69	3.5
Professional, Scientific, Management, Administrative & Waste Mgmt	91	4.6
Education, Health & Social Services	775	39.0
Arts, Entertainment, Recreation, accommodation & Food Services	54	2.7
Other Services (except public administration)	61	3.1

Public Administration	331	16.6

In 2017, 415 fishermen from the Dillingham Census Area engaged in commercial salmon fishing with total estimated gross earnings of $28,042,691. Residents of the area who hold commercial salmon fishing permits make up approximately 6 percent of Alaska's total commercial salmon fishing permit holders (Table 4-23). Non-residents of Alaska account for 28 percent (ACFEC 2017).

Table 4-23. Alaska Commercial Salmon Fishing Data (ACFEC 2017).

Group	Number of Fisherman Who Fished	Number of Permits Fished	Total Pounds Landed	Estimated Gross Earnings
Dillingham Census Area Residents	411	404	24,902,672	$28,042,691
Alaska Residents	5,105	5,281	670,103,405	$473,075,769
All Fisherman	7,134	7,307	985,970,869	$745,424,153

The Dillingham Census Area has a lower median household income and higher unemployment and poverty rates than the State as a whole, as shown in Table 4-24. Levelock Census Designated Place (CDP) has a median household income of just $25,000, the lowest in the study area and less than one third of the State median. Ekwok has a 22.4 percent unemployment rate and a 33.3 percent poverty rate, the highest in the study area and more than 4 times that of the State. The City of Dillingham has the highest income and lowest unemployment and poverty statistics in the study area. This is unsurprising, as the major industries in the area are based in the hub community (e.g., government, education, and healthcare) (U.S. Census 2010).

Table 4-24. Median Household Income, Unemployment and Poverty Rates in the Project Area (U.S. Census 2010).

Location	Median Household Income	Unemployment (%)	Poverty (%)
State of Alaska	$76,114	5.2	6.9
Dillingham Census Area	$58,708	7.1	14.6
City of Dillingham	$75,764	3.6	6.9
Aleknagik	$42,083	9.0	14.9
Koliganek (CDP)	$53,750	6.7	10.0
New Stuyahok	$43,750	11.8	23.7
Ekwok	$28,750	22.4	33.3

Levelock (CDP)	$25,000	10.9	21.1

Though not a formal industry sector, subsistence is a very important aspect of the economy for rural Alaskan communities. In addition to providing food in a remote area with a high cost of living, subsistence activities are integral to the life and identity of many rural Alaska residents, particularly Alaska Native peoples. Traditionally, community members hunt, fish and gather foods which are distributed throughout the community so that everyone is fed and cared for. Residents within the Dillingham Census Area harvest approximately 369 pounds of wild food per person each year, 15-20 times more than residents in Alaska's urban areas.

There is a direct relationship between subsistence practices and the formal job-based economy. Where subsistence resources are plentiful, these practices allow community members to meet their food and other needs without having to participate as much in the formal job-based economy. Some workers choose to forego formal employment if it conflicts with established community subsistence practices. This decision is also supported by dividends paid to shareholders in Alaska Native regional or village corporations, and by the State of Alaska Permanent Fund program, which can provide significant yearly household income (Wolfe 2004).

4.11.4 Electricity

Utilities in the Bristol Bay area primarily use diesel generators to generate electricity. The cities of Dillingham and Aleknagik are supplied by Nushagak Electric & Telephone Cooperative, Inc., a member owned and operated cooperative. The Alaska Village Electrical Cooperative (AVEC) supplies electricity for communities throughout Alaska, including Ekwok and New Stuyahok. The New Koliganek Village Council provides electricity to Koliganek, and Levelock Electrical Cooperative provides electricity to Levelock.

Rural Alaskans pay significantly higher energy costs than in urban areas. In response to and in anticipation of rising electricity costs for rural residents, the State of Alaska created the Power Cost Equalization (PCE) program in 1985. The PCE program is administered by the Alaska Energy Authority (AEA) with funding appropriated by the legislature and paid out to individual utilities across the state. The PCE subsidy is intended to bring residential electric rates (cents per kWh) for rural Alaskans closer to that paid by urban residents (SWAMC 2015).

4.11.5 Potential Adverse Effects

No potential adverse impacts related to Project construction and operations have been identified for socioeconomic resources.

5.0 PRELIMINARY ISSUES AND STUDIES LIST (18 CFR § 5.6 (D)(4))

The Cooperative has gone to considerable effort to communicate with agencies and stakeholders to acquire existing Project area natural resource information as part of the PAD development process. These data have allowed for the identification of data gaps, potential Project impacts (from construction and operations) and thus, areas of potential study need. Based upon this data acquisition and subsequent analysis, the Cooperative has developed a preliminary list of potential study areas to be investigated during the relicensing process. These areas have been itemized by resource area, consistent with Section 4.0 of this PAD. It is notable that the study areas described below are preliminary and the overall study program will be further refined and detailed based upon dialogue with stakeholders during the study plan development process to take place in late 2019 and early 2020. Further, results from the initial study season will define the need and type of supplemental assessments to be carried out during the second study season. Ultimately, it is the Cooperative's hope that the results of these studies along with consistent and collaborative dialogue with stakeholders will result in Protection, Mitigation and Enhancement measures (PM&Es) to be incorporated into the FERC License Order.

During a November 19, 2018 meeting with the University of Washington's Fisheries Research Institute (FRI), the Cooperative was made aware of additional Nushagak River drainage fisheries data collected by FRI recently. While considerable effort was made by the Cooperative to acquire these data and incorporate them into this PAD, access has not been granted to date. The Cooperative only points this out to highlight our recognition that additional natural resource data may exist. As a first step in the overall study program, all data utilized in Section 4.0 along with any additional data that is identified will be utilized in a desktop analysis to further assess baseline conditions in advance of any field study efforts. These desktop analyses will be integrated into the methods sections of the respective natural resource study plans that make up the Proposed Study Plan (PSP).

5.1 Issues Pertaining to the Identified Resources

To date, data gaps and key areas of potential Project impact that have been identified include:

- Reduced flows over Nuyakuk Falls and impacts (positive and negative) to upstream and downstream passage
- Site-specific hydrologic record establishment
- Site-specific water quality evaluation
- Potential entrainment of fish via the Project intake
- False attraction flows for upstream migrating fish from Project outflow, via the tailrace
- Potential for reduced sediment transport over Nuyakuk Falls
- Potential for impact to migratory wildlife species resulting from the installation and operation of the transmission line
- Potential for impact to botanical species as a result of resulting from the installation and operation of the transmission line
- Potential for impact to any species of concern present in the Project area
- Cultural and/or Tribal resources that may be impacted by Project construction and operations

- Potential impact to recreational and visual observation activities that occur in the Project area
- Project development (ground disturbance, infrastructure establishment, etc.) and operations activities and their associated impacts to the Project area

5.2 Potential Studies or Information Gathering

The Cooperative has developed a list of potential studies, by resource area, that may be needed during the study program to inform the license application and further refine the development of the appropriate Project layout and operational scenario. The primary studies listed below may consist of a series of itemized tasks intended for synthesis during the analysis phase to answer a fundamental question. In addition to a robust and collaboratively developed natural resource study program, a comprehensive engineering analysis will occur concurrently that will define the optimal layout and operational scenario for the Project. This engineering assessment will also account for any risks associated with construction and long-term operation of the Project. Finally, it is important to note that the initial list of natural resource studies described below will likely be refined based upon collaborative discussions with stakeholders and the final set of studies will be outlined in the PSP.

5.2.1 Geology and Soils

Limited information exists related to overall soil/substrate type and composition the Project site. During initial site visits, the Cooperative has visually observed a significant amount of bedrock both in the river channel and the out of water areas where significant pieces of Project infrastructure would be placed. The viability and process of these substrate types will be the focus of these studies. Key areas of focus will be to assess the material conditions both in-water and out of water associated with the layout of the Project. Confirmation of appropriate rock composition for infrastructure would be acquired via hard rock drilling techniques. A majority of the focus will be placed on the main infrastructural components (intake, tunnel, penstock, powerhouse, etc.). The transmission line corridor will be assessed as well.

<u>Potential Studies</u>

- Geotechnical Assessment of the Project Site

5.2.2 Water Resources

Information collected during the water resources evaluations will be used to further inform the baseline condition at the Project site and assess impacts, if any, to water quality, sediment transport and hydrologic conditions at the Project site. Certain components of these study results will also be integrated into the Fish and Aquatic Resources studies described below and utilized to assess various modeled flow scenarios over Nuyakuk Falls to determine acceptable levels of Project withdrawal that maintain passage for fish species.

<u>Potential Studies</u>

- Water Quality and Water Temperature Assessment of the Nuyakuk River near the Project Site

- Hydrologic Data Collection at the Project Site (Stream Gaging)
- Sediment Transport Assessment and Modeling

5.2.3 Fish and Aquatic Resources

Nuyakuk Falls will be the "bypass reach" on the Nuyakuk River associated with this Project. These Falls consist of a series of high velocity bedrock cascades. Given the small footprint of the proposed Project and limited amount of spawning and rearing habitat that is anticipated to be impacted as a result of Project operations, the primary focus of the fisheries investigation will focus on the Falls and appropriate seasonal and species-specific flow levels required to maintain safe and effective upstream and downstream passage for the anadromous and resident fish species present. On-site data collection and modeling will be utilized to document a variety of operational scenarios and compare/contrast them with respective species' passage requirements. A site-specific baseline inventory of fish species seasonally present near the Project site will also occur to confirm existing data and the appropriate passage criteria to utilize.

Potential Studies

- Fish Species Seasonal Distribution and Abundance near the Project Site
- Bathymetric Modeling of Nuyakuk Falls
- Nuyakuk Falls Fish Passage Evaluation and Modeling

5.2.4 Wildlife and Botanical Resources

In addition to a general assessment of wildlife and botanical species presence in the Project area, the key focus of the wildlife and botanical effort will be to:

- Assess impacts to migratory wildlife species as a result of transmission line corridor development and operation
- Assess impacts to key avian species as a result of transmission line corridor development and operation
- Assess impacts to botanical species as a result of overall Project construction and operation

These efforts will initiate with a comprehensive desktop analysis of all existing data related to seasonal species presence in the Project area. These studies will then be supplemented by aerial and on-foot surveys in focus areas identified via the desktop analysis and based on Project design and layout. Focus will also be placed on identifying any rare, threatened and/or endangered species with the potential to occur in the Project area.

Potential Studies

- Wildlife Presence, Distribution and Migratory Assessments
- Botanical Presence and Distribution Evaluation

- Invasive Weed Presence and Proliferation Assessment
- Rare, Threatened and Endangered Species Assessment

5.2.5 Wetlands and Riparian Habitat

An initial review of all existing information documenting wetland presence, type and quantity in the Project area will culminate in an aerial and on-foot field survey of wetland areas that will be potentially impacted by the Project. At this time, it is anticipated that wetlands that would be potentially impacted (if any) would be primarily associated with the construction and operation of the transmission line.

Potential Studies

- Project area wetland assessment

5.2.6 Recreation, Land Use, Aesthetics and Visual Resources

Given the remote location of the Project site, relatively limited recreational activity occurs in the area. However, there are lodges located in the drainage upstream of the Project site. Both guides associated with those lodges and other individuals fish for a variety of species in the river near the Project site and utilize it as a transportation corridor for hunting activities. Overland activities utilizing snowmobiles and ATVs also occur in the area along with aerial sightseeing. Given these activities, a comprehensive visual and recreational assessment of the Project area will occur with the intent of defining the extent of the recreational activities that occur in the Project area and describing all of the potential impacts associated with Project development and operations. The on-site data collection component of this effort would likely be conducted primarily from the air.

Potential Studies

- Recreation and Aesthetics Evaluation

5.2.7 Cultural and Tribal Resources

The Cooperative recognizes the potential for cultural and Tribal resources to be present in the area and will conduct a comprehensive assessment to determine the presence of any culturally significant sites. The intent of a cultural resources study would be to conduct desktop analysis and field studies to identify document and classify all traditional cultural and historical properties in the Project area. On-foot and aerial surveys of the Project area will occur. Per the NHPA Section 106 compliance process, the Cooperative would work collaboratively with all requisite Tribal, state and federal entities to define the APE associated with the Project and take part in extensive collaboration with the State Historical Preservation Office (SHPO). This effort would ultimately result in an HPMP to be implemented and maintained over the course of the initial operating license.

Potential Studies

- Project Area Cultural Resources Assessment

5.2.8 Socioeconomic Resources

The Cooperative believes the economic impact to the area impacted by the Project will largely be positive. A desktop analysis will be conducted to define existing population, social and economic conditions in the Project area and assesses the impacts associated with Project development and operations.

Potential Studies

- Socioeconomic Evaluation of Potentially Impacted Area

5.3 Relevant Comprehensive Plans

Local, state, regional, and federal comprehensive plans relevant to the proposed Project include:

Alaska Administrative Code. 2012. 5 AAC § 39.222 Policy for the Management of Sustainable Salmon Fisheries. Juneau, Alaska.

Alaska Administrative Code. 2003. 5 AAC § 75.222 Policy for the Management of Sustainable Wild Trout Fisheries. Juneau, Alaska.

Alaska Department of Fish and Game. 2006. Management Plan for Invasive Northern Pike in Alaska. Anchorage, Alaska. 2006.

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Alaska Department of Fish and Game. U.S. Fish and Wildlife Service. 2007. Black Oystercatcher (*Haematopus bachmani*) Conservation Action Plan. Anchorage, Alaska. April 2007.

Alaska Department of Natural Resources. Alaska's Outdoor Legacy: Statewide Comprehensive Outdoor Recreation Plan (SCORP): 2009-2014. Anchorage, Alaska.

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Alaska Department of Natural Resources. 2005. Bristol Bay Area Plan for State Lands. Anchorage, Alaska. April 2005.

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U.S. Fish and Wildlife Service, et al. 2008. Alaska Shorebird Conservation Plan. Version II. Anchorage, Alaska. November 2008.

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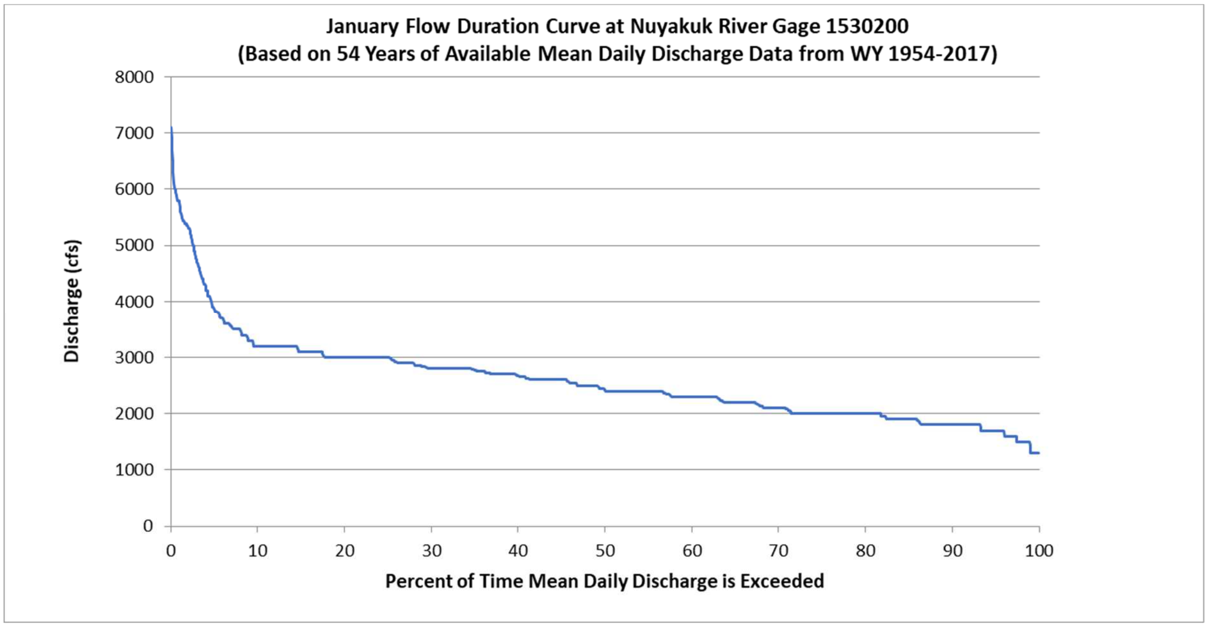
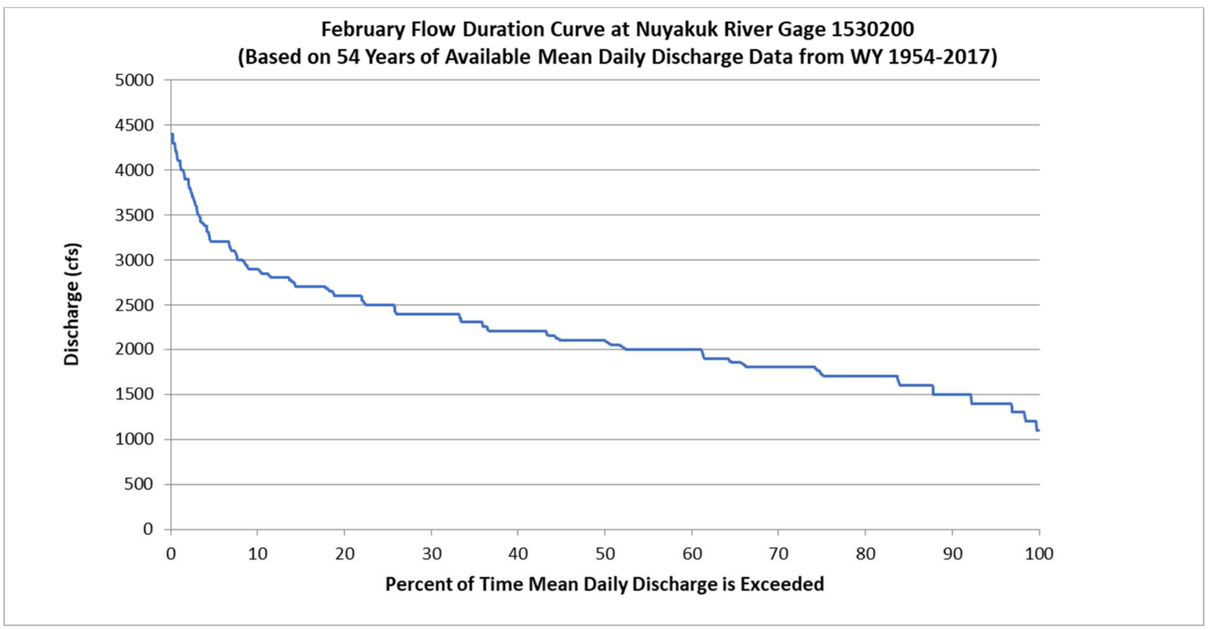
APPENDIX A:
FERC Form 587*

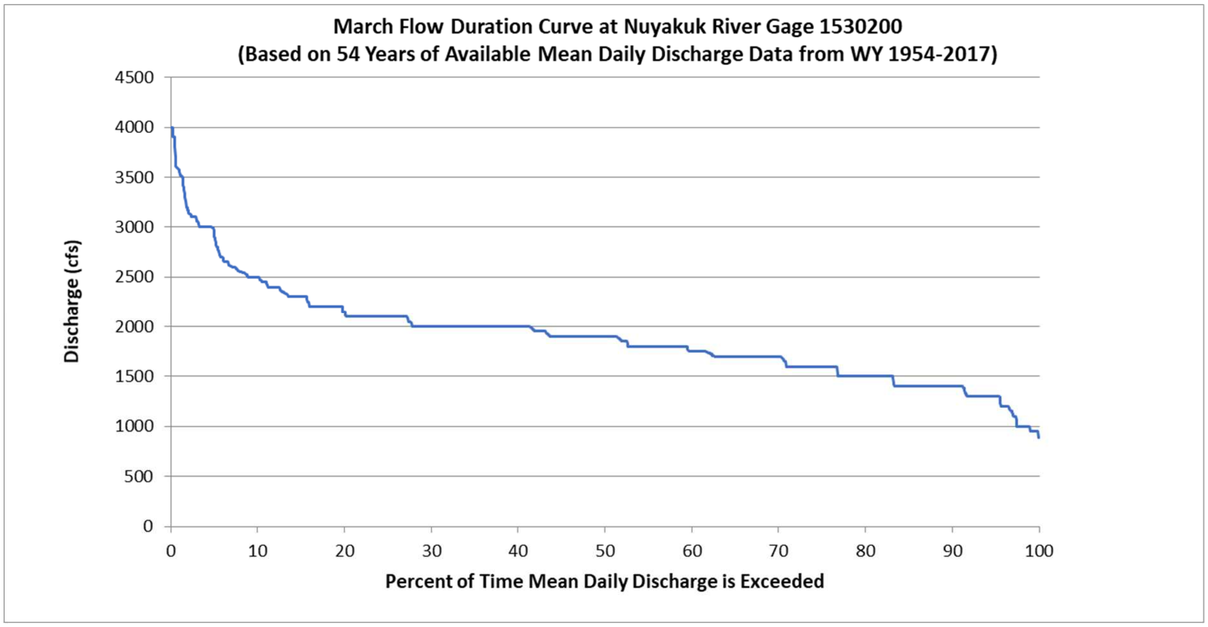
*FERC Form 587 data have changed since the previous filing with the Preliminary Permit Application filing in April 2018, due to alterations in the proposed Project transmission route.

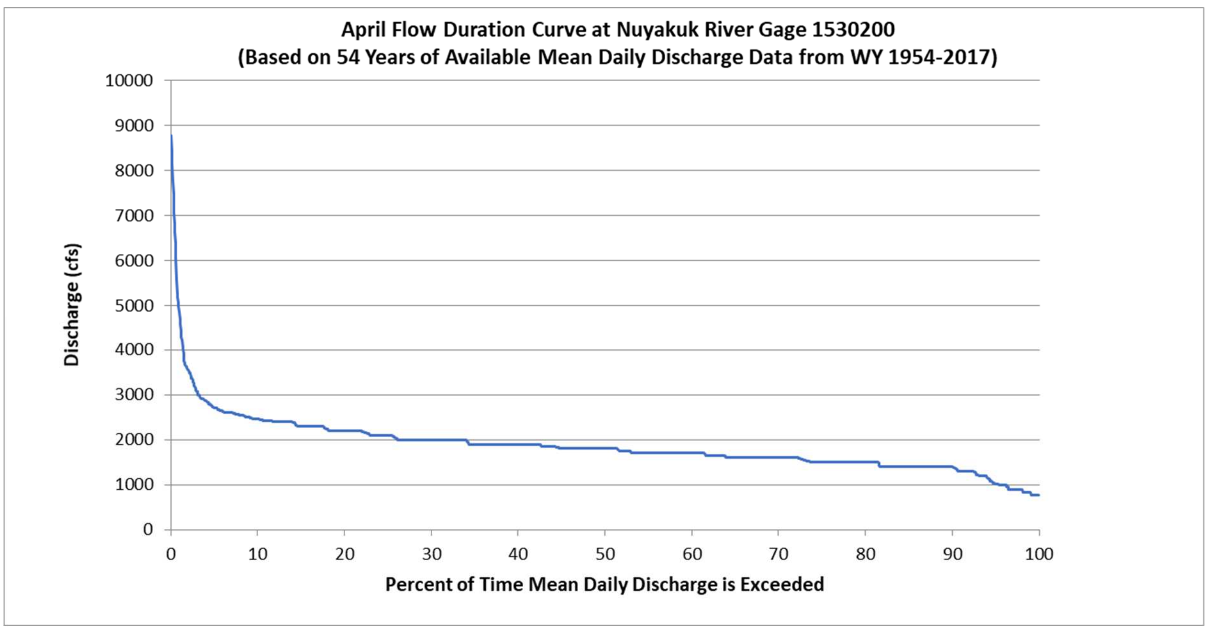
APPENDIX B:
Monthly Flow Duration Curves

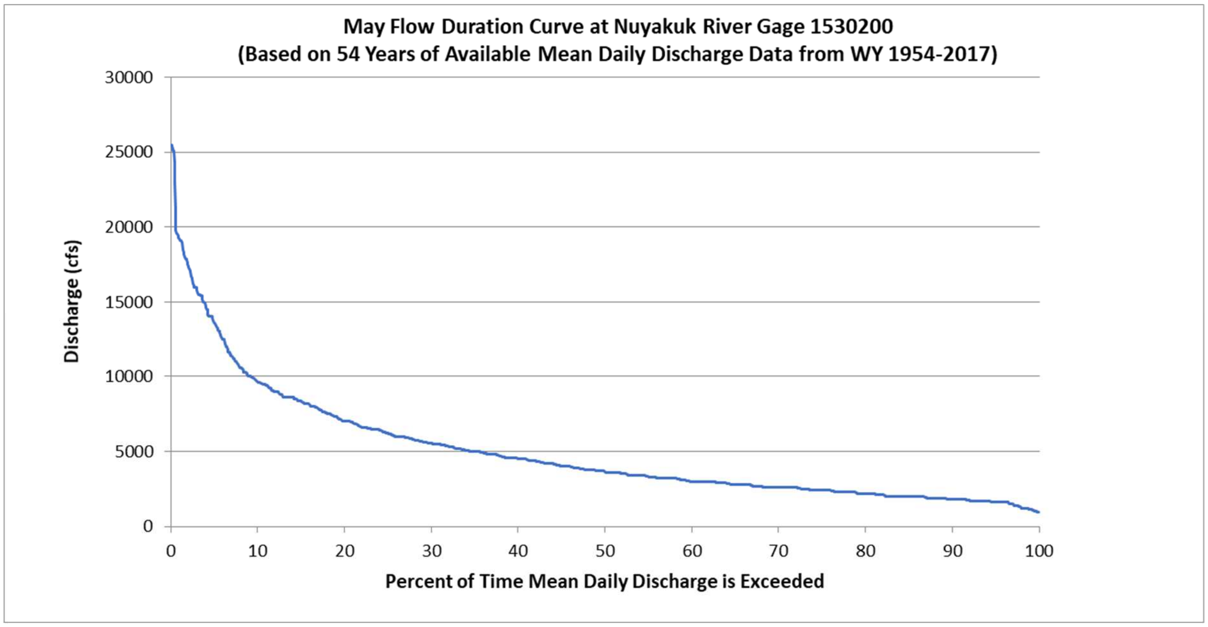
Monthly flow duration curves for the Nuyakuk River at Nuyakuk River Gage 1530200 are presented below. The flow duration curves are based on 54 years of available mean discharge data from WY 1954-2017.

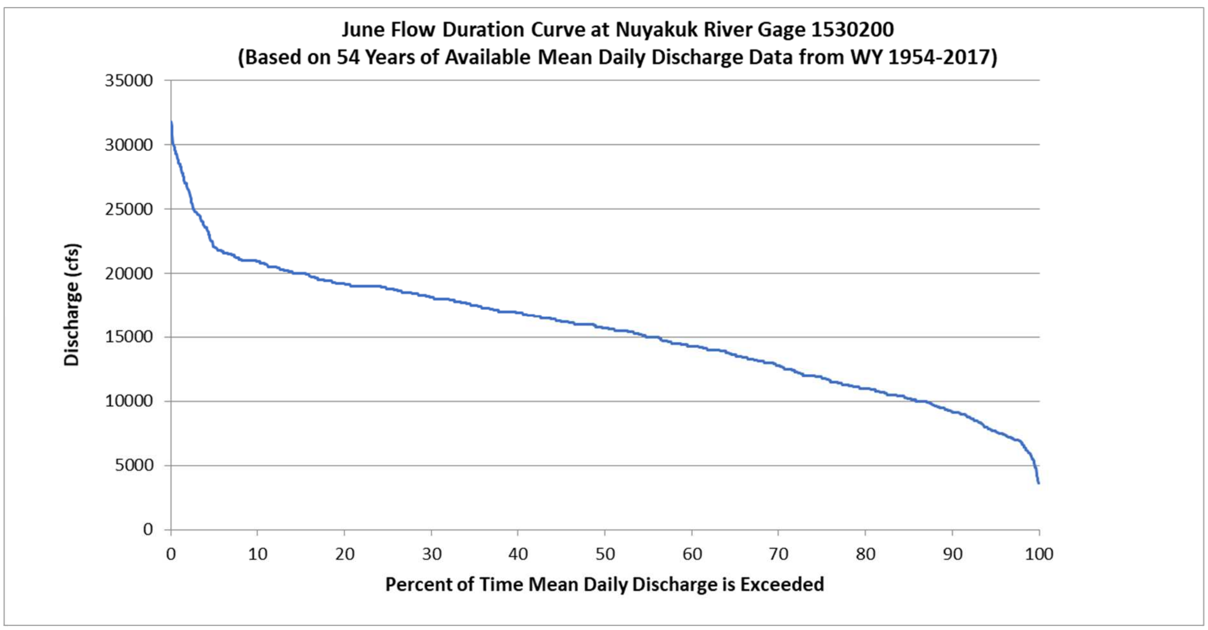


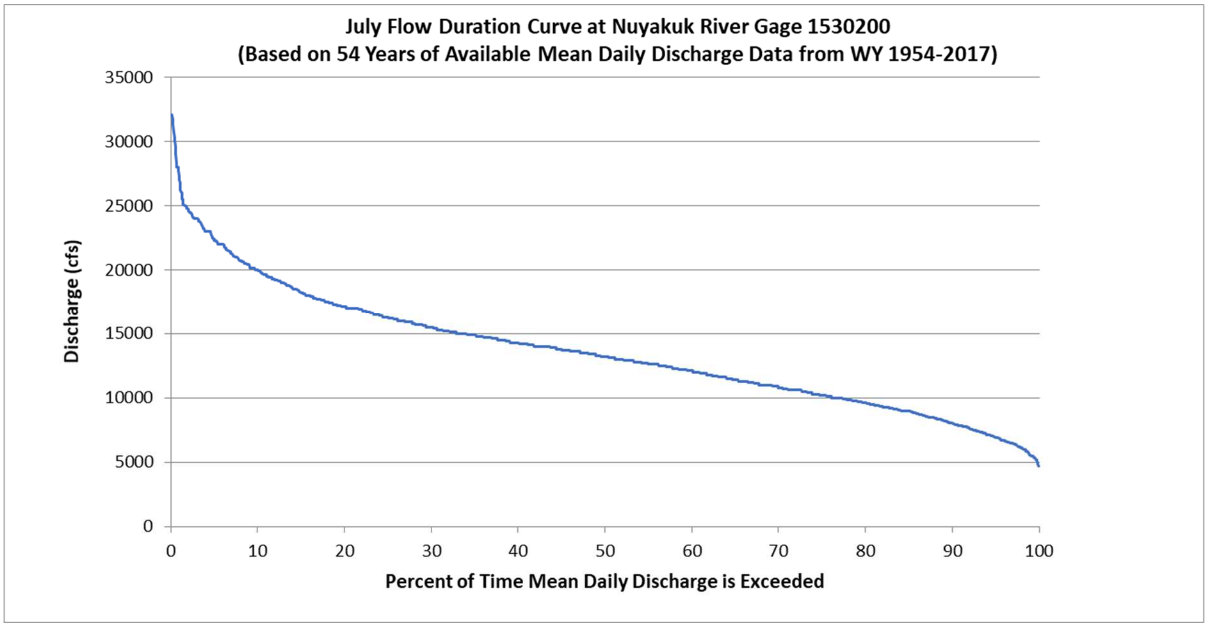


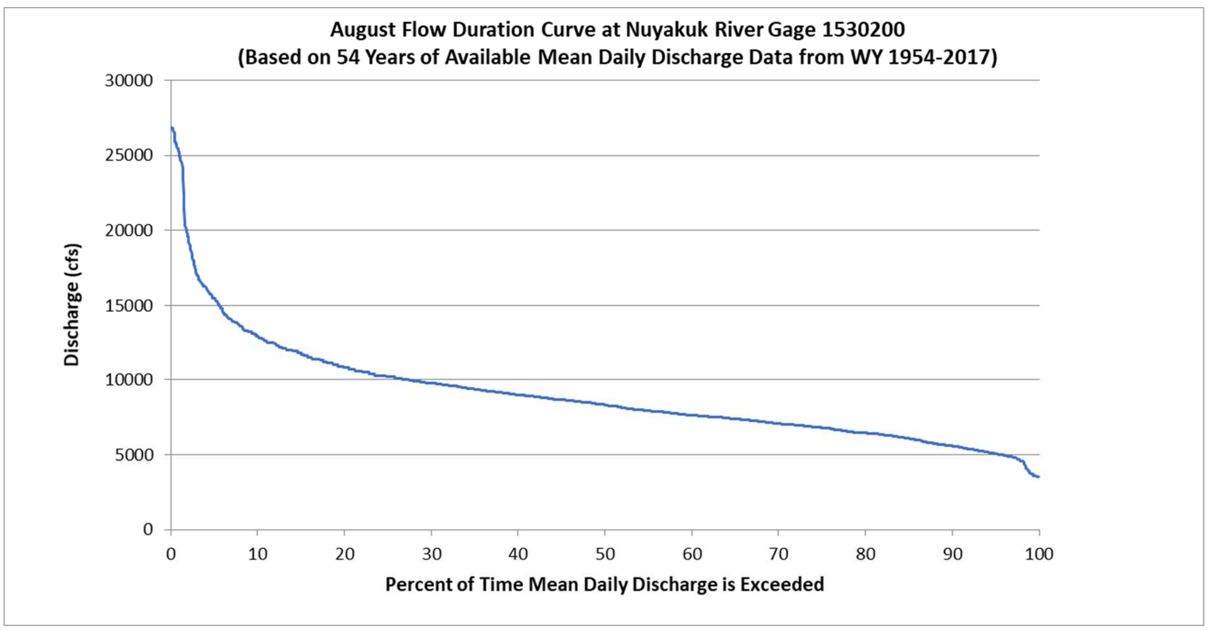

March Flow Duration Curve at Nuyakuk River Gage 1530200
(Based on 54 Years of Available Mean Daily Discharge Data from WY 1954-2017)
Discharge (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0 10 20 30 40 50 60 70 80 90 100
Percent of Time Mean Daily Discharge is Exceeded

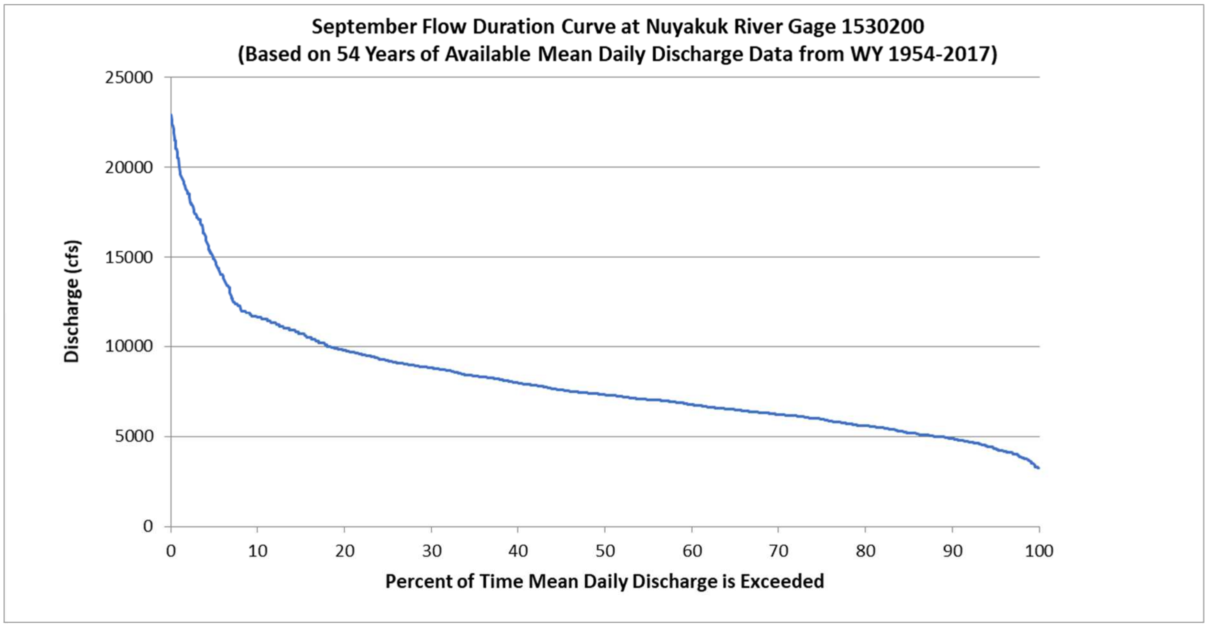

April Flow Duration Curve at Nuyakuk River Gage 1530200
(Based on 54 Years of Available Mean Daily Discharge Data from WY 1954-2017)
Discharge (cfs)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0 10 20 30 40 50 60 70 80 90 100
Percent of Time Mean Daily Discharge is Exceeded

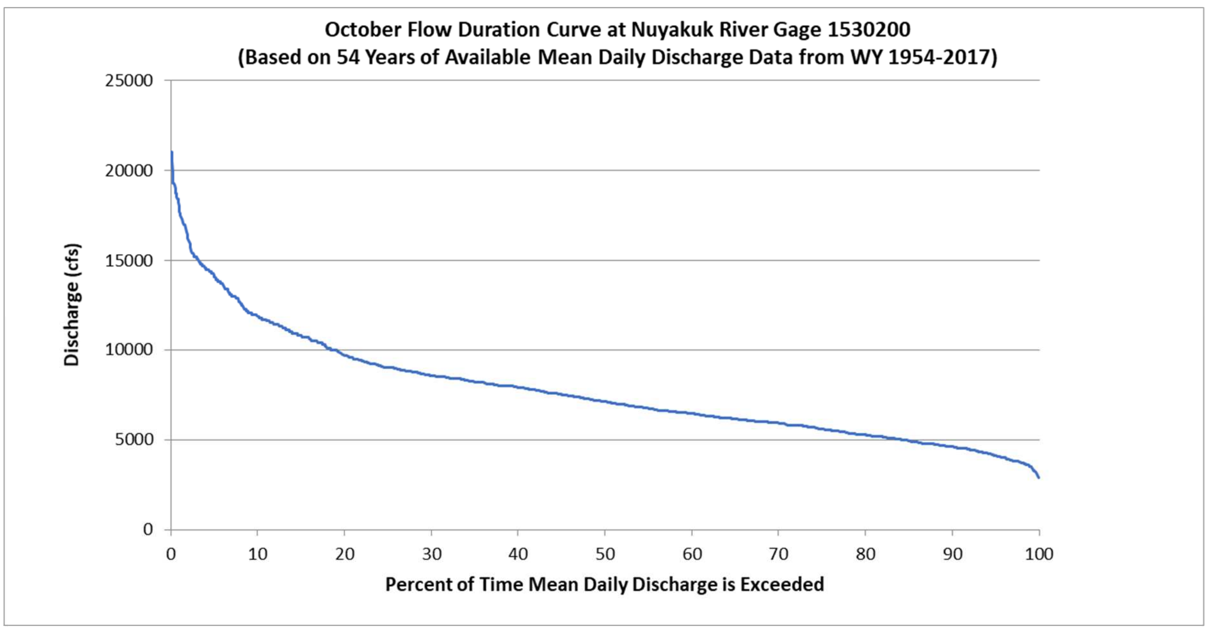

May Flow Duration Curve at Nuyakuk River Gage 1530200
(Based on 54 Years of Available Mean Daily Discharge Data from WY 1954-2017)
Discharge (cfs)
30000
25000
20000
15000
10000
5000
0
0 10 20 30 40 50 60 70 80 90 100
Percent of Time Mean Daily Discharge is Exceeded

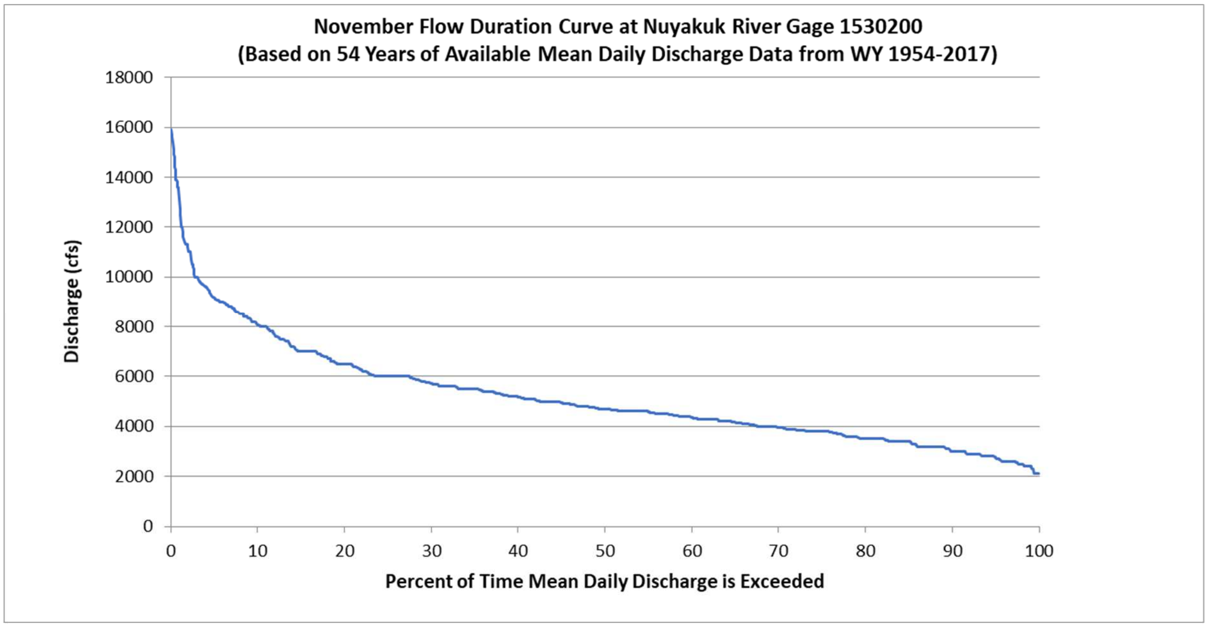

June Flow Duration Curve at Nuyakuk River Gage 1530200
(Based on 54 Years of Available Mean Daily Discharge Data from WY 1954-2017)
Discharge (cfs)
35000
30000
25000
20000
15000
10000
5000
0
0 10 20 30 40 50 60 70 80 90 100
Percent of Time Mean Daily Discharge is Exceeded

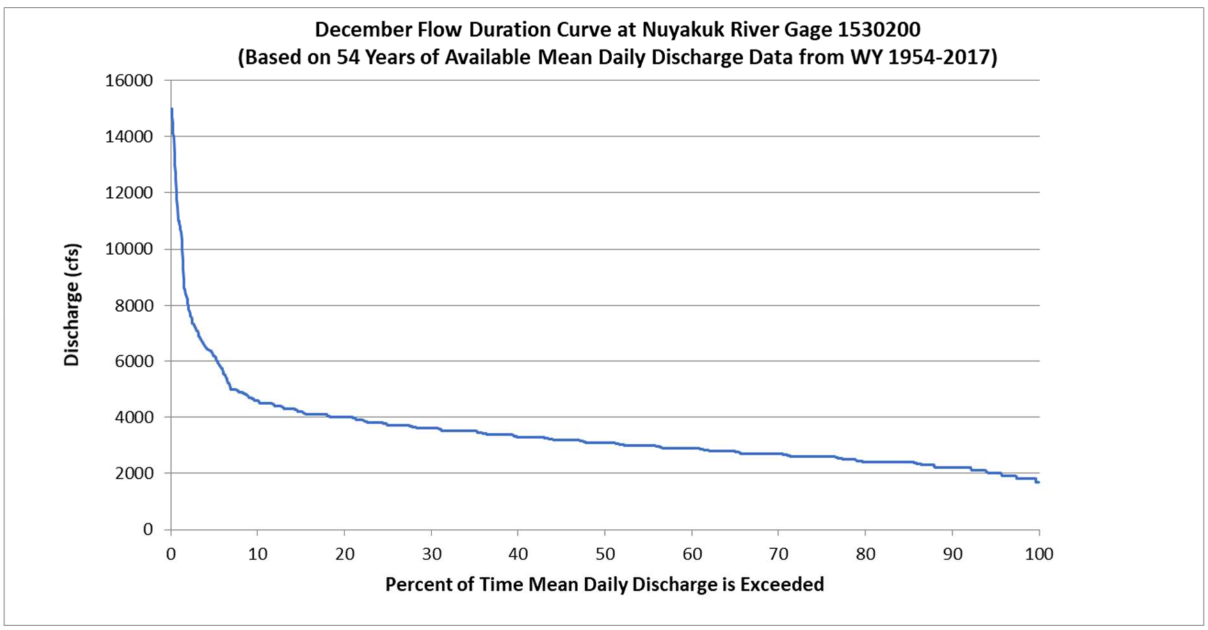

July Flow Duration Curve at Nuyakuk River Gage 1530200
(Based on 54 Years of Available Mean Daily Discharge Data from WY 1954-2017)
35000
30000
25000
20000
15000
10000
5000
0
Discharge (cfs)
0
10
20
30
40
50
60
70
80
90
100
Percent of Time Mean Daily Discharge is Exceeded


August Flow Duration Curve at Nuyakuk River Gage 1530200
(Based on 54 Years of Available Mean Daily Discharge Data from WY 1954-2017)
30000
25000
20000
15000
10000
5000
0
Discharge (cfs)
0
10
20
30
40
50
60
70
80
90
100
Percent of Time Mean Daily Discharge is Exceeded


September Flow Duration Curve at Nuyakuk River Gage 1530200
(Based on 54 Years of Available Mean Daily Discharge Data from WY 1954-2017)
Discharge (cfs)
25000
20000
15000
10000
5000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of Time Mean Daily Discharge is Exceeded


October Flow Duration Curve at Nuyakuk River Gage 1530200
(Based on 54 Years of Available Mean Daily Discharge Data from WY 1954-2017)
Discharge (cfs)
25000
20000
15000
10000
5000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of Time Mean Daily Discharge is Exceeded


November Flow Duration Curve at Nuyakuk River Gage 1530200
(Based on 54 Years of Available Mean Daily Discharge Data from WY 1954-2017)
Discharge (cfs)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of Time Mean Daily Discharge is Exceeded


December Flow Duration Curve at Nuyakuk River Gage 1530200
(Based on 54 Years of Available Mean Daily Discharge Data from WY 1954-2017)
Discharge (cfs)
16000
14000
12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of Time Mean Daily Discharge is Exceeded