DOCKET NO. CP17-___-000

ESSENTIAL FISH HABITAT (EFH) ASSESSMENT REPORT

PUBLIC

USAI-P2-SRZZZ-00-000009-000

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1.0 INTRODUCTION AND PROJECT DESCRIPTION

1.1 INTRODUCTION

The Alaska LNG Project (Project) includes the following: a liquefaction facility (Liquefaction Facility) in Southcentral Alaska; an approximately 807-mile gas pipeline (Mainline); a gas treatment plant (GTP) within the PBU on the North Slope; an approximately 63-mile gas transmission line connecting the GTP to the PTU gas production facility (PTU Gas Transmission Line or PTTL); and an approximately 1-mile gas transmission line connecting the GTP to the PBU gas production facility (PBU Gas Transmission Line or PBTL).

Some activities associated with the Project would occur within areas that have been designated as Essential Fish Habitat (EFH), and therefore could potentially affect the EFH. Under the Magnuson-Stevens Act (MSA) when a federal action agency (the Federal Energy Regulatory Commission {FERC}) determines if the action it is approving may adversely affect EFH, the action agency must consult with the National Marine Fisheries Service (NMFS) on all proposed actions that may adversely affect EFH. As the non-federal representative for the FERC Section 3 Natural Gas Act (NGA) application, informal consultation was undertaken with NMFS to initiate an assessment of Project impacts to EFH. The following report is a draft EFH Assessment for the Project, a required component of the EFH consultation. This report will be updated for the FERC application after review and comment by FERC, NMFS, and the Alaska Department of Fish and Game (ADF&G). FERC will take the analysis in the FERC application and finalize the consultation with NMFS and ADF&G.

1.2 PROJECT DESCRIPTION

The Project includes a Liquefaction Facility on the Kenai Peninsula and Interdependent Project Facilities consisting of the Mainline, GTP, PTTL, and PBTL.

There are also five identifiable categories of facilities that (i) are outside the scope of the proposed Project, (ii) would be owned and operated by third parties, (iii) are beyond FERC's jurisdiction under the NGA, but (iv) are connected actions to the Project:

- Modifications/new facilities at the PTU (PTU Expansion project).
- Modifications/new facilities at the PBU (referred to as the PBU Major Gas Sales (MGS) project), including a new pipeline from the GTP to the PBU to transfer GTP Byproduct back to the PBU.
- Relocation of the Kenai Spur Highway.
- Possible modifications to or construction of manufacturing facilities to fabricate Project components outside of Alaska.
- Third-party pipelines and associated infrastructure to transport natural gas from the gas interconnection points to markets within Alaska (Gas Interconnect Point Facilities).

During construction, heavy-lift vessels would transport prefabricated modules through the Bering, Chukchi, and Beaufort seas to Prudhoe Bay as well as through the Gulf of Alaska to Cook Inlet. Once constructed, Liquefied Natural Gas Carriers (LNGCs) would be required to deliver LNG to foreign markets. LNGCs would likely transit through the Aleutian Islands, Gulf of Alaska, Shelikof Strait or Kennedy/Stevenson Entrances, and Cook Inlet to markets in Asia.

A full description of the Project is provided in Resource Report No. 1. The description summary provided here is focused only on activities associated with the construction and operation of the Project that could have direct or indirect effects on EFH. These components are:

- Construction and operation of the Marine Terminal in Cook Inlet.
- Construction and operation of the Mainline when within or near EFH.
- Construction and operation of the Mainline across Cook Inlet, including modification and use of an existing dock on the west side of Cook Inlet (or construction of a new temporary Material Offloading Facility {MOF}).
- Modification and use of West Dock in Prudhoe Bay.
- Vessel traffic associated with construction and operation of the Project in Cook Inlet, the Gulf of Alaska, Bering Sea, Chukchi Sea, and the Beaufort Sea.
- Minor components of the non-jurisdictional facilities (PBU MGS and PTU expansion) such as some proposed dredging at an existing dock head.

These Project components are described in the following sections and are depicted in Figures 1 through 4.

1.2.1 Marine Terminal

The Marine Terminal would be constructed adjacent to the LNG Plant in Cook Inlet and would allow LNGCs to dock and load LNG. As shown on Figure 4, marine facilities would include:

- Product loading facility (PLF) that would support the piping that delivers LNG from the shore to LNGCs and would include all of the equipment to dock LNGCs. No dredging would be required to construct or operate the PLF.
- MOF that would be a dock used during Project construction to enable direct deliveries of materials, equipment, and other cargo in order to reduce the transport of large and heavy loads over road infrastructure. Dredging would be required to operate the temporary MOF during construction.

The PLF would be a permanent facility for the duration of the LNG export operations. The MOF comprises temporary facilities that would be removed during operations of the LNG Plant.

The schedule for Marine Terminal offshore construction activities is based on using ice-free working windows in Cook Inlet from approximately April 1 through October 31. Land required for construction and operation of the Marine Terminal is indicated in Table 1.

Table 1: Land Required for Construction and Operation of the Marine Terminal

Facility	Land Affected During Construction (acres)	Land Affected During Operation (acres)
Temporary MOF	11.32 [a]	0.00
Temporary MOF Dredging Area	50.70 [a]	0.00
Dredge Disposal Area	1,200 (600 acres/year during construction)	0.00
Shoreline Protection	1.54	0.00
PLF	18.67	18.67
Marine Terminal Total	1,282.22	18.67

[a] Temporary MOF total is 28.3 acres; however, 16.98 acres is included within the MOF dredging area footprint.

PROJECT OVERVIEW

FIGURE 1

ALASKA LNG

LEGEND

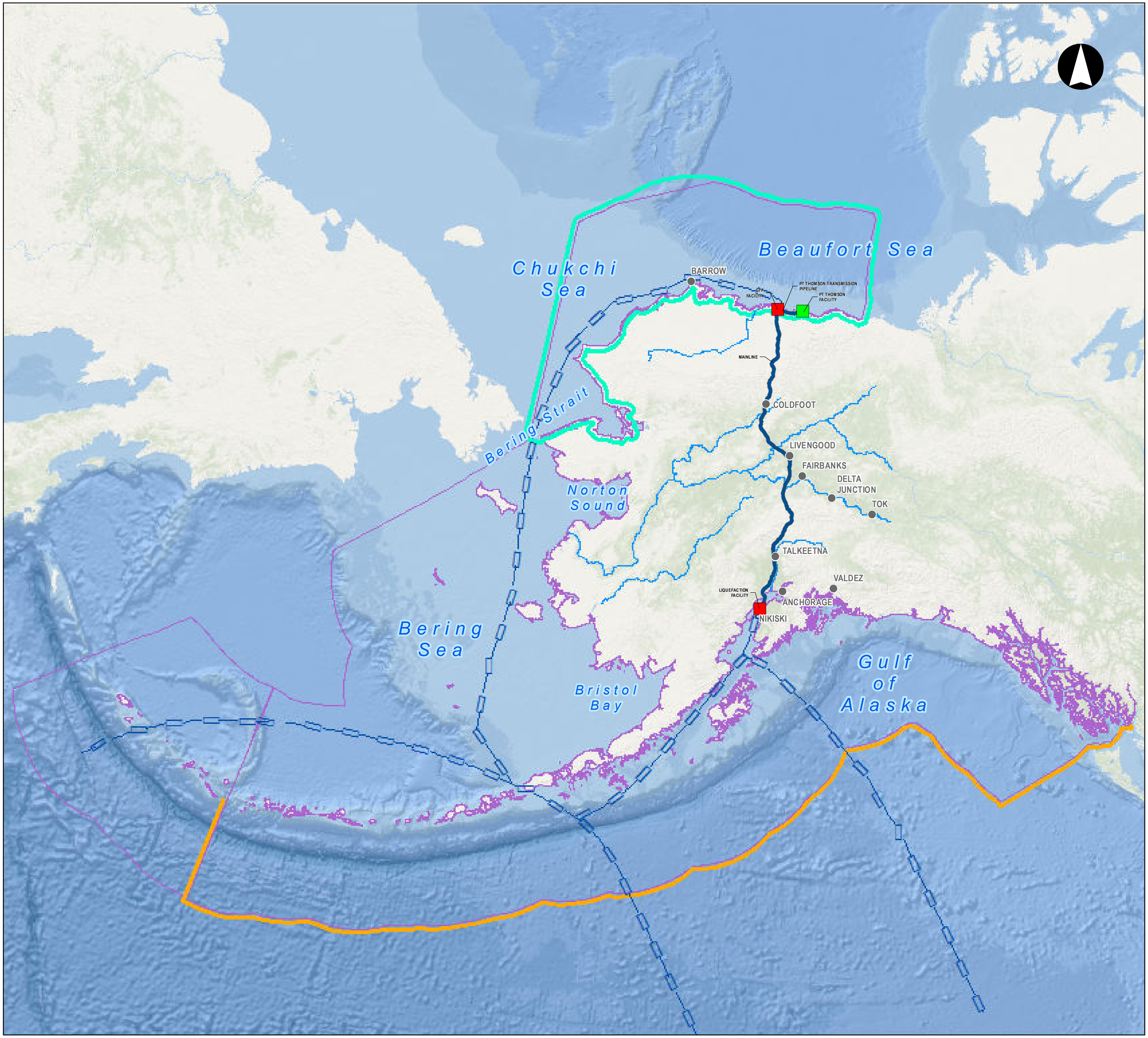
- Project Facility
- Existing Facility
- Alaska LNG Rev C2 Route
- Potential Marine Transportation Routes
- Major Highways
- Major Rivers

Fishery Management Plan Areas

- Arctic Region
- Gulf of Alaska Groundfish
- Pacific Salmon

Source:
NPFMC, 2012
NPFMC, 2013

0 50 100 200 Miles



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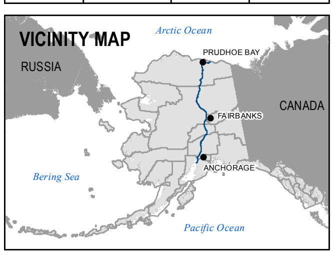
VICINITY MAP



X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 1 Project Overview.mxd

LOCATION OF THE PROPOSED PROJECT MARINE TERMINAL

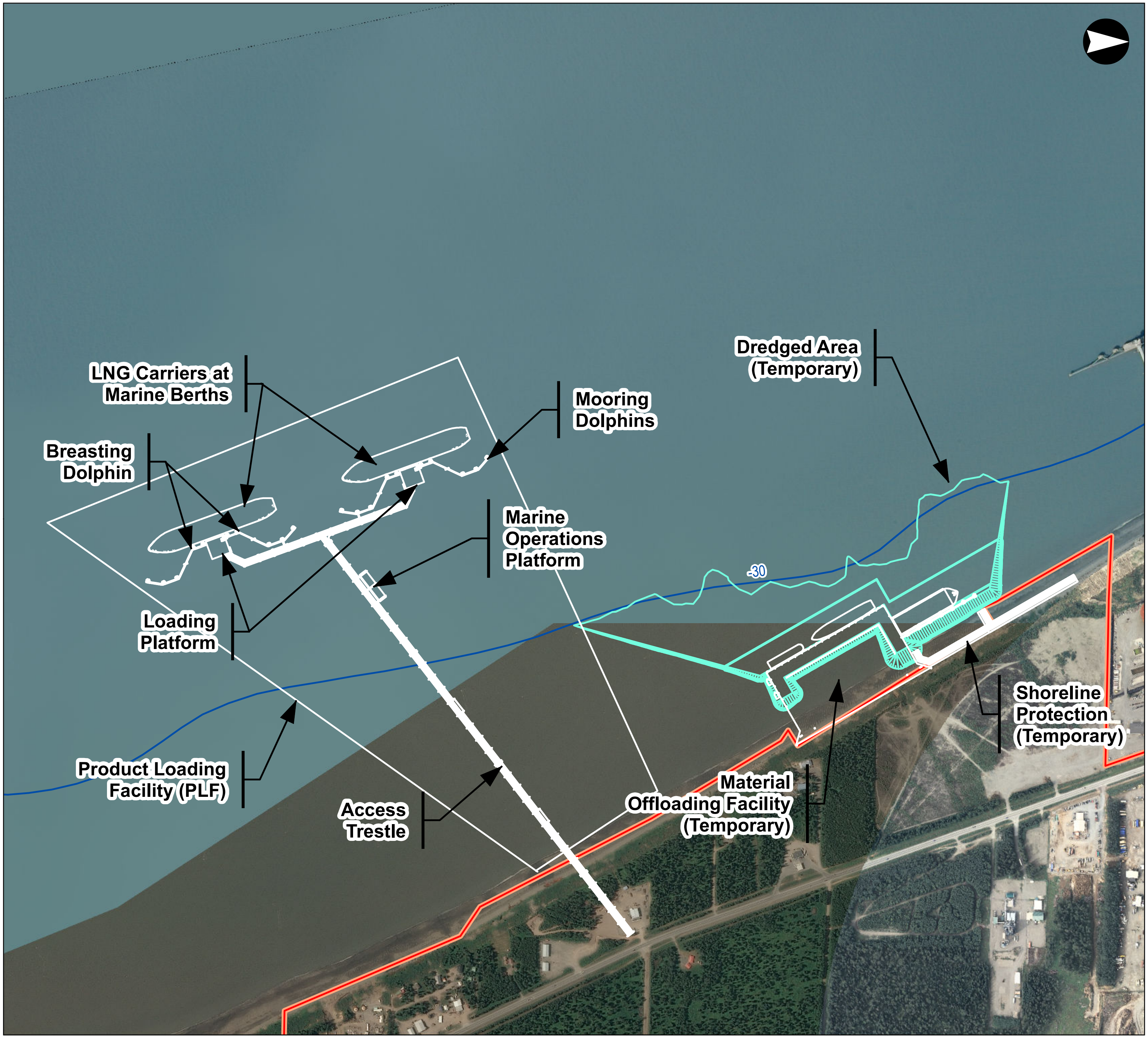
FIGURE 2

ALASKA LNG

LEGEND

- 30 foot Bathymetry Contour from Project Surveys
- LNG Marine Facility
- MOF Dredging Area
- Proposed Plant Boundary

0 250 500 1,000 Feet



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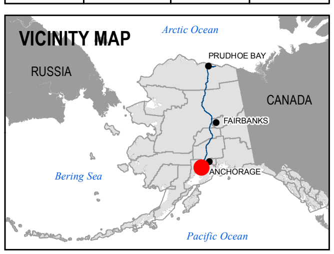
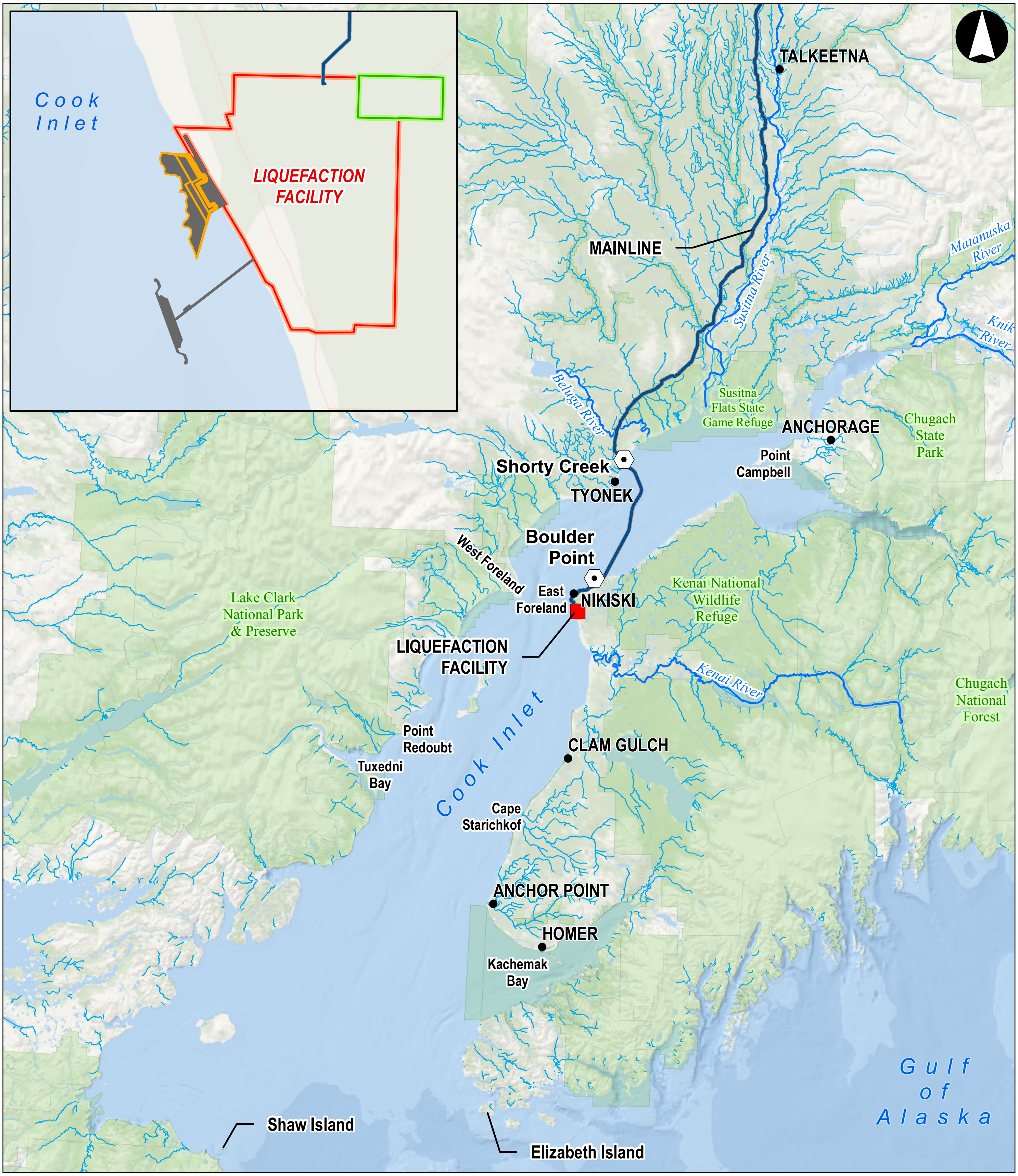
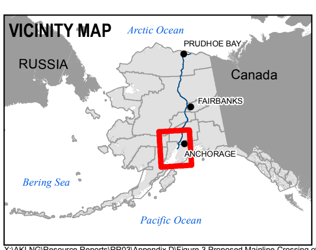
VICINITY MAP



X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 2 Location of the Proposed Project Marine Terminal.mxd





LEGEND

- Alaska Place Names
- Project Facility
- Crossing Point
- Alaska LNG Rev C2 Route
- Anadromous Waters
- Major Rivers
- Dredge Area
- Marine Facility
- State and Federal Conservation Lands

Liquefaction Facility

- LNG Operations Area
- LNG Construction Camp

0 10 20 40 Miles

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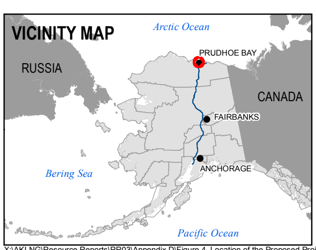
PROPOSED MAINLINE CROSSING OF COOK INLET

FIGURE 3

ALASKA LNG

X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 3 Proposed Mainline Crossing of Cook Inlet.mxd

VICINITY MAP



LEGEND

Alaska LNG Rev C2 Route

PTTL

Existing Infrastructure

GTP Facility

Facility

Study Area

0 0.5 1 2 Miles

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LOCATION OF THE PROPOSED PROJECT WEST DOCK MODIFICATIONS

FIGURE 4

ALASKA LNG

X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 4 Location of the Proposed Project West Dock Modifications.mxd

1.2.1.1 Product Loading Facility (PLF)

Use of the PLF

The purpose of the PLF would be to load LNGCs for export of LNG from the Liquefaction Facility. Based on a nominal 176,000-cubic-meter LNGC design vessel, approximately 21 vessel visits per month would be required to export the produced LNG. The LNGCs would range in size between 125,000 cubic meters (approximately 30 vessel visits per month) and 216,000 cubic meters (approximately 17 vessel visits per month).

Ballast and Cooling Water Discharges

LNGCs calling at the Marine Terminal would be carrying ballast water (sea water) upon arrival to Cook Inlet. The ballast water would have been exchanged in international waters per regulatory requirements. As LNG is loaded onto the LNGCs at the Marine Terminal, the LNGCs would release the ballast water, thereby replacing the sea water with LNG product as ballast to maintain stability of the LNGC during transit. Approximately 2.9–3.2 billion gallons of ballast water would be discharged per year from LNGCs during LNG loading operations at the Marine Terminal, with the range in annual discharge volume due to varying LNGC sizes and number of voyages that may call at the Marine Terminal (between 204 and 360 LNGCs). The water discharged would be approximately 0–25 degrees Fahrenheit (°F) warmer than ambient water temperature in Cook Inlet.

Approximately 1.6–2.4 billion gallons of sea water per year may be taken in and discharged by LNGCs as cooling water while at the Marine Terminal (between 204 and 360 LNGCs per year). The water would undergo minimal filtration upon intake and supports a non-contact heat exchange process to provide cool water needed for the LNGC integrated cooling systems for equipment onboard such as main engines and diesel generators. The range in intake/discharge volumes account for the varying LNGC sizes and estimates of the number of LNGC calls at the Marine Terminal. The water discharged could be approximately 5 °F warmer than the ambient water temperature in Cook Inlet.

1.2.1.2 Material Offloading Facility (MOF)

Description of the Temporary MOF

The temporary MOF would facilitate the marine import of bulk materials, equipment, and modules during construction. The MOF would be a temporary facility and would be removed approximately 10 years after completion of its construction.

The temporary MOF area would be approximately 1,050 feet by 525 feet with a deck elevation +32 feet mean lower low water (MLLW), which would provide sufficient space for cargo discharge operations, and up to three sealift seasons of module shipments. MOF construction would be land-based work. The MOF would consist of a combi-wall of pilings and sheets backfilled with granular materials and tied back to a sheet pile anchor wall.

Dredging for the Temporary MOF

The approach and berths at the site for the temporary MOF would be dredged to depths of -30 feet and -32 feet MLLW, respectively, with an additional allowance of no more than -2 feet overdredge. Several disposal and/or reuse options are under consideration. Given the total volume of dredging planned at the site and the potential for multi-year maintenance dredging, an offshore unconfined aquatic disposal site would be the preferred option for disposition of the dredged material. The proposed dredge disposal area is located approximately 3–5 miles west of the dredge area in relatively deep water (-60 feet to -100 feet MLLW) with strong northerly currents (over 6.5 knots peak flood and over 5.5 knots peak ebb), which are expected to disperse the dredge sediment, but not carry the material back toward shore. The deep water and strong currents are expected to disperse the material with no impact on water depth (navigation).

The dredged material is anticipated to be a heterogeneous mix of sandy silt and sand with hard-packed clay. The estimated volume of material that would be dredged for the Marine Terminal totals approximately 800,000 cubic yards. Additionally, 140,000 cubic yards (approximately) of maintenance dredging is expected to be necessary at the temporary MOF berths and approach during the later construction seasons. Dredging would temporarily impact approximately 50.70 acres of seafloor.

Dredging at the temporary MOF during the first season of marine construction may be conducted with either an excavator or clamshell (both mechanical dredges). Dredging at the temporary MOF during the second season of marine construction at Nikiski would be conducted with either a hydraulic (cutterhead) dredger or a mechanical dredger.

1.2.2 Construction and Operation of the Mainline

The Mainline would be a 42-inch-diameter natural gas pipeline, approximately 807 miles in length, extending from the GTP to the Liquefaction Facility on the shore of Cook Inlet near Nikiski, including an offshore pipeline section crossing Cook Inlet. The pipeline would be a buried pipeline with the exception of four planned aerial water crossings, aboveground crossings of active faults, and the offshore pipeline.

Construction/installation of the pipeline itself would occur over a period of about two years with additional time on either end for site preparation and facility construction. Various right-of-way (ROW) construction methods would be used to support the construction: ice work pad; winter frost packed; granular work pad; graded cross slopes; and mountain-graded cut. A total of 514 waterbodies would be crossed by the Mainline. These streams would be crossed using one of the following crossing methods depending on the conditions at the crossing and engineering requirements: open cut (summer), frozen cut (winter), buried trenchless, and aerial.

1.2.2.1 Facilities and Infrastructure

Access roads would be required during construction of the pipelines and aboveground facilities to transport equipment, material, pipe, and personnel to the ROW, compressor stations, material sites, and other locations. These access roads include existing public roads, existing non-public roads, newly built access roads, and shoo-flies. If existing roads are not readily available, or do not provide adequate access, new temporary or permanent access roads using available native material, imported granular material, or temporary use of snow/ice would be required, depending on the intended traffic load, duration, and timing of use. Construction of some new permanent roads to access compressor stations and the heater station would be needed. Permanent or temporary bridges would be constructed, if needed, to cross waterbodies, depending on water levels.

1.2.2.2 Material Sites

Various materials (e.g., sand, granular material, and stone) would be required for construction, including base material for work pads, aboveground facility sites, temporary construction facilities, access roads, and other uses. The material required for these facilities would be obtained from material sites that are either existing or would be developed for the Project. A preliminary list of potential sources for these various materials is included in Appendix F of Resource Report No. 6. Approximately 32 million cubic yards of granular fill would be needed for construction of the Project, 20 million of which is for Mainline construction. This granular fill would be sourced from multiple locations over the seven-year construction period. Access to these material sites would be by winter road, all-weather road, Project footprint (e.g., pipeline ROW) or some combination of these.

After the conclusion of construction activities, material sites would likely either be used for other projects by the landowner (such as for road construction administered by the Alaska Department of Transportation and Public Facilities {ADOT&PF}) or closed as per land-use agreements and regulatory requirements.

1.2.2.3 Hydrostatic Testing

After backfilling, the pipeline would be pressure tested. The proposed hydrostatic test approach, including pipeline cleaning, gauging plate pig run, pressure testing, caliper pig run, and pipeline dehydration is based on testing up to 20-mile-long sections during the summer or fall. Potential water sources for pipeline hydrostatic testing include streams crossed by the pipeline ROW and nearby lakes and parallel streams. Anticipated required volumes and potential sources of test water are provided in the *Water Use Plan*, located in Resource Report No. 2, Appendix K. Once final water sources are identified, pressure test plans for each construction spreads would list all permitted water sources, the associated pipeline milepost, and the permitted water volume and conditions for water withdrawals and discharge received from the regulatory authorities.

Hydrostatic testing is planned for the summer and fall, however some testing may also be carried out during the winter. If testing is done during summer or fall, additives, including antifreeze chemicals, biocides, corrosion inhibitors, oxygen scavengers, or leak detection tracers, would likely not be added to the test water. If winter testing becomes necessary, the pressure test plans would list which additives are proposed for use and how the water would be treated to comply with regulatory requirements for water discharge. North of the Brooks Range, hydrostatic test waters may be discharged to an Underground Injection Control well.

1.2.3 Point Thomson Gas Transmission Line (PTTL)

1.2.3.1 Description of the PTTL

The GTP and associated facilities, located in the Prudhoe Bay area, would receive natural gas from the PTU by way of the PTTL. As proposed, the PTTL would be an approximately 62.5-mile, 32-inch-diameter aboveground pipeline. The PTTL would be installed on vertical support members (VSMs). The PTTL would be constructed primarily during the winter season from ice roads and ice pads. Surface water would be the source of water required to make the work pads.

Waterbody Crossings of PTTL

As detailed in Resource Report No. 2, the PTTL would cross several named waterbodies. Three crossings (i.e., Shaviovik River, Kadleroshilik River, and Sagavanirktok River Main Channel) would be buried with conventional open-cut methods in the winter. Designs of these buried crossings will be provided in the FERC application. The remaining three crossings—the West Channel of the Sagavanirktok River, an Unnamed Tributary to Putuligayuk River, and the Putuligayuk River would be installed with aboveground pipeline crossings. The West Channel of the Sagavanirktok River would be crossed by adding structural extensions to an existing pipeline bridge, while the Putuligayuk River and its unnamed tributary would be crossed using standard VSMs.

1.2.4 Cook Inlet Crossing

1.2.4.1 Description of the Cook Inlet Crossing

The proposed Cook Inlet crossing route for the Mainline is an approximate 28-mile stretch between Shorty Creek near the village of Beluga on the western shore of upper Cook Inlet to Boulder Point on the eastern side of the inlet. Figure 3 provides an overview of the Cook Inlet Mainline crossing. Land requirements for construction and operation of the Mainline are provided in Table 2. These numbers do not represent expected impacts; they are based on ROW widths. The construction

ROW encompasses an area 1.25 mile on either side of the centerline to include all areas where anchors may be set. The expected footprint of the 12 plus anchors within the 2.5-mile-wide construction ROW is expected to be less than 1 acre each time the anchors are picked up and moved. The number of times the anchors are reset would be dictated by weather and current conditions and the rate of pipe lay progress, but of the construction ROW required, a fraction would be impacted.

Table 2: Land Requirements for Construction and Operation of the Cook Inlet Crossing

Facility	ROW Required During Construction (acres)	Land Affected During Operation (acres)
Construction	38,131.76 1	330.11

Construction of the Cook Inlet Crossing

The pipeline crossing would be installed over two years, with the working window for construction in Cook Inlet being mid-April to mid-October. The expected pipelay vessel progress would be between approximately 2,000 and 5,000 feet per 24-hour day, depending on currents and weather. The shoreline crossings would be constructed in the first year and the main pipelay operation across Cook Inlet would occur the second year.

The pipe would be laid using a pipelay vessel, which moves by pulling on its anchors or through the assistance of its dedicated support vessels. Certain pipelay vessels may also have integral thrusters to provide propulsion. The specific vessel that would be used will be finalized during procurement of the installation contractor. Several anchor handling tugs (AHTs) would be used to reposition the anchors as pipe is welded and lowered over the back of the pipelay vessel. Primary underwater sound sources would be from the AHTs during the anchor-handling, vessel power generation and thrusters from the pipelay vessel (if equipped).

Shoreline Crossings

The pipeline would be installed at the shoreline crossings on both sides of Cook Inlet using the open cut method. In Cook Inlet, the pipeline would be buried from the shoreline out to a water depth of between 35 to 45 feet, which represents a distance of up to about 8,300 to 8,800 feet on the western shore and 6,400 to 6,600 feet on the eastern shore. Seaward of these locations, the pipeline would be laid on the seafloor. Construction methods would differ between the nearshore and offshore portions of these trenched sections.

The trench for each shoreline is expected to be constructed using amphibious or barge-based excavators to trench to a transition water depth where a dredge vessel can be employed. A backhoe dredge could also be required to work in the nearshore region. Backfill would take place following pipeline installation.

In the event the pipeline is required to be buried beyond water depths accessible by amphibious excavators, a trailing suction hopper dredger (TSHD) would be used in advance to provide the necessary trench for the pipeline. Alternative dredging or burial techniques, such as plowing, or jetting, will be evaluated once sufficient geotechnical information is collected and analyzed along the route. After installation of the nearshore pipelines, a jetsled or mechanical burial sled could be used to achieve post dredge burial depths.

Hydrostatic Testing

Seawater from the Cook Inlet would be used to hydrostatically test the integrity of the pipeline after welding. Water is pumped into the pipeline behind a fill plug, pressurized above intended operating pressures, and then discharged after the required test holding period (usually 48 hours). The necessity of additives (e.g. corrosion inhibitor, biocide) or freshwater will be evaluated during permitting. The hydrotest water discharge would be performed in compliance with regulatory requirements.

1.2.5 West Dock Modifications

The West Dock Causeway, which runs approximately 2.5 miles from the shoreline to the west end of Prudhoe Bay, is a solid fill granular material structure that was constructed in three segments between 1974 and 1981. Construction of the GTP at Prudhoe Bay would require barge delivery of modules to West Dock over four sealift seasons. Modifications of the existing West Dock facilities would be necessary to facilitate offloading a large number of barges within a short ice-free work window. Land requirements for the construction and operation of Project facilities at West Dock are identified in Table 3. Further information regarding modifications to West Dock is provided in Resource Report 1, Section 1.3.2.8.12 (West Dock Modifications) and Section 1.5.2.4.2 (West Dock Modifications and Dredging), Resource Report 2, Section 2.3.11.2.2.1 (West Dock Modifications and Dredging) and Resource Report 10, Section 10.5.7.1 (West Dock).

Table 3: Land Required for Construction and Operation of the West Dock Facilities

Facility	Land Affected During Construction (acres)	Land Affected During Operation (acres)
West Dock Modification Dock Head 4Construction	31.05	0.00[a]
Barge Bridge	2.58	0.00[a]
Turning Basin	13.70	0.00
Total	47.33	0.00

1.2.5.1 Dock Head 4 (DH 4)

A new Dock Head (DH 4) would be built at the seawater treatment plant and five berths would be constructed. The West Dock DH 4 addition would include installing sheet piling and fill material behind the sheet piling, and installing mooring dolphins and barge ballasting in front of DH 4. Most of the piles would be placed with an impact hammer during the winter. A barge bridge would be required to facilitate construction. The dock face would be approximately 1,000 feet wide and elevated approximately 8 feet. The new dock would provide a working area of approximately 31 acres with five or more new berths dedicated to Project operations.

<u>Barge Bridge</u>

An existing bridge within the West Dock causeway spans 650-foot channel/breach located between DH 2 and DH 3. The bridge limits the roadway to a single-lane, to light vehicle traffic at a width of 20 feet, and to an approximate load limit of 100 tons. A bridge with capacity to support the modules would be required for a successful sealift. Therefore, a temporary barge bridge, consisting of two barges ballasted to the sea floor, would be used to span the gap. The barges would be placed at the beginning of the open-water season prior to each sealift.

The barge bridge will provide up to three areas for fish passage, if required during the proposed time of use (e.g. between the barges and between each barge and the adjacent bulkhead). Pre-work would be performed a year before the first sealift to prepare the seafloor and install a minimum of four breasting-dolphins for the barge bridge support.

The barges would be removed at the end of each sealift and the surface would need to be prepared again prior to each sealift year. As additional data is acquired and further guidance received on fish passage requirements, the barge bridge surface, structures, and mooring systems will be re-analyzed and may require updates.

Use of DH 4

Major components of the GTP would be built as modules offsite and delivered to Dock Head 4 in a series of sealifts. Four consecutive summer sealift seasons and corresponding construction periods are planned. The expected frequencies of large vessel traffic into Dock Head 4 for construction of GTP are indicated in Section 1.2.6 and in Table 5.

Due to the size of the modules required for the GTP, large oceangoing vessels would be used. All cargo barges would be grounded for the modules offloaded at DH 4. The grounding pad for the barges would be prepared in advance of each sealift. In total, construction for the GTP facility would last 8 years.

1.2.6 Vessel Traffic

Marine vessel traffic associated with the Project would occur during construction and operation. In addition to the mobilization of vessels for marine construction, vessels would be required to bring in facility modules, pipe, equipment and supplies. The primary ports that would be utilized are the Port of Anchorage, the temporary MOF in Cook Inlet, Port of Seward, and West Dock in Prudhoe Bay. During facilities operations, LNGCs would deliver natural gas to foreign markets. Vessel routes are unknown at this time; however, likely corridors are indicated in Figure 1.

1.2.6.1 Vessel Traffic during Construction

The anticipated numbers and types of vessels needed to support construction are listed in Table 4.

Table 4: Typical Vessel Types that would be used during Project Construction

Facility	Activity	Vessel	Anticipated Number of Vessels
Marine Terminal	Dredging	Hydraulic Dredge	1
		Dredging Barge (barge-mounted crane, clamshell)	1
		Deck Barge/Material Barges	TBD
		Scow/Hopper Barges	TBD
		Tug Boats	TBD
		Work/Crew Boats	TBD
		Survey Vessel	1
	Marine Construction Spreads	Derrick Barge	TBD
		Material Barge	TBD
		Tug	TBD
		Work/Crew Boats	TBD
	Materials Transport	Geared Heavy Lift Vessel	TBD
		Heavy Transport Vessel	TBD
		Ocean Tug and Barge	TBD
Pipeline	Pipeline Shipments	Ocean Tug and Barges	TBD
	Marine Construction Spreads	Pipelay Vessel	1
		Pull Barge	1
		Anchor Handling Tugs	3

Facility	Activity	Vessel	Anticipated Number of Vessels
		Supply/Pipe-Haul Vessels	2
		Work/Crew Boats	1
		Survey Vessel	1
		Nearshore Trenching/Backfilling Spreads	TBD
[1] Each tug and barge would consist of one ocean going tug and one barge; they would be supported by up to 2 primary and 4 secondary assist tugs.			

[1] Each consists of one oceangoing tug and one barge; they would be supported by primary (8) and secondary (16) assist tugs.

[2] Total for 4 sealifts

Construction Vessel Traffic at the Temporary MOF

There would be approximately 60 module shipments made directly to the temporary MOF from fabrication yards during the three years of active Liquefaction Facility construction. The Pioneer MOF is also expected to receive approximately 20 shipments of small modules for construction of the Marine Terminal during the third year of construction. It is anticipated that approximately 10 barges would be circulating from the ports of Anchorage and Seward to the Project's onsite temporary MOF on a weekly basis for three years.

Modules would be fabricated outside of Alaska and transported directly to the Nikiski Liquefaction Facility site. Modules weighing up to 770 U.S. tons would be transported by lift-on/lift-off (Lo/Lo) self-propelled geared heavy-lift ships. Modules weighing more than 770 U.S. tons would be loaded and discharged by roll-on/roll-off (Ro/Ro) methods using a self-propelled modular transporter. Typical vessels for dredging, marine construction spreads, material transport, and heavy lift are summarized in Table 1.

Construction Vessel Traffic for Cook Inlet Crossing Pipelay

Platform supply vessels would be used to support the trenching and pipelay activities during construction of the Mainline crossing of Cook Inlet. Typical vessels for dredging, marine construction spreads, material transport, and heavy lift are summarized in Table 4. Approximately 100 trips between the pipelay/trenching spread and a shore base (assumed to be Port Mackenzie) would be required to supply and support these activities over the course of the construction window. Barge-based vessels that would be used for logistics or pipelay have a typical transit speed of 5 knots while towed. The transit speed of platform supply vessels or anchor handling tug supply vessels is generally in the range of 10–12 knots. Pipelay (HLV) vessels transit at speeds in the range of 8–15 knots.

Construction Vessel Traffic Associated with Pipe Delivery

The pipe for the Mainline and PTTL would be shipped to the Port of Anchorage or Seward from outside of Alaska. The pipe would be delivered to Anchorage or Seward in 15,000–18,000-ton ships over several construction seasons. An estimated 47 vessel trips would be made to the port over a 34-month shipping schedule (approximately 0.7 trip per month or 1 every 22 days) in the 2.5 years prior to the start of pipeline construction.

The ships would be Handymax class vessels or similar and would transit at speeds of 10 to 14 knots in the open ocean. Vessels transiting within Cook Inlet or Resurrection Bay (to or from Seward) would transit at about 10-14 knots. From Anchorage or Seward, pipe would be distributed to onshore pipe storage yards by rail or by barge to multiple locations, including to the Mainline MOF on the west side of Cook Inlet.

Construction Vessel Traffic at West Dock

During GTP construction, it is anticipated that approximately 116 modules would be delivered to West Dock, approximately 65 modules during pre-sealift and 51 modules as part of four planned sealifts (Table 5).

The improvements at West Dock would include construction of DH 4. The new area would be dedicated to Project activities only during construction. The West Dock DH 4 addition would include installing sheet piling and fill material behind the sheet piling, and installing mooring dolphins, and barge ballasting. A barge bridge would be required to facilitate construction (see Resource Report 1, Section 1.3.4.3.1).

Table 5: Vessels and Vessel Traffic at West Dock for GTP Construction

Sea Lift Year	Number of Sealift Modules	Number of Barges 400x105 & 400x130	Oceangoing Tugs (120-ton)	Primary Assist Tugs (42.5-ton)	Secondary Assist Tugs (15-ton)
Sea Lift 1	17	12	12	2	4
Sea Lift 2	15	12	12	2	4
Sea Lift 3	10	10	10	2	4
Sea Lift 4	9	9	9	2	4

1.2.6.2 Vessel Traffic During Operations

Operational traffic would include LNGCs traveling to and from the Liquefaction Facility to foreign markets. LNGC sizes have not been determined at this time, but are expected to range in length from 306.2 to 344.5 yards with capacities of between 163,493 and 281,209 cubic yards. Depending on the LNGC size, an LNGC would arrive at the Marine Terminal 17 to 30 times per month. Additional vessels to be used during operations would include a pilot boat and one or more Azimuth Stern Drive tugs to support carrier approach and docking (Table 6). LNGCs would transit open ocean waters at speeds of about 19 knots or less. In Cook Inlet, the LNGCs would transit at 10-19 knots depending on currents and requirements for safe steerage.

Table 6: Typical Vessel Types that Would Be Used During Project Operation

Facility	Activity	Vessel
Marine Terminal	LNG Operations	Liquefied Natural Gas Carrier
		ASD Tug
		Southwest Alaska Pilots Association Pilot Boat

1.2.7 Non-jurisdictional Facilities

1.2.7.1 Prudhoe Bay Unit (PBU) Major Gas Sales (MGS) Project

Approximately 75 percent of the natural gas that would supply the Project would be sourced from the Prudhoe Bay field. The PBU has been a large oil producing and gas cycling operation since 1977. The purpose of the PBU MGS Project is to allow the natural gas currently being produced, compressed, and injected within the PBU to be transported to the GTP for processing to remove Byproduct, and compressing of the hydrocarbon gas to enter the Mainline for transport to the LNG Plant. PBU MGS project components include expansion of an existing pad and four new pipelines. Additional details are provided in Resource Report No. 1. None of these components would affect marine EFH. One of the new pipelines would cross the Kuparuk and Sagavanirktok rivers, which contain salmon habitat.

1.2.7.2 PTU Expansion Project

Approximately 25 percent of the natural gas that would supply the GTP would be sourced from the Thomson Sand gas condensate field located on the eastern Beaufort Coastal Plain Ecoregion approximately 60 miles east of the Prudhoe Bay fields.

The existing infrastructure would need to be expanded to produce gas for delivery to the PTTL. The PTU operator is currently developing the PTU Expansion project. The proposed PTU Expansion project facilities would integrate with the Initial Production System (IPS) facilities, drilling, and infrastructure to produce the natural gas instead of reinjecting it back into the reservoir. The PTU Expansion project facilities would be designed, permitted, constructed, and operated by the PTU operator. The timing of construction would coincide with that of the Project to support commercial delivery of natural gas to the first gas conditioning train at the GTP.

The scope of new development for the PTU Expansion project would include pad expansions, construction of new pipelines, granular mine development and rehabilitation, and construction of facilities and support structures. Additional details are provided in Resource Report No. 1. None of the options would affect freshwater EFH. Potential effects to marine EFH would be from:

- Widening of the sectional bridge and installation of additional mooring dolphins to enable module delivery at the marine facilities.

These modifications have been previously reviewed in an EFH assessment prepared for the Point Thomson Project EIS. NMFS (2012) agreed with the assessment, which concluded that the proposed activities may adversely affect EFH, primarily due marine and freshwater withdrawal for ice road construction, but added that the proposed mitigation measures may avoid or minimize the impacts to fish and EFH.

1.2.7.3 Relocation of the Kenai Spur Highway

The planned Liquefaction Facility location would require that an approximately 1.33-mile segment of the existing Kenai Spur Highway be relocated to the east. It is anticipated that the relocation would be completed prior to the start of Project construction. ADOT&PF and Kenai Peninsula Borough have been consulted to assist with the highway relocation planning including routing discussions, public engagement, permitting, and construction. A summary of preliminary options under consideration is provided in Resource Report No. 1. None of the options would affect freshwater or marine EFH.

2.0 DEFINITION OF ESSENTIAL FISH HABITAT

The 1996 Sustainable Fisheries Act reauthorized the MSA (MSA; 16 USC.1801, et seq.), introducing new requirements for:

- The description and identification of EFH in fishery management plans (FMPs).
- Minimizing adverse impacts on EFH.
- Proposing actions to conserve and enhance EFH.

EFH guidelines were set forth by NMFS to help Fisheries Management Councils (FMCs) fulfill requirements of the MSA. Consultation between federal permitting or action agencies and the NMFS Habitat Conservation Division is required by the MSA when a federal action agency determines the action it is approving may adversely affect EFH designated through federal FMPs. The MSA also requires that the federal permitting or action agency respond to comments made by NMFS.

EFH is defined as waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (50 Code of Federal Regulations {C.F.R.} Part 600). For the purposes of this definition:

- "Waters" means aquatic areas and their associated physical, chemical, and biological properties.
- "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities.
- "Necessary" means the habitat required to support a sustainable fishery and healthy ecosystem.
- "Spawning, feeding, and breeding" is meant to encompass the complete life cycle of a species (50 C.F.R. Part 600).

EFH is designated based on the best available scientific information and the levels defined by the MSA (NMFS, 2005):

- Level 1 information corresponds to distribution.
- Level 2 information corresponds to density or relative abundance.
- Level 3 information corresponds to growth, reproduction, or survival rates.
- Level 4 information corresponds to production rates.

EFH has been designated in or near areas where Project activities would occur under the following FMPs:

- Salmon Fisheries in the Exclusive Economic Zone (EEZ) off the Coast of Alaska (Salmon FMP).
- Arctic Management Area (Arctic FMP).
- Groundfish of the Gulf of Alaska (GOA) (GOA Groundfish FMP).

3.0 ESSENTIAL FISH HABITAT IN THE PROJECT AREA

The Project footprint would occur in areas under the jurisdiction of three FMPs: Salmon FMP, Arctic FMP, and GOA Groundfish FMP (Figure 1). Project components that would occur within EFH are identified in Table 7 and discussed below. Specific locations of EFH are found in Appendices Tables A-1, A-2, A-3, and A-4 in Appendix A. Detailed descriptions of EFH species within the Project area are provided in Section 3.1. Potential effects on EFH and the EFH species are identified in Section 5.

Table 7: Designated EFH in the Vicinity of Project Components

Project Component	Salmon FMP	GOA Groundfish FMP	Arctic FMP
Marine Terminal	Pacific salmon marine EFH	--	--
Mainline	Pacific salmon freshwater EFH	--	--
Cook Inlet Crossing	Pacific salmon marine EFH	--	--
PTTL	Pacific salmon freshwater EFH	--	--
West Dock Modifications	Pacific salmon marine EFH	--	Arctic cod EFH
PBU MGS Project	Pacific salmon marine EFH	--	Arctic cod EFH
PTU Expansion Project	Pacific salmon marine EFH	--	Arctic cod EFH
Relocation of the Kenai Spur Highway	--	--	--

The Salmon FMP has designated all waters offshore of Alaska as EFH for all five species of Pacific salmon (Figure 5). This EFH extends from the baseline (shoreline) out to the seaward limits of the EEZ. The FMP also designates waters identified in the ADF&G Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes (Johnson and Litchfield, 2015 a, b, and c) as important for Pacific salmon, as EFH. Project components that would be located within Pacific salmon EFH designated by the Salmon FMP would be:

- Construction and operation of the Marine Terminal in Cook Inlet, including uptake and discharge of ballast and cooling waters by LNGCs.
- Construction and operation of the Mainline pipeline across Cook Inlet, including the possible construction of a Mainline MOF.
- Construction and use of the West Dock modifications.
- Construction of the Mainline and PTTL pipelines in and near streams identified as freshwater EFH for Pacific salmon. This includes construction of pipeline waterbody crossings, access roads, hydrostatic testing, and material sites.
- Dredging associated with any dock improvements for the PTU modifications/new facilities.

The Project footprint within freshwater EFH for Pacific salmon is detailed in Tables A-1 and A-3 in Appendix A. The Mainline would cross 65 streams containing EFH, and the PTTL would cross three such streams. A total of 56 sites that may be used for extraction of granular materials (material sites) are located within 0.25 mile of EFH streams; while only 6 are within 300 feet of any freshwater EFH. Surface waterbodies that may be used as water sources for construction of the Project (Mainline and PTTL) include 32 streams with EFH.

The Arctic FMP designated EFH for three species: Arctic cod, saffron cod (*Eleginus gracilis*), and opilio or snow crab (*Chionoecetes opilio*). EFH for saffron cod and snow crab are not found in the Beaufort Sea east of Barrow (Figure 6). Designated Arctic cod EFH encompasses all waters of the Beaufort Sea from the baseline (shoreline) out to the seaward limits of the EEZ. Project components that would be located within Arctic cod EFH designated by the Arctic FMP would be:

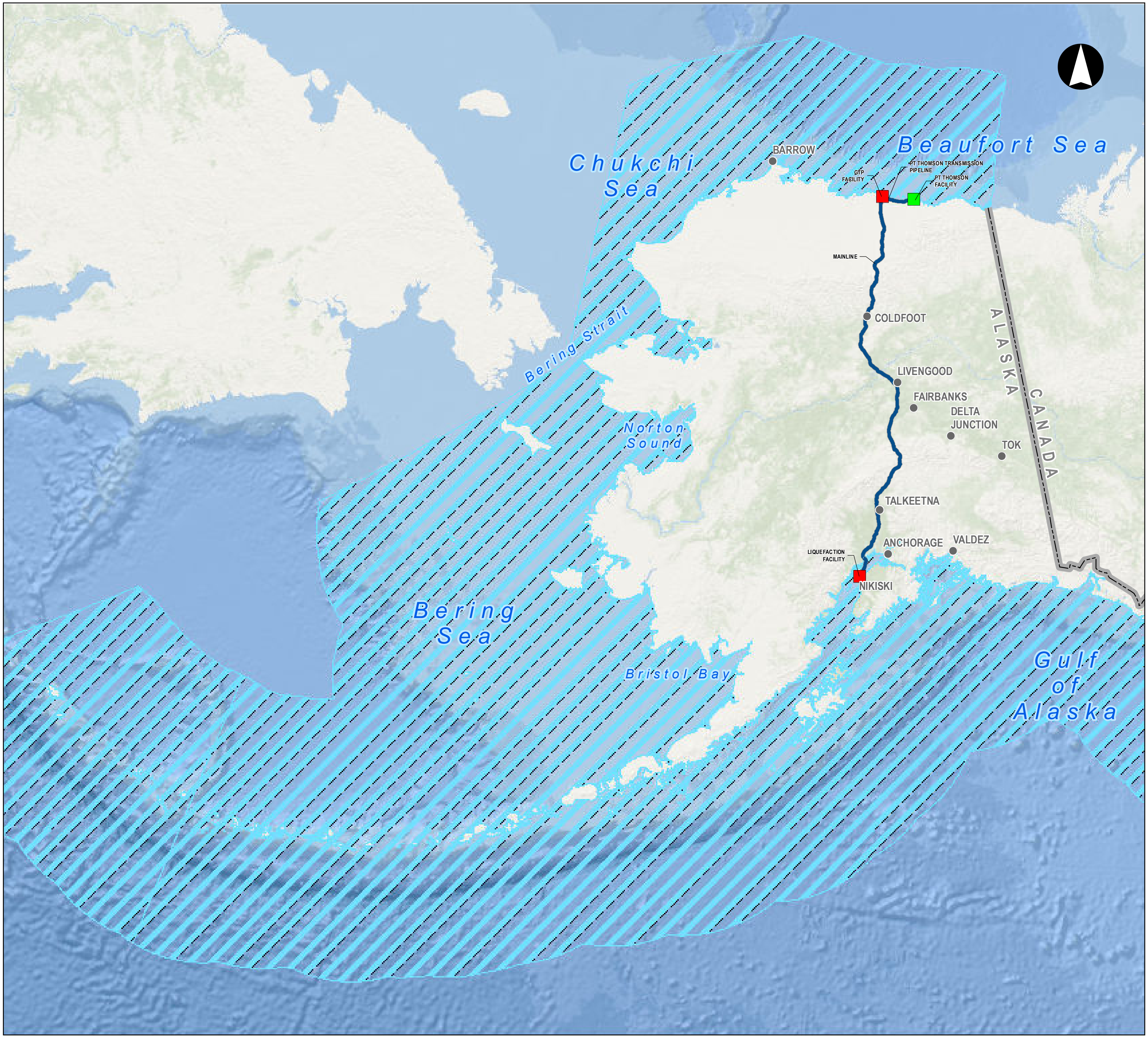
- Construction and use of the West Dock modifications.
- Dredging associated with any dock improvements for the PTU modifications.

The GOA Groundfish FMP provides for the management of 25 species of groundfish and nine forage fish complexes. Designated EFH for 12 of these species (Table 7) is within waters surrounding the Cook Inlet. The closest designated GOA Groundfish FMP EFH to the Project footprint would be walleye pollock EFH (Figure 7), which is located more than 70 miles south of the nearest Project footprint (proposed Marine Terminal).

MARINE ESSENTIAL FISH HABITAT FOR PACIFIC SALMON

FIGURE 5

ALASKA LNG



LEGEND

- Project Facility
- Existing Facility
- Alaska LNG Rev C2 Route
- Major Highways
- Marine EFH for Pacific Salmon (Data: EEZ for Alaska)

Source:
NPFMC, 2012
NPFMC, 2013

0 50 100 200 Miles

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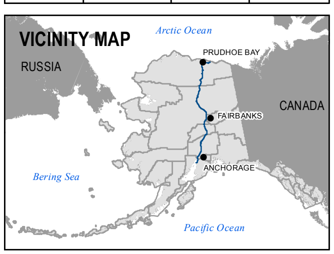
VICINITY MAP



X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 5 Marine EFH for Pacific Salmon.mxd

EFH FOR ARCTIC COD, SAFFRON COD AND SNOW CRAB

FIGURE 6

ALASKA LNG

LEGEND

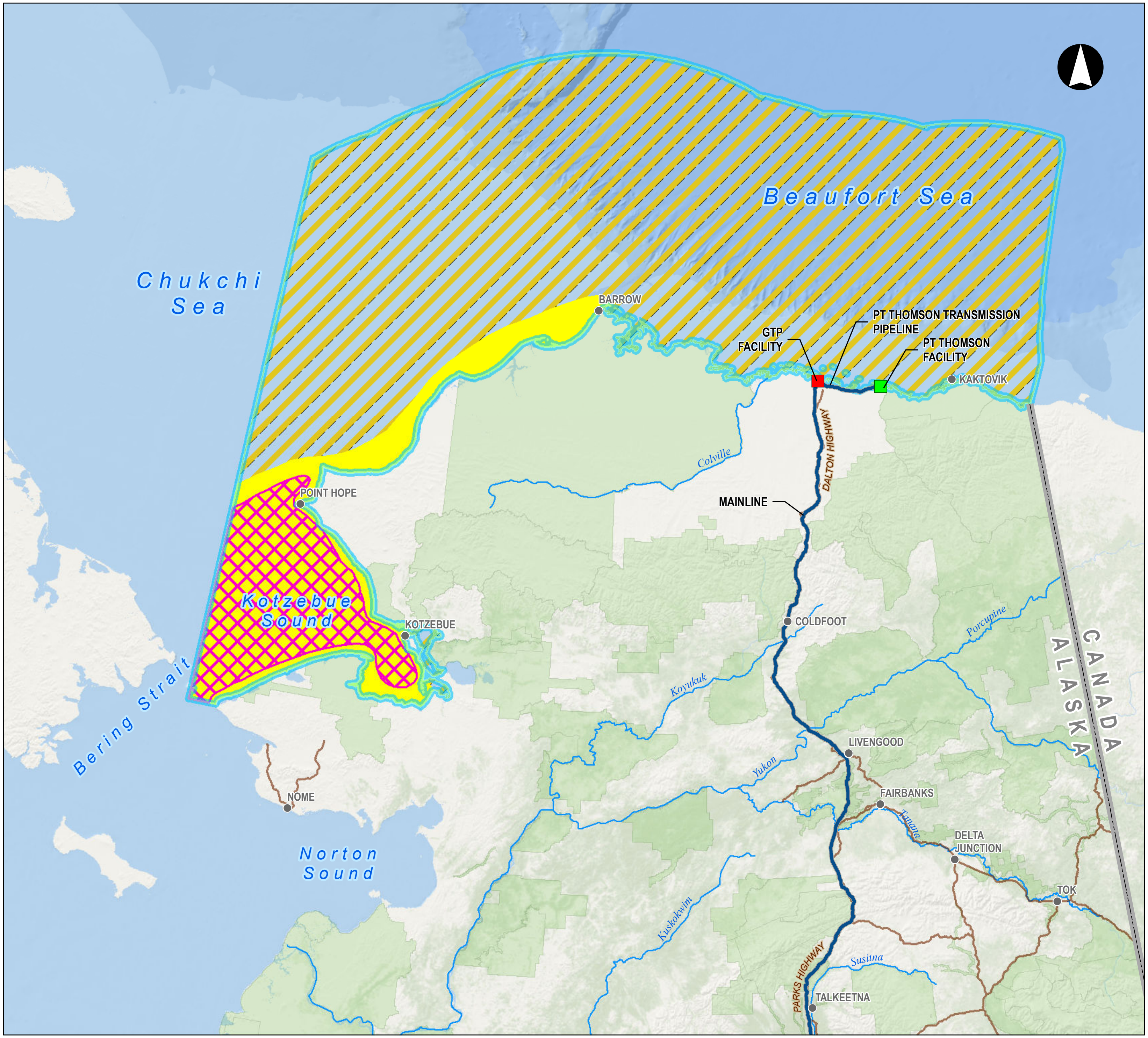
- Project Facility
- Existing Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Major Highways
- Major Rivers
- Arctic Management Area
- State and Federal Conservation Lands

Essential Fish Habitat

- Saffron Cod
- Opilio Crab
- Arctic Cod

Source: NPFMC, 2014

0 25 50 100 Miles



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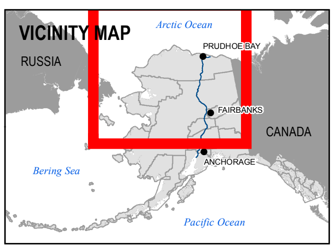
VICINITY MAP



X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 6 EFH for Arctic Cod Saffron Cod and Snow Crab.mxd

EFH FOR WALLEYED POLLOCK LATE JUVENILE AND ADULT LIFE STAGES

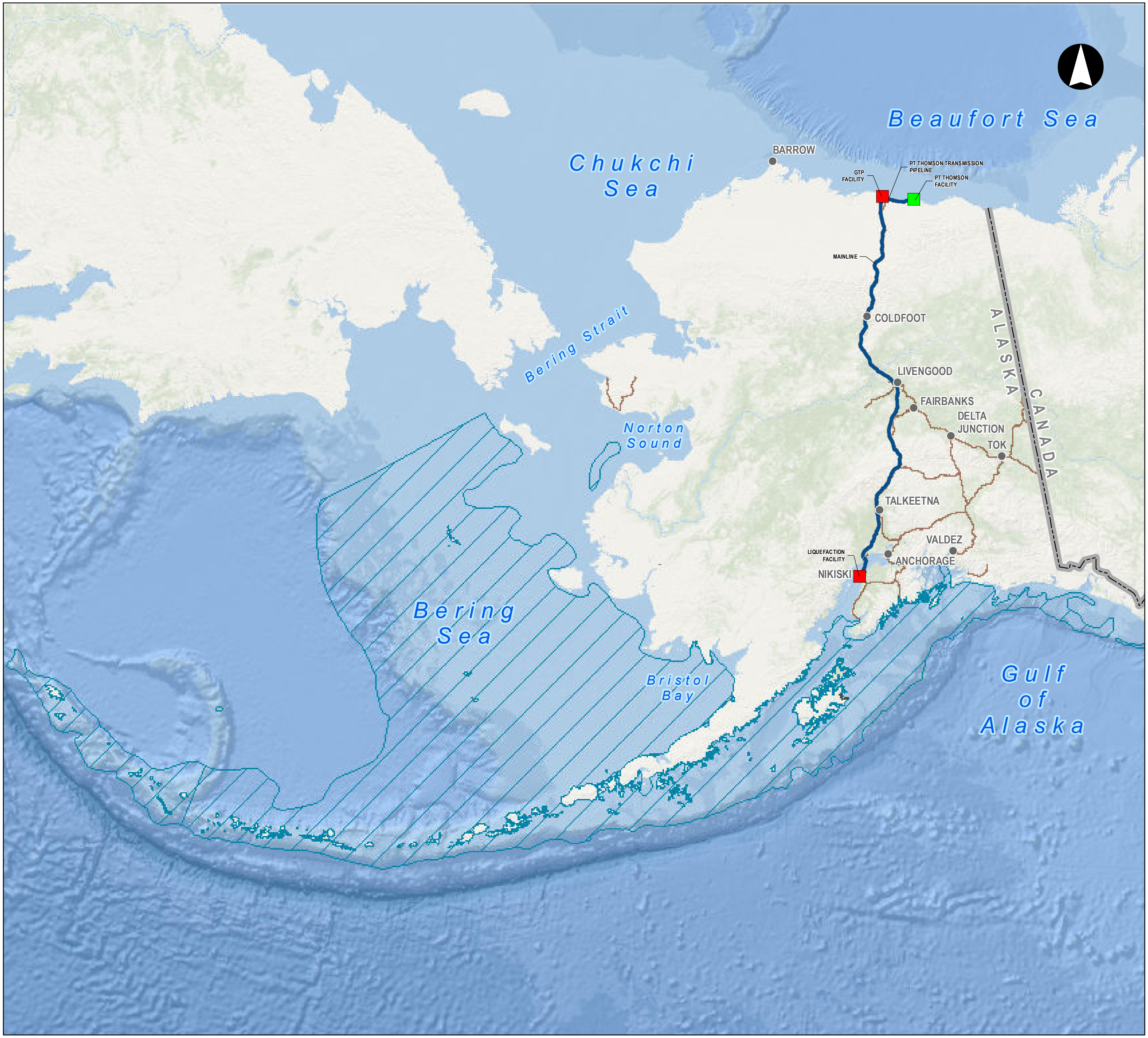
FIGURE 7

ALASKA LNG

LEGEND

- Project Facility
- Existing Facility
- Alaska LNG Rev C2 Route
- Major Highways
- Essential Fish Habitat - Juvenile and Mature Walleye Pollock

0 50 100 200 Miles



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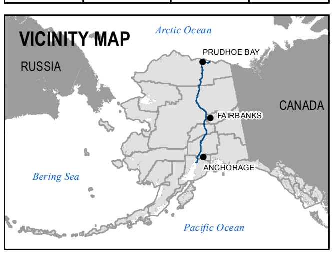
VICINITY MAP



X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 7 EFH for Walleyed Pollock Late Juvenile Adult Life Stages.mxd

Marine and freshwater EFH is established for all five pacific salmon species within the EEZ of Cook Inlet, the North Slope, and some freshwater streams along the Mainline route, including all tidally submerged marine and estuarine habitat within Cook Inlet. Freshwater habitats documented as important for the spawning, rearing, and migration of salmon as specified under Alaska Statute 16.05.871 are also considered EFH. These habitats are directly managed by the ADF&G. The limitations of the designations under AS16.05.871 are recognized and those systems listed are considered a subset of available and used freshwater EFH in Alaska.

3.1 EFH SPECIES

Fish with designated EFH that are found in the vicinity of the Project are listed in Table 8.

Table 8: Fish Species with Designated EFH in the Vicinity of Project Components

Gulf of Alaska Groundfish		Arctic	Alaska Stocks of Pacific Salmon
Skates (Rajidae)	Rex Sole	Arctic Cod	Chinook
Walleye Pollock	Dover Sole	Saffron Cod	Coho
Pacific Cod	Flathead Sole		Sockeye
Pacific Ocean Perch	Yellowfin Sole		Pink
Thornyhead Rockfish	Rock Sole		Chum
Rougheye Rockfish	Arrowtooth Flounder		
Yelloweye Rockfish	Sculpins (Cottidae)		
Shortraker Rockfish	Atka mackerel		
Northern Rockfish	Sharks		
Dusky Rockfish	Forage Fish Complex		
Sablefish	Squid		
Alaska Plaice	Octopus		

EFH consultation is expected to focus on species managed under these FMPs:

- Salmon Fisheries in the EEZ off the Coast of Alaska (Salmon FMP).
- Arctic Management Area (Arctic FMP).
- Groundfish of the GOA.

The five species of Pacific salmon are the primary species of interest within the entire Project area. All of Cook Inlet has been designated Pacific salmon EFH; the nearshore areas are most important for salmon as they serve as a migratory corridor (NPFMC et al., 2012). The Mainline crosses a number of streams important to these species. West Dock is also located within Pacific salmon EFH.

Arctic cod is a ubiquitous species within the West Dock area and can found there year-round. West Dock is also located within Pacific salmon EFH and is in an area designated as Arctic cod EFH.

No EFH species are expected to be exposed to continuous Project disturbance. Impacts to EFH and EFH species are discussed in Section 5.0, Potential Effects to EFH and EFH Species.

3.1.1 Salmon Fisheries Management Plan (FMP)

Both the Liquefaction Facility and Interdependent Project Facilities portions of the Project would be within the jurisdiction of the FMP for the Salmon Fisheries in the EEZ of Alaska (NPFMC et al., 2012), which lists five species of Pacific salmon that could occur within the Project area: Chinook (*Oncorhynchus tshawytscha*), sockeye (*O. nerka*), coho (*O. kisutch*), chum (*O. keta*), and pink (*O. gorbuscha*) salmon (Figure 5).

Pacific salmon populations within the Project area are all in the West Management Area, which includes all federal waters west of Cape Suckling in the GOA to Demarcation Point in the Beaufort Sea; with the exception of three excluded areas in northern Gulf of Alaska. Pacific salmon EFH in Alaska are designated based on Level 1 (distribution) information (NMFS, 2005). The Salmon FMP identifies EFH for each species' life stage and, in most cases, is based on either the general distribution of the life stage or the general distribution of the life stage in waters identified by the ADF&G Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes (Johnson and Litchfield, 2015 a, b, and c).

Pacific salmon are the species of interest within the West Dock, Marine Terminal, and Mainline areas of the Project, and any fishery based on these species could potentially be affected during Project construction and operations. Life stages that would likely be exposed to these activities in the Project area include: freshwater eggs, freshwater larvae and juveniles, estuarine juveniles, marine juveniles, and freshwater adults depending on the location (Table 9).

Table 9: Salmon Species EFH Life Stages Present in the Project Area

Salmon Species	Freshwater Eggs	Freshwater Larvae and Juveniles	Estuarine Juveniles	Marine Juveniles	Marine Immature and Maturing Adults	Freshwater Adults
Chinook	√	√	√	√	√	√
Sockeye	√	√	√	√	√	√
Coho	√	√	√	√	√	√
Chum	√	√	√	√	√	√
Pink	√	√	√	√	√	√

Source: NMFS 2015

A brief synopsis of the five Pacific salmon is provided as follows.

3.1.1.1 Chinook Salmon

Chinook salmon are distributed throughout the Cook Inlet/Yukon Evaluation Area of the Project with highest frequency of freshwater habitat use occurring within the drainages flowing into Cook Inlet. Farther north, Chinook salmon are associated with major tributaries of the Yukon, Tanana, and Koyukuk rivers. North of the Brooks Range, Chinook salmon have not been consistently identified and important freshwater habitats for the species have not been identified within the Project area (Johnson and Litchfield 2015 a, b, and c) (Figure 8).

WATERS IMPORTANT FOR THE SPAWNING, REARING AND MIGRATION OF CHINOOK SALMON IN ALASKA

FIGURE 8

ALASKA LNG

LEGEND

- Project Facility
- Existing Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Anadromous Waters - Chinook Salmon
- Major Highways
- Major Rivers

Source:
Johnson and Litchfield 2015, a, b and c

0 25 50 100 Miles

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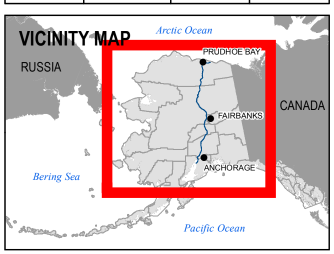

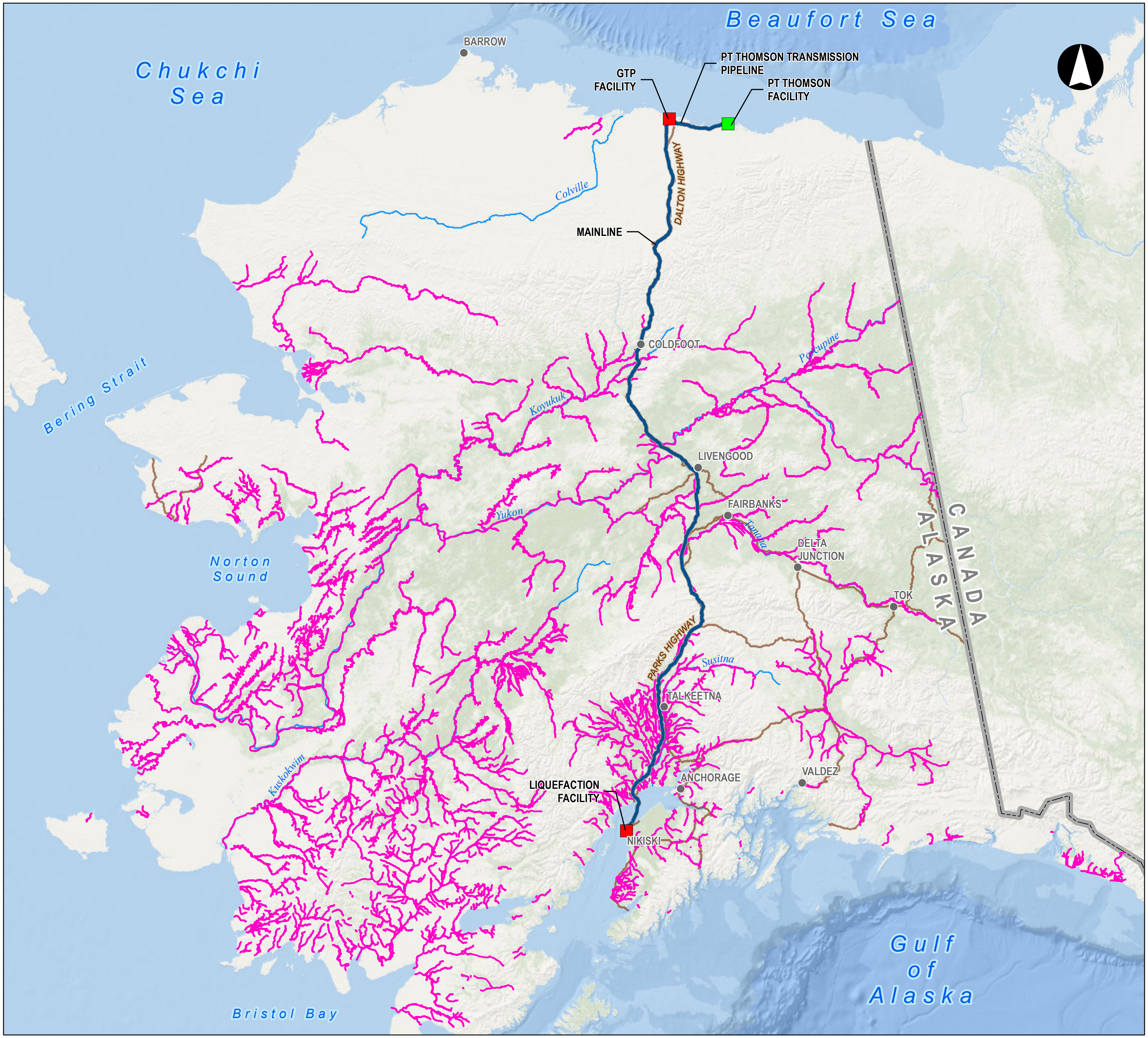

X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 8 Waters important for the spawning rearing and migration of Chinook salmon in Alaska.mxd

Chinook salmon spawn in rivers throughout Interior and Southcentral Alaska, including the Yukon River and its tributaries, and Upper Cook Inlet tributaries. Adults move into freshwater streams to spawn from May through July with latest runs usually occurring in tributaries to the Upper Yukon and Tanana rivers where spawners usually begin to arrive on spawning grounds in early July. Females may deposit 2,000 to 17,000 eggs in gravel beds. Chinook fry hatch in late winter or spring and most juvenile Chinook remain in freshwater until the following spring when they begin to move toward marine habitats.

In the Cook Inlet region, Chinook juveniles normally leave freshwater and enter marine waters during the summer of their second or third year. Information from the Susitna River indicates Chinook salmon leave that system as both age-0 and age-1 fish (Roth and Stratton, 1985). Age-0 outmigrants leave the system from mid-June to late August at mean lengths of 43 to 75 millimeters, while age-1 smolts leave the river from late May to mid-June at 80 to 89 millimeters. Chinook smolts feed on plankton and insects in freshwater. After migrating to sea, young Chinook salmon initially feed in shallow nearshore areas along the coast. As they grow, they gradually move offshore and into deeper water. Chinook remain within the coastal area throughout their marine phase. Prey initially include a variety of marine plankton, including copepods, amphipods, euphausiids, and small fishes. With increasing size, fish become the dominant food item, with Pacific herring (*Clupea pallasii*) and Pacific sandlance (*Ammodytes hexapterus*), as well as squid and crustaceans, providing a high percent of the diet. Chinook salmon enter tributaries on the western side of the Susitna River in May and June, continuing until August, with peak recreational harvests occurring at the mouth of Alexander Creek during the first week of June, and at the mouth of the Deshka River during mid-June (Ivey and Sweet, 2004). Catches from commercial setnets along the western side of northern Cook Inlet, between 2001 and 2005, indicate that 90 percent of the catch occurs between May 25 and June 18.

Moulton (1997) captured juvenile Chinook salmon smolts along the northwestern shore of Upper Cook Inlet in the Susitna, Tyonek, and Trading Bay regions. Catch rates peaked in mid-June and mid-July, and no Chinook smolts were caught in September. Chinook smolts captured in June were primarily age-1, while those captured in July were ages-0 and -1. Small numbers of age-2 and -3 juvenile Chinook were also caught. In Knik Arm, Chinook salmon comprised 25.6 percent of all juvenile salmon captured from April to July 2005 (Houghton et al., 2005a). Peak abundance occurred in June and no significant difference in the catch per unit effort occurred among stations throughout the Knik Arm. In April, most of the Chinook were age-0 fish from 30 to 40 millimeters (1.2 to 1.6 inches) in length. Beginning in May, fish greater than 61 millimeters (2.4 inches) dominated the catch, many of which appeared to be of hatchery origin. Multiple cohorts were also present in tow net samples collected in May. Chinook smolt abundance declined in Knik Arm in mid- to late summer.

Bradley (2012) captured the highest number of age-1 smolt in the upper Yukon and Tanana rivers in late May through June while age-0 fish, presumably moving within the drainage and not smolting, were captured starting in early June with peak numbers incurring in June and into mid-July. Similarly, Durst 2001, only captured Chinook salmon smolt in glacial waters of the Tanana River near Delta Junction in May and June. Hemming et.al 1999, identified similar patterns for Tanana River Chinook salmon smolt in the Tanana River near Fairbanks and Delta Junction. Chinook smolt were only captured in the glacial waters of the Tanana River in May in the Fairbanks area and none in the Delta Junction area.

EFH Description – Chinook Salmon – Freshwater Eggs
EFH for Chinook salmon eggs is the general distribution for this life stage, located in gravel substrates in those waters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes and includes those identified as spawning habitats for Chinook salmon (Johnson and Litchfield 2015 a, b, and c).

EFH Description – Chinook Salmon – Freshwater Larvae and Juveniles
EFH for larval and juvenile Chinook salmon is the general distribution area for this life stage, located in those waters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes and includes those identified as rearing habitats for Chinook salmon (Johnson and Litchfield 2015 a, b, and c) and contiguous rearing areas within the boundaries of ordinary high water. Juvenile Chinook salmon outmigrate from freshwater areas in spring to early summer toward the sea and may spend up to a year in a major tributaries or rivers, such as the Kenai, Yukon, Taku, and Copper rivers.

EFH Description – Chinook Salmon – Estuarine Juveniles
Estuarine EFH for juvenile Chinook salmon is the general distribution area for this life stage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters. Chinook salmon smolts and post-smolt juveniles may be present in these estuarine habitats from April through September.

EFH Description – Chinook Salmon – Marine Juveniles
Marine EFH for juvenile Chinook salmon is the general distribution area for this life stage, located in all marine waters off the coast of Alaska from the mean higher tide line to the 200-nautical mile limit of the EEZ, including the GOA, Eastern Bering Sea, Chukchi Sea, and Arctic Ocean. Juvenile marine Chinook salmon are at this life stage from April until annulus formation in January or February during their first winter at sea.

EFH Description – Chinook Salmon – Marine Immature and Maturing Adults
EFH for immature and maturing adult Chinook salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska and ranging from the mean higher tide line to the 200-nautical-mile limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

EFH Description – Chinook Salmon – Freshwater Adults
EFH for adult Chinook salmon is the general distribution area for this life stage, located in fresh waters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes (Johnson and Litchfield 2015 a, b, and c) wherever there are spawning substrates consisting of gravels from April through September.

3.1.1.2 Sockeye Salmon

Sockeye salmon are distributed throughout the Cook Inlet region but freshwater habitats important for the spawning, rearing, and migration of sockeye salmon have not been identified north of the Alaska Range within the Project area (Johnson and Litchfield 2015 a, b, and c) (Figure 9).

Sockeye salmon is an important commercial, sport, and subsistence fish throughout Cook Inlet, with major runs to the Kenai, Susitna, and other rivers in the region. Sockeye typically spawn in lakes or rivers associated with lake systems, although they can occur in river systems without lakes. Female sockeye salmon deposit 2,000 to 4,500 eggs in gravel nests. When lakes are available, sockeye fry may spend one to three years in freshwater before entering the ocean. In systems without lakes, sockeye generally spend less time in fresh water. Some sockeye salmon populations are landlocked (i.e., kokanee) and spend their entire lives in freshwater.

WATERS IMPORTANT FOR THE SPAWNING, REARING AND MIGRATION OF SOCKEYE SALMON IN ALASKA

FIGURE 9

ALASKA LNG

LEGEND

- Project Facility
- Existing Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Anadromous Waters - Sockeye Salmon
- Major Highways
- Major Rivers

Source:
Johnson and Litchfield 2015, a, b and c

0 25 50 100 Miles

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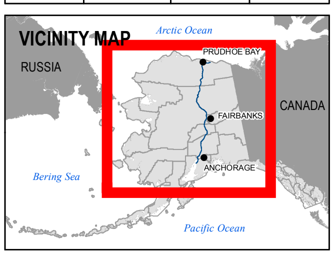

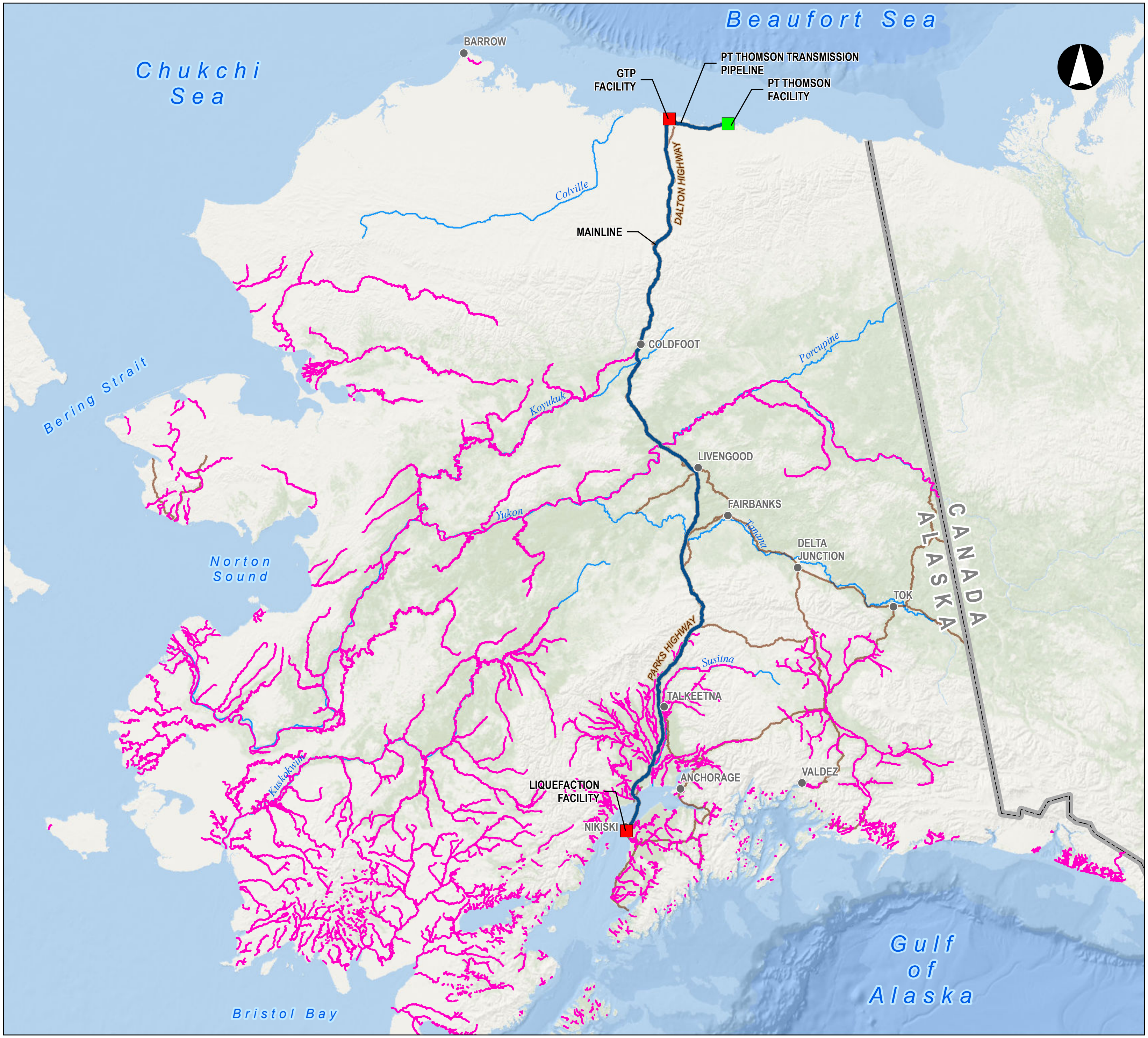

X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 9 Waters important for the spawning rearing and migration of Sockeye salmon in Alaska.mxd

Adult sockeye salmon are present from June to October in Upper Cook Inlet waters (ADF&G, 2014d) with a historic peak return to the southern boundary of Upper Cook Inlet marine waters around July 15 (Shields and Willette, 2005). Approximately 50 percent of Susitna River sockeye are thought to be produced in the Yentna River tributary (Ivey and Sweet, 2004). Catches from commercial setnets along the western side of northern Cook Inlet between 2001 and 2005 indicate that 90 percent of the catch occurs between July 1 and 31, although they are present from early June into early August.

Juvenile sockeye salmon were caught in Upper Cook Inlet in June and July, but in limited numbers (Moulton, 1997). During June, juvenile sockeye were caught throughout the study area in Upper Cook Inlet; in July, they were caught mostly in the eastern and middle portions of Moulton's (1997) study area. Age-1 (one winter in freshwater) was dominant in the June tows, but ages-0 and -1 were caught in equal numbers in July. No juvenile sockeye salmon were caught in September.

Sockeye juveniles normally leave freshwater and enter marine waters during the summer of their second or third year. In the Susitna River, sockeye were observed to leave the system at age-0 and -1 (Roth and Stratton, 1985). Age-0 sockeye outmigrated from the Susitna River in mid-May to late August at mean lengths of 40–53 millimeters. Age-1 sockeye from the Susitna River show a more typical outmigration, with 90 percent outmigrating from mid-May to mid-June at mean lengths of 71–78 millimeters in 1984 and 80 millimeters in 1985.

In Knik Arm in 2004, juvenile sockeye were the most frequently caught salmon during beach seining from July to November (Houghton et al., 2005a, b). Catches peaked in August 2004. In 2005, juvenile sockeye catches were low in April and May, peaked in June, and continued in July. Based on length measurements, two cohorts of sockeye (ages-0 and -1) were present in Knik Arm during both years. Juvenile sockeye in Knik Arm appeared to have substantial body growth from July through September 2004.

EFH Description – Sockeye Salmon – Freshwater Eggs
EFH for sockeye salmon eggs is the general distribution area for this life stage, located in gravel substrates in those waters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes and includes those identified as spawning habitats for sockeye salmon (Johnson and Litchfield 2015 a, b, and c).

EFH Description – Sockeye Salmon – Freshwater Larvae and Juveniles
EFH for larval and juvenile sockeye salmon is the general distribution area for this life stage, located in those waters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes and includes those identified as rearing habitats for sockeye salmon (Johnson and Litchfield 2015 a, b, and c and contiguous rearing areas within the boundaries of ordinary high water. Juvenile sockeye salmon require year-round rearing habitat. Fry generally migrate downstream to a lake or, in systems lacking a freshwater lake, to estuarine and riverine rearing areas for up to two years. Fry outmigration occurs from approximately April to November and smolts generally migrate during the spring and summer.

EFH Description – Sockeye Salmon – Estuarine Juveniles
Estuarine EFH for juvenile sockeye salmon is the general distribution area for this life stage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters. Under-yearling, yearling, and older smolts occupy estuaries from March through early August.

EFH Description – Sockeye Salmon – Marine Juveniles
Marine EFH for juvenile sockeye salmon is the general distribution area for this life stage, located in all marine waters off the coast of Alaska to depths of 50 meters and range from the mean higher

tide line to the 200-nautical-mile limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean from midsummer until December of their first year at sea.

EFH Description – Sockeye Salmon – Marine Immature and Maturing Adults
EFH for immature and maturing adult sockeye salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to depths of 200 meters and range from the mean higher tide line to the 200-nautical-mile limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

EFH Description – Sockeye Salmon – Freshwater Adults
EFH for sockeye salmon is the general distribution area for this life stage, located in freshwaters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes (ADF&G 1998a) and wherever there are spawning substrates consisting of medium to course gravel containing less than 15 percent fine sediment (less than 2 millimeters in diameter) and finer substrates can be used in upwelling areas of streams and sloughs from June through September. Sockeye often spawn in lake substrates, as well as in streams.

3.1.1.3 Coho Salmon

Coho salmon are distributed throughout the Cook Inlet/Yukon Evaluation Area of the Project with highest frequency of freshwater habitat use occurring within the drainages flowing into Cook Inlet. Farther north, Coho salmon are associated with some tributaries of the Yukon, Tanana, and Koyukuk rivers. North of the Brooks Range, Coho salmon have not been consistently identified and important freshwater habitats for the species have not been identified (Johnson and Litchfield 2015 a, b, and c) (Figure 10).

Coho salmon is a popular commercial and sport fish, occurring in most river systems within Cook Inlet. Coho salmon spawn in many types of freshwater habitats and are known to migrate up the Yukon River to the Alaska/Canada border. Adult Coho salmon return to spawn later than other species and may be found in spawning streams from July through November. The timing of spawning runs may vary depending on environmental conditions, and barriers in small headwater streams they often spawn in. Females deposit 2,000 to 4,500 eggs into gravel beds.

Juvenile Coho salmon usually rear from one to three winters in freshwater (ADF&G, 2014d). Juvenile Coho salmon can establish winter territories in freshwater pools and lakes, and may move between brackish estuarine water during spring and summer for feeding and move back to freshwater in fall (ADF&G, 2014d).

Adult Coho salmon are well represented throughout Upper Cook Inlet with runs beginning in July and continuing into October. The peak of the run in the west-side Susitna area, an early-run stock, is generally in the last week of July (Ivey and Sweet, 2004). The Little Susitna River has proven to be a good indicator of Coho run strength throughout the region, and the Susitna River drainage supports the largest Coho stock in Upper Cook Inlet. The greatest recreational harvest of Coho salmon generally occurs in the Knik and Eastside Susitna Management Units, followed closely by the Westside Susitna Unit (Ivey and Sweet, 2004). Lake Creek is the greatest contributor to sport fish catches in the Westside Unit. Catches from commercial set nets along the western side of northern Cook Inlet between 2001 and 2005 indicate that 90 percent of the catch occurs between July 12 and August 15, although they are present from early July into late August.

WATERS IMPORTANT FOR THE SPAWNING, REARING AND MIGRATION OF COHO SALMON IN ALASKA

FIGURE 10

ALASKA LNG

LEGEND

- Project Facility
- Existing Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Anadromous Waters - Coho Salmon
- Major Highways
- Major Rivers

Source:
Johnson and Litchfield 2015, a, b and c

0 25 50 100 Miles

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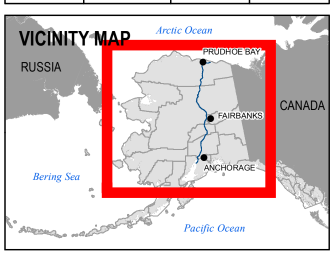
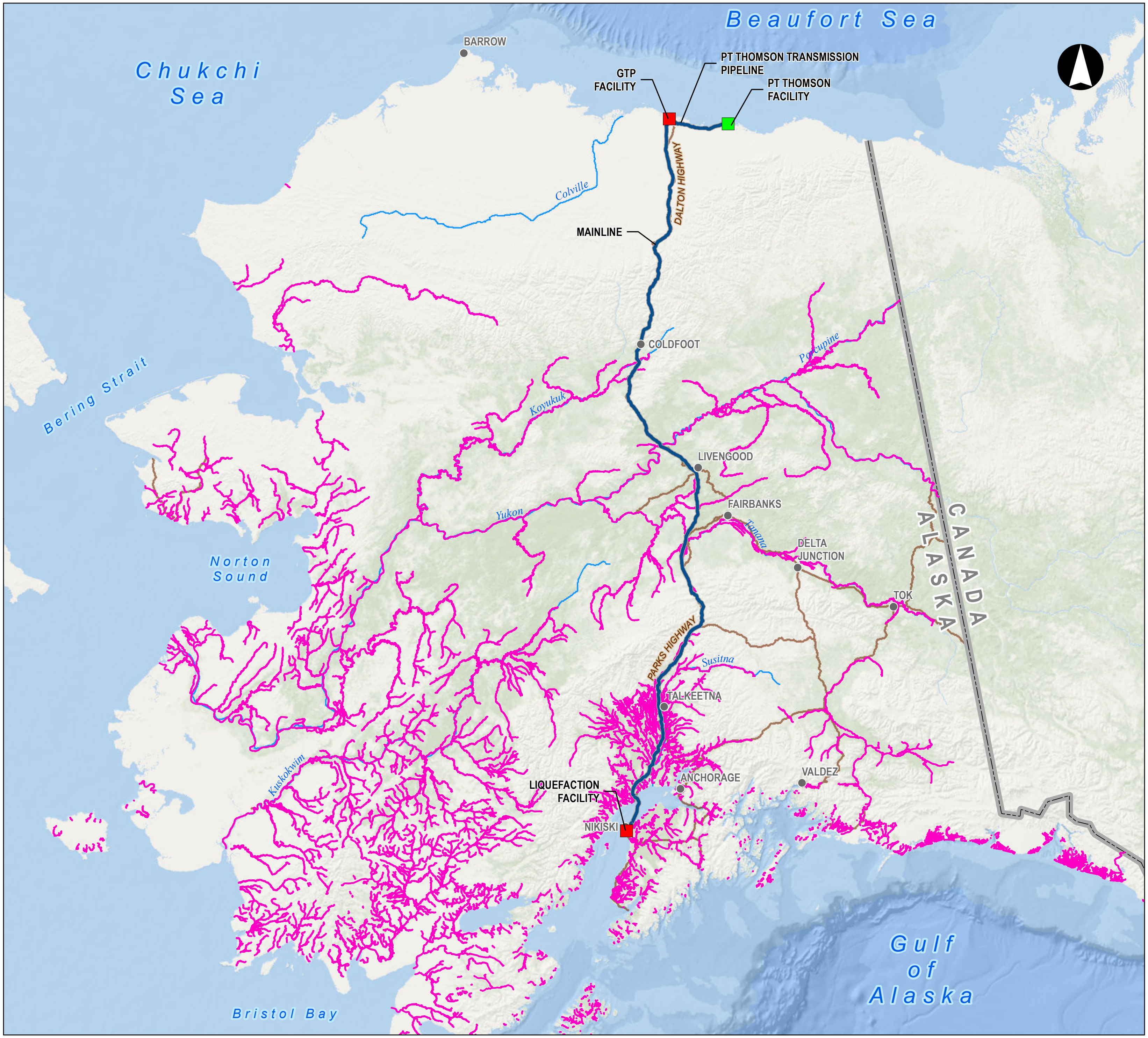
VICINITY MAP





X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 10 Waters important for the spawning rearing and migration of Coho salmon in Alaska.mxd

Juvenile Coho in northern Cook Inlet streams spend from one to three years in the freshwater streams. In the Susitna and Little Susitna rivers, most of the returning adults have spent either one or two summers in freshwater, migrating out as smelts the following summer. Neither age group appears to be consistently dominant (ADF&G, 1983; Barrett et al., 1984, 1985; Bartlett, 1992; Waltemyer, 1991). Migration of smolts out of the Susitna River to marine waters occurs from mid-May to September. Age-0 smolts left the river in late July through August in both 1984 and 1985. In 1984, ages-1 and -2 showed a similar outmigration pattern, while in 1985, the older smolts outmigrated in June and early July. Age-1 smolts left at mean lengths of 85–113 millimeters in 1984 and 89–108 millimeters in 1985, while age-2 smolts were 126–141 millimeters in 1984 and averaged 132 millimeters in 1985. Upon entry into the marine waters, coho tend to remain near shorelines where they feed on planktonic crustaceans, pink and chum salmon fry, and juveniles and larvae of other fishes. As they grow, they move into deeper, offshore waters and are eventually distributed across the North Pacific Ocean and into the Bering Sea. As the coho grow, their diet shifts to larger pelagic prey.

In Knik Arm, juvenile coho salmon were the second-most-abundant juvenile salmon species captured in beach seines in 2004, and the most abundant species in 2005 (Houghton et al., 2005a). Coho salmon smolts were captured as early as April and were present in Knik Arm into late November. In both 2004 and 2005, catches of juvenile coho peaked in July, but continued into August. In 2005, coho salmon were distributed throughout Knik Arm but were more abundant on the western side (Houghton et al., 2005a). Several cohorts were present throughout the study period and a relatively high frequency of 101- to 140-millimeter coho captured in June 2005 may have resulted from the smolt release from Ship Creek hatcheries. Houghton et al. (2005a) reported that adult coho comprised 0.9 percent of the total beach seine catch and that most adult coho were captured in July with smaller numbers in August. In northern Cook Inlet, catch rates of juvenile coho salmon were highest in mid-June and mid-July, and the greatest numbers were caught near the Susitna River delta (Moulton, 1997). Juvenile coho were the only salmon caught in September.

In the Tanana River between Fairbanks and Delta Junction, Hemming and Morris, 1999, found coho salmon smolt numbers were greater in May in mainstem Tanana River sampling than during other times of the summer. Durst 2001, reported similar results from sampling in the Delta Junction area of the Tanana River in 1999 and 2000, where May seine haul catches identified coho salmon in all habitats sampled including 13 glacial water sites only in May 2000. During other periods of the summer, coho juveniles were captured most frequently in clear-water streams indicating that fish captured in May were likely outmigrating smolts (Durst 2001).

EFH Description – Coho Salmon – Freshwater Eggs

EFH for coho salmon eggs is the general distribution area for this life stage, located in gravel substrates in those waters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes and includes those identified as spawning habitats for coho salmon (Johnson and Litchfield 2015 a, b, and c).

EFH Description – Coho Salmon – Freshwater Larvae and Juveniles

EFH for larval and juvenile coho salmon is the general distribution area for this life stage, located in those waters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes and includes those identified as rearing habitats for coho salmon (Johnson and Litchfield 2015 a, b, and c) and contiguous rearing areas within the boundaries of ordinary high water. Fry generally migrate to a lake, slough, or estuary and rear in these areas for up to two years.

EFH Description – Coho Salmon – Estuarine Juveniles

Estuarine EFH for juvenile coho salmon is the general distribution area for this life stage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters. Juvenile coho salmon require year-round rearing and migration habitats from April to November to provide access to and from the estuary.

EFH Description – Coho Salmon – Marine Juveniles
Marine EFH for juvenile coho salmon is the general distribution area for this life stage, located in all marine waters off the coast of Alaska from the mean higher tide line to the 200-nm limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

EFH Description – Coho Salmon – Marine Immature and Maturing Adults
EFH for immature and maturing adult coho salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to 200 meters in depth and range from the mean higher tide line to the 200-nautical-mile limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

EFH Description – Coho Salmon – Freshwater Adults
EFH for coho salmon is the general distribution area for this life stage, located in freshwaters as identified in ADF&G's Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes (ADF&G 1998a) and wherever there are spawning substrates consisting mainly of gravel containing less than 15 percent fine sediment (less than 2 millimeters in diameter) from July to December.

3.1.1.4 Chum Salmon

Chum salmon are distributed throughout the Cook Inlet/Yukon and Arctic Evaluation Areas of the Project with highest frequency of freshwater habitat use occurring within the drainages flowing into Cook Inlet and Yukon tributaries. However, chum salmon are also common in drainages on Alaska's North Slope including the Sagavanirktok River. Important freshwater habitats for chum salmon have been identified throughout the evaluation area (Johnson and Litchfield 2015 a, b, and c) (Figure 11).

Chum salmon in Upper Cook Inlet are most abundant in the Susitna River, although they occur in other rivers as well. Chum salmon spawn in coastal streams and intertidal areas, but may also travel great distances inland. Some chum salmon are known to migrate up the Yukon River to the Yukon Territory to spawn, a distance of over 2,000 miles. Females may lay up to 4,000 eggs.

Chum fry move toward marine waters soon after hatching, usually shortly after ice breaks up from their natal rivers. Chum may not feed before reaching saltwater, thus making marine food resources of special importance. Juvenile chum in Cook Inlet are thought to enter marine water from late May through July. By their first winter, Cook Inlet chum salmon have moved into the Gulf of Alaska and spend three to four years in the ocean before returning to natal streams (ADF&G, 2008).

Adult chum salmon are not well represented in the west-side Susitna drainages of the Upper Cook Inlet. Their peak run timing is mid-July through mid-August; however, their run continues into September (ADF&G, 2008). Upper Cook Inlet chum stocks are only monitored at one location, Clearwater Creek, with an escapement index generated by peak run time aerial survey counts (Hasbrouck and Edmundson, 2005). Chum production in the Susitna River declined in the mid-1980s to the mid-1990s but a steady increase in production has been observed in Upper Cook Inlet since the mid-1990s (Fox and Shields, 2005). Catches from commercial setnets along the western side of northern Cook Inlet between 2001 and 2005 indicate that the return of adult chum salmon falls between that of sockeye and coho, with 90 percent of the catch occurring between July 8 and August 7, although they are present from early July into late August.

WATERS IMPORTANT FOR THE SPAWNING, REARING AND MIGRATION OF CHUM SALMON IN ALASKA

FIGURE 11

ALASKA LNG

LEGEND

- Project Facility
- Existing Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Anadromous Waters - Chum Salmon
- Major Highways
- Major Rivers

Source:
Johnson and Litchfield 2015, a, b and c

0 25 50 100 Miles

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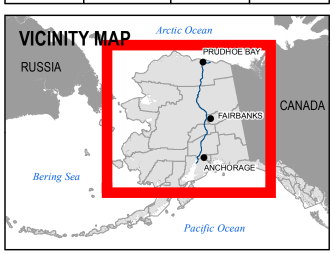
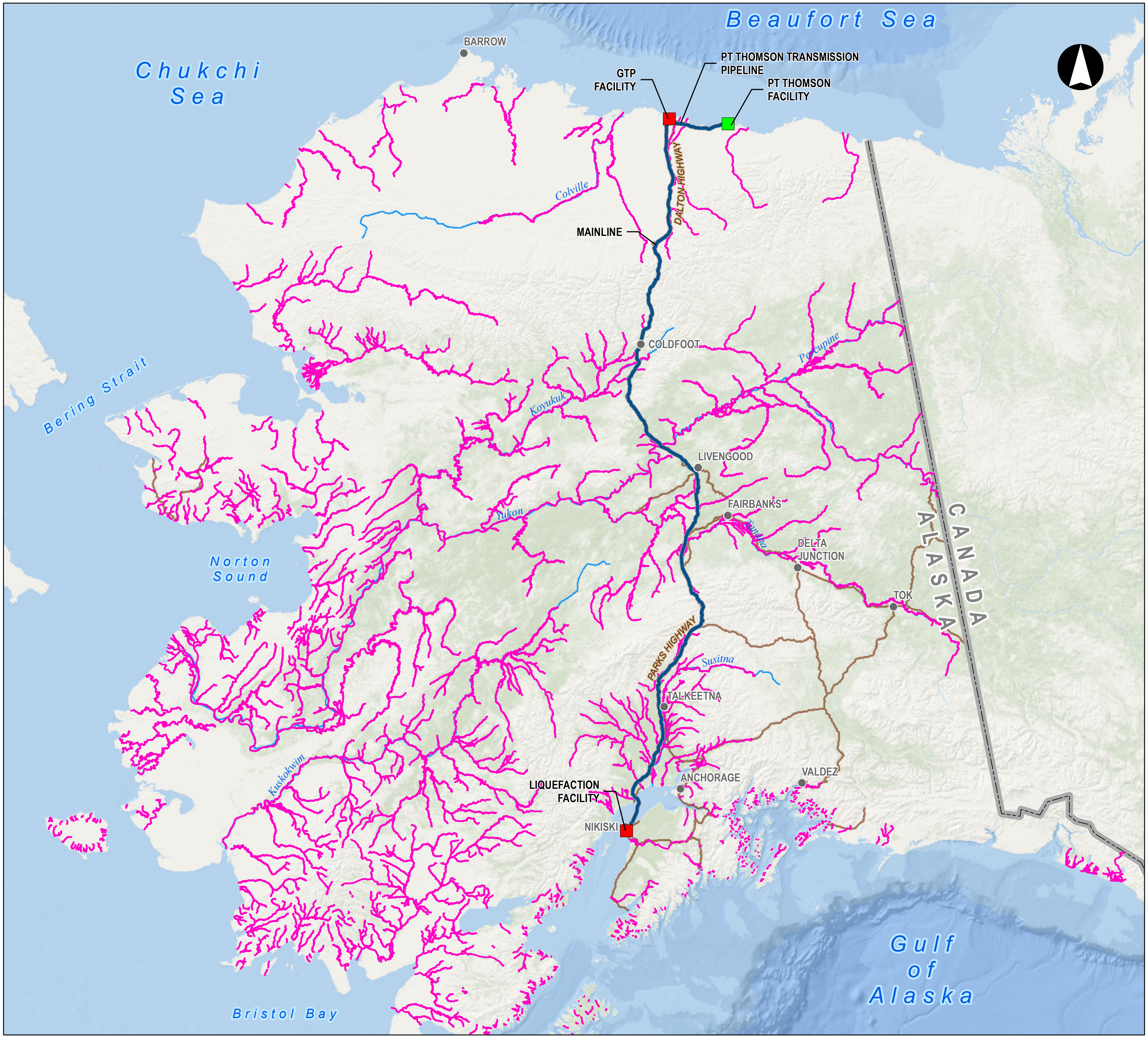
VICINITY MAP





Juvenile chum salmon emerge from the streambed in spring and immediately begin moving downstream to the sea. The duration of this migration depends on the total distance traveled, and water velocities encountered. In most cases, the downstream migration takes a few hours to a few days. Little or no feeding occurs in streams where the downstream migration is completed in a small time after emergence. In the Susitna River, chum leave during June through early July at a mean size of 42 to 43 millimeters. In both 1984 and 1985, chum salmon between 50 and 60 millimeters were caught in the river, which was interpreted to indicate growth prior to outmigration.

Chum salmon smolts were the second-most-abundant salmon reported by Moulton (1997) in Upper Cook Inlet and comprised 10.2 percent of the total catch. Chum salmon showed a steady increase in size through the study period with mean lengths ranging from 43.6 millimeters (1.7 inches) in early June to 57.7 millimeters (2.3 inches) in mid-July. The growth rate of chum smolt appeared to be greater in July than in June and may have been related to warmer temperatures or to a decrease in the numbers of smolt emigrating from freshwater (Moulton, 1997).

During beach seine sampling in Knik Arm, Houghton et al. (2005a) captured only five juvenile chum in 2004 and concluded that most chum had probably migrated out of the area before sampling began in late July. Sampling in 2005 began earlier than in 2004 and small numbers of juvenile chum were captured in April with significant increases in May and June. As in 2004, no chum smolts were captured with beach seines in July 2005. Chum salmon smolts were the most abundant salmon captured in tow-net sampling in Knik Arm (Houghton et al., 2005a). Chum smolt were most abundant in May and numbers declined in June and July. Houghton et al. (2005a) reported that adult chum salmon comprised 0.1 percent of the total beach seine catch.

Once in the estuary, juveniles form schools and normally remain close to shorelines for several months to feed and grow prior to moving onto the high seas. Salo (1991) describes chum salmon juveniles as depending on a detritus-based food web in the estuarine habitat. Fish larvae and insects were important components of juvenile chum diet in northern Cook Inlet during June, while insects became dominant in July (Moulton, 1997). Prey studies often describe harpacticoid copepods as dominant food item. By late summer, juvenile chum salmon move to offshore waters. Multiple runs of chum salmon occur within some spawning systems of Interior Alaska with summer chums arriving to spawn in July and August and fall runs occurring in October and into November. Chum smolt in the Interior almost immediately after emerging from the gravel and they begin their downstream migration just after spring snow melt water flows recede. Chum were the most frequent salmon smolt captured in the Tanana River between Fairbanks and Delta Junction in May 1997 and May 2000 (Hemming and Morris 1999, Durst 2001).

Chum salmon adults move into spawning habitats on Alaska's North Slope between July and September. Chum smolt likely migrate to the Beaufort Sea during break-up as few individuals have ever been captured in systems with known spawning populations.

EFH Description – Chum Salmon – Freshwater Eggs
EFH for chum salmon eggs is the general distribution area for this life stage, located in gravel substrates in those waters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes and includes those identified as spawning habitats for chum salmon (Johnson and Litchfield 2015 a, b, and c).

EFH Description – Chum Salmon – Freshwater Larvae and Juveniles
EFH for larval and juvenile chum salmon is the general distribution area for this life stage, located in those waters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes and includes those identified as rearing habitats for chum salmon (Johnson and Litchfield 2015 a, b, and c) and contiguous rearing areas within the boundaries of ordinary high water and contiguous rearing areas within the boundaries of ordinary high water during the spring, generally migrate in darkness in the upper water column. Fry leave streams in within 15 days and the duration of migration from a stream toward sea may last two months.

EFH Description – Chum Salmon – Estuarine Juveniles
Estuarine EFH for juvenile chum salmon is the general distribution area for this life stage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters from late April through June.

EFH Description – Chum Salmon – Marine Juveniles
Marine EFH for juvenile chum salmon is the general distribution area for this life stage, located in all marine waters off the coast of Alaska to approximately 50 meters in depth from the mean higher tide line to the 200-nautical-mile limit of the EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

EFH Description – Chum Salmon – Marine Immature and Maturing Adults
EFH for immature and maturing adult chum salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to depths of 200 meters and ranging from the mean higher tide line to the 200-nautical-mile limit of the EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

EFH Description – Chum Salmon – Freshwater Adults
EFH for chum salmon is the general distribution area for this life stage, located in freshwaters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes (ADF&G 1998a) and wherever there are spawning substrates consisting of medium to course gravel containing less than 15 percent fine sediment (less than 2 millimeters in diameter) and finer substrates can be used in upwelling areas of streams and sloughs from June through January.

3.1.1.5 Pink Salmon

Pink Salmon are distributed throughout the Cook Inlet and Arctic Evaluation Areas of the Project with highest frequency of freshwater habitat use occurring within the drainages flowing into Cook Inlet. Pink salmon are also common in drainages on Alaska's North Slope Including the Sagavanirktok, Shaviovik and Kavik rivers. Important freshwater habitats for chum salmon have been identified throughout the Cook Inlet area and the Arctic Evaluation area, but not within Interior Alaska (Johnson and Litchfield 2015 a, b, and c) (Figure 12).

Pink salmon are the smallest of the Pacific salmon, with a maximum length of 76 centimeters (30 inches) and weight of 6.4 kilograms (14 pounds; Mecklenburg et al., 2002). Adult pink salmon return to rivers and streams throughout Upper Cook Inlet. They are harvested in commercial and subsistence fisheries, but usually in the course of effort directed at other species. Females may deposit as many as 1,500 to 2,000 eggs in a gravel nest in freshwater or occasionally in intertidal areas. The eggs hatch during winter and the developing fish, or alevins, remain in the gravel using their yolk sacs for nourishment. Fry emerge from the gravel in late winter or early spring and immediately move downstream to marine waters.

In the ocean, juvenile pink salmon smolt feed on plankton and larval fish, and may reach 4 to 6 inches in length by their first winter. They spend the next year in the open ocean, returning the following fall to spawn in their natal streams. This life cycle of the Pacific salmon is generally the shortest (two years from hatching to spawning).

WATERS IMPORTANT FOR THE SPAWNING, REARING AND MIGRATION OF PINK SALMON IN ALASKA

FIGURE 12

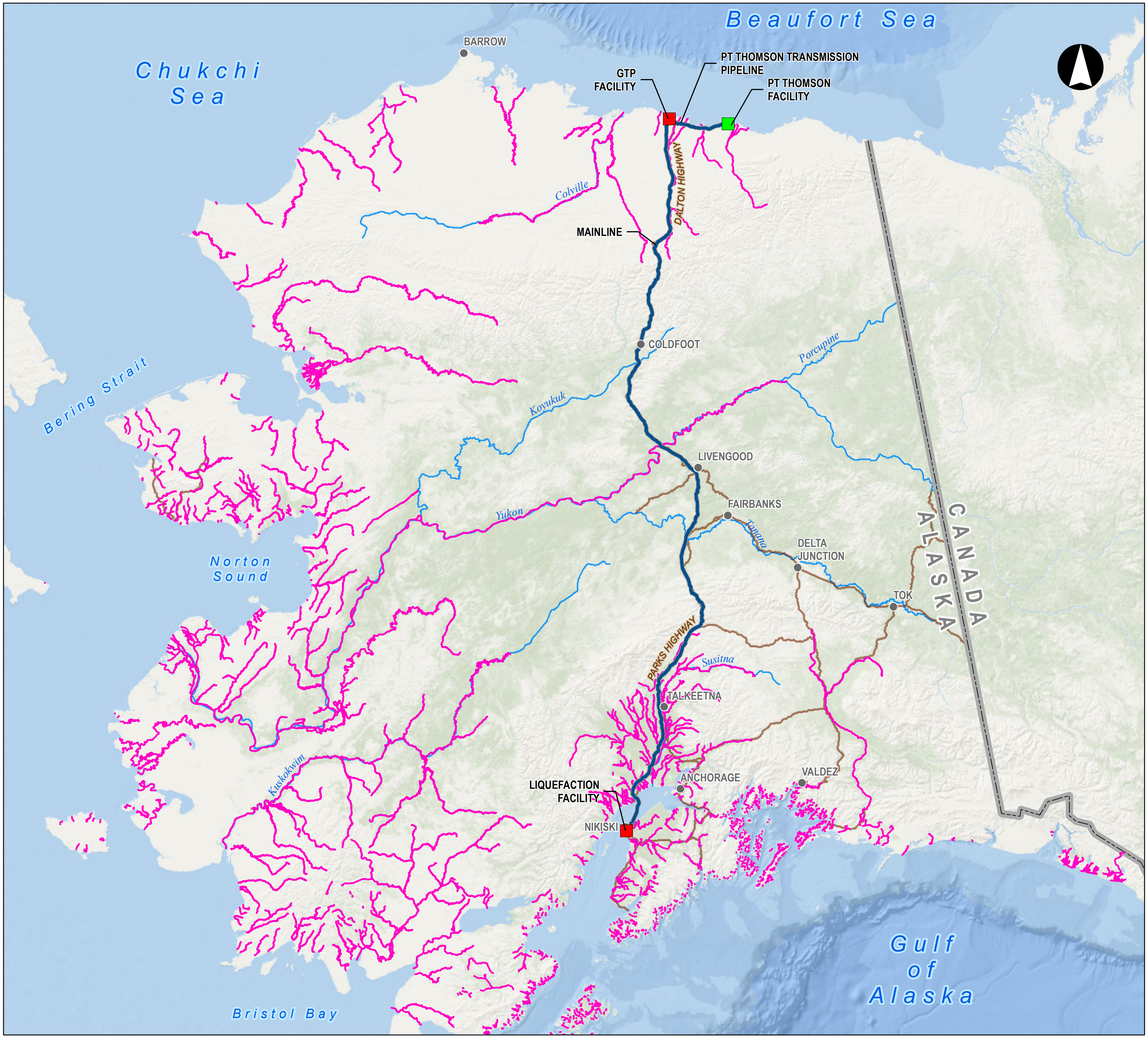
ALASKA LNG

LEGEND

- Project Facility
- Existing Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Anadromous Waters - Pink Salmon
- Major Highways
- Major Rivers

Source:
Johnson and Litchfield 2015, a, b and c

0 25 50 100 Miles



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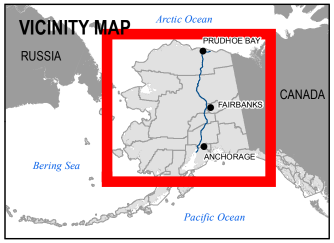
VICINITY MAP



X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 12 Waters important for the spawning rearing and migration of Pink salmon in Alaska.mxd

Because pink salmon spawn at 2 years of age, two separate lines of unrelated fish develop in alternating odd- and even-year cycles. In some locations one line may be dominant over the other in abundance. In the Cook Inlet region, larger pink salmon runs occur during even years.

Adult pink salmon probably feed relatively little in Cook Inlet because they are close to entering their natal stream. Based on the diets of juvenile pinks in Prince William Sound and the northern Gulf of Alaska, pink salmon are known to feed on a mixture of gastropods, cladocerans, copepods, and bivalves early on, ranging to larger prey such pteropods, larvaceans, amphipods and euphausiids later in summer (Bolt and Haldorson, 2003).

Adult pink salmon return to Upper Cook Inlet from early July to mid-August, with Westside Susitna drainages having peak runs in July. Upper Cook Inlet pink salmon runs are even-year dominated, with the 2000 and 2002 returns being characterized as strong or very strong, as opposed to diminished returns since the mid-1980s. However, harvest levels of pink salmon have been low, owing to restrictions in place to ensure sockeye salmon escapement. Pink salmon returns in 2004 were deemed average to above average (Fox and Shields, 2005). Catches from commercial setnets along the western side of northern Cook Inlet between 2001 and 2005 indicate that the adult return timing is quite similar to that of sockeye salmon, with 90 percent of the catch occurs between July 1 and 31, although they are present from mid-June into early August.

Pink salmon emerge from gravel substrate in April and May, and immediately migrate downstream to the estuary. The time spent in freshwater varies, depending on the distance the juveniles must travel, and average stream velocities they encounter along the way. Freshwater residence of a few hours to a few days is typical. Feeding does not normally occur during this downstream migration. During 1985, pink salmon left the Susitna River throughout June, with the outmigration essentially finished by the first week in July (Roth et al., 1986). Outmigrating pink salmon averaged 37 millimeters, with a maximum of 48 millimeters.

Juvenile pink salmon were the most abundant salmon reported by Moulton (1997) during tow-net sampling in Upper Cook Inlet in June and July of 1993, comprising 16.5 percent of the total catch. Pink salmon were caught in 92 percent of the tows in June, comprising approximately 25 percent of the total catch. Pink salmon numbers decreased in July, when they occurred in only 70 percent of the tows. Pink salmon were abundant throughout the study area from the East and West Forelands to Fire Island near Anchorage, but were most abundant in mid-June near the mouth of the Susitna River. However, a large number of pink salmon was also caught in a single mid-channel tow in mid-July in the eastern portion of the study area.

Houghton et al. (2005a) did not capture any pink salmon smolt in Knik Arm during beach seine sampling in 2004, although few were expected. The larger even-year pink runs in Cook Inlet produce a larger number of odd-year outmigrants, and the numbers of pink salmon smolt expected in even years are much lower. In 2005, Houghton et al. (2005a) captured 33 pink salmon by beach seine, which was 1.9 percent of all juvenile salmonids. Most pink salmon were captured in May and were young-of-the-year outmigrants between 31 and 40 millimeters (1.2 to 1.6 inches) in length. Houghton et al. (2005a) also captured pink salmon smolt during tow-net sampling in Knik Arm. Pink salmon smolt were most abundant in May and numbers declined in June and July.

Pink salmon juveniles entering marine habitats begin feeding on small invertebrates, particularly calanoid and harpacticoid copepods (Cooney et al., 1981; Sturdevant et a1., 1993). Other important foods are often decapod larvae, fish larvae, invertebrate eggs, and insects (Heard, 1991). As they grow, the juveniles move away from estuaries, but usually remain close to shorelines for several weeks. In Prince William Sound, pink salmon fry enter the marine area at lengths of around 35 millimeters in late April to early May and have reached mean lengths of 40 to 45 millimeters by early June, depending on growing conditions (Celewycz and Wertheimer, 1993). By late summer, the juveniles have grown to a length of about 60–80 millimeters and they begin moving offshore. Pink salmon from northern Cook Inlet likely move to the GOA during the late summer and early fall.

Pink salmon adults move into spawning areas on Alaska's North Slope between July and September and, similar to chum salmon smolts, pink smolts appear to migrate to the Beaufort Sea during spring melt as few smolt have been captured after peak spring flows have receded.

EFH Description - Pink Salmon – Freshwater Eggs
EFH for pink salmon eggs is the general distribution area for this life stage, located in gravel substrates in those waters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes and includes those identified as spawning habitats for pink salmon (Johnson and Litchfield 2015 a, b, and c).

EFH Description – Pink Salmon – Freshwater Larvae and Juveniles
EFH for larval and juvenile pink salmon is the general distribution area for this life stage, located in those waters identified in ADF&G's Catalogue of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes and includes those identified as rearing habitats for pink salmon (Johnson and Litchfield 2015 a, b, and c and contiguous rearing areas within the boundaries of ordinary high water during the spring, generally migrate in darkness in the upper water column. Fry leave streams in within 15 days and the duration of migration from a stream toward sea may last two months.

EFH Description – Pink Salmon – Estuarine Juveniles
Estuarine EFH for juvenile pink salmon is the general distribution area for this life stage, located in estuarine areas, as identified by the salinity transition zone (ecotone) and the mean higher tide line, within nearshore waters and generally present from late April through June.

EFH Description – Pink Salmon – Marine Juveniles
Marine EFH for juvenile pink salmon is the general distribution area for this life stage, located in all marine waters off the coast of Alaska from the mean higher tide line to the 200-nautical-mile limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean.

EFH Description – Pink Salmon – Marine Immature and Maturing Adults
EFH for immature and maturing adult pink salmon is the general distribution area for this life stage, located in marine waters off the coast of Alaska to depths of 200 meters and range from the mean higher tide line to the 200-nautical-mile limit of the U.S. EEZ, including the GOA, EBS, Chukchi Sea, and Arctic Ocean. Mature adult pink salmon frequently spawn in intertidal areas and are known to associate with smaller coastal streams.

EFH Description – Pink Salmon – Freshwater Adults
EFH for pink salmon is the general distribution area for this life stage, located in freshwaters identified in ADF&G's Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes (ADF&G 1998a) and wherever there are spawning substrates consisting of medium to course gravel containing less than 15 percent fine sediment (less than 2 millimeters diameter), 15 to 50 centimeters in depth from June through September.

3.1.2 GOA Groundfish FMP

Cook Inlet occurs within the purview of the GOA Groundfish FMP, which supports more than 24 species of groundfish and nine forage fish complexes. The GOA Groundfish FMP includes: big skate, longnose skate, octopus, sharks, and the shallow water flatfish complex. Spatial data does not exist for all the managed species in this area. Marine species expected to occur in the temporary MOF area include forage fish species, such as walleye pollock (*Theragra chalcogramma*), Pacific herring, eulachon (*Thaleichtys pacificus*), longfin smelt, capelin, Pacific sandfish (*Trichodon trichodon*), Pacific sand lance, snake prickleback (*Lumpenus sagitta*), Pacific staghorn sculpin, and starry flounder (*Platichthys stellatus*) (Moulton, 1997; Houghton et al., 2005a, b). Pollock, eulachon, capelin, and starry flounder are considered target species of the GOA Groundfish FMP (NPFMC, 2014) and are important prey species for Cook Inlet beluga whales in Upper Cook Inlet.

There is no defined EFH for ground fish or forage fish species in the Upper Cook Inlet or in the project area. However, juveniles for some groundfish and all life stages of some forage fish can be assumed. Walleye pollock juveniles were the most abundantly captured juvenile groundifsh in Upper Cook Inlet surveys conducted by Moulton in 1997 and therefore are considered below. Of the forage fish complex, eulachon and capelin are some of the more abundant in coastal Alaska including within Upper Cook Inlet and they are described in the following section.

3.1.2.1 Forage Fishes

Forage fishes are those species that are a critical food source for marine mammal, seabird, and fish species. The forage fish species category was established to allow for the management of these species in a manner that prevents the development of a commercially directed fishery for forage fish (NPFMC 2014). Common forage fish species within Cook Inlet include members of Family Osmeridae (eulachon, capelin, and other smelt) and Ammodytidae (Pacific sand lance). Table 10 lists the most frequently caught members of the Forage Fish Complex for GOA Groundfish FMPs that are expected to have potential occurrence within the Cook Inlet Project areas.

Table 10: Gulf of Alaska Forage Fish Complex

Type of Fish
Capelin
Eulachon
Giant Grenadier
Gunnels
Lanternfishes (*Myctophidae*)
Pacific Sandfish
Pricklebacks (*Stichaeidae*)

No EFH has been designated for the Gulf of Alaska Forage Fish Complex because insufficient information is available (NPFMC 2014).

3.1.2.1.1 Eulachon

Eulachon generally spawn in lower reaches of rivers or streams, broadcasting their eggs over stream bottoms where the eggs attach to sand, gravel, or woody debris. Eggs hatch in three to six weeks and the young are carried to the sea with the current, where they feed mainly on copepod larvae and other plankton (ADF&G 1994). Both juvenile and adult eulachon feed primarily on plankton and after three to five years at sea, they return to their spawning grounds. In Southcentral Alaska, eulachon typically gather in April in large schools at the mouth of spawning streams (ADF&G 1994). Eulachon are one of a variety of prey of Cook Inlet belugas when present.

3.1.2.1.2 Capelin

Capelin are abundant in coastal areas of Alaska; however, stocks have undergone dramatic declines since the 1970s. These declines are attributed to various threats including ecosystem shifts due to climate change, incidental bycatch, and contamination/destruction of spawning habitat (e.g., oil spills) (ADFG 2005). Spawning occurs from mid-May through July when adults (2–3 years) move inshore to spawn on coarse gravel and/or sand beaches. Eggs incubate in the substrate hatching 15–30 days later with larvae being subjected to the tides (Doyle et al. 2002).

Capelin are a high energy forage fish that plays a key role in the overall marine food web. These fishes are a common food source—especially during/after spawning events—used by numerous predators including sea birds, salmon and marine mammals, including pinnipeds and cetaceans.

3.1.2.2 Walleye Pollock

Walleye pollock is an abundant species in the Bering Sea and the Gulf of Alaska, and is also found in Cook Inlet. Pollock range from the Chukchi Sea south through the Bering Sea and Pacific Ocean to central California and Japan. Pollock reach 91 centimeters (36 inches) in length and are an important species in commercial fisheries. Walleye pollock are demersal and may occur at depths to 950 meters (3,117 feet), but are also pelagic and occur in schools near the surface and in mid-water habitats (Mecklenburg et al., 2002). Small pollock feed on copepods and other zooplankton and larger pollock feed on fish. Although walleye pollock is grouped with groundfish, young pollock are the dominant forage fish consumed by larger fish, including adult pollock, and many marine bird and mammal species (Schumacher et al., 2003). Walleye pollock consistently spawn in the Shelikof Strait area and were the second-most abundant groundfish species captured during small-mesh trawl sampling in Kachemak Bay in 2000 (Gustafson and Bechtol, 2005). Walleye pollock are scarce in the upper portions of Cook Inlet and the nearest EFH identified, based on general distribution information, is for late juveniles and adults (Figure 7).

EFH Description – Walleye Pollock – Eggs
EFH for walleye pollock eggs is the general distribution area for this life stage, located in pelagic waters along the entire shelf (0 to 200 meters), upper slope (200 to 500 meters), and intermediate slope (500 to 1,000 meters) throughout the GOA.

EFH Description – Walleye Pollock – Larvae
EFH for larval walleye pollock is the general distribution area for this life stage, located in epipelagic waters along the entire shelf (0 to 200 meters), upper slope (200 to 500 meters), and intermediate slope (500 to 1,000 meters) throughout the GOA.

EFH Description – Walleye Pollock - Early Juveniles—No EFH Description Determined
Limited information exists to describe walleye pollock early juvenile larval general distribution.

EFH Description – Walleye Pollock - Late Juveniles
EFH for late juvenile walleye pollock is the general distribution area for this life stage, located in the lower and middle portion of the water column along the inner (0 to 50 meters), middle (50 to 100 meters), and outer (100 to 200 meters) shelf along the throughout the GOA. No known preference for substrates exists.

EFH Description – Walleye Pollock – Adults
EFH for adult walleye pollock is the general distribution area for this life stage, located in the lower and middle portion of the water column along the entire shelf (0 to 200 meters) and slope (200 to 1,000 meters) throughout the GOA (Figure 7). No known preference for particular substrates exists.

3.1.3 Arctic FMP

The FMP for the Fish Resources of the Arctic Management Area (NPFMC, 2009; 74 C.F.R. 56734) manages three target species: (1) Arctic cod, (2) saffron cod (*Eleginus gracilis*), and (3) snow crab (*Chionoecetes opilio*) (Figure 6). Of these three target species, snow crabs are more associated with deep water (Logerwell et al., 2010), and are not expected to be found within the Project area.

Arctic cod EFH is designated based on Level 1 information for only adults and late juveniles; insufficient information is available to designate EFH for eggs, larvae, and early juveniles (NPFMC, 2009). Arctic cod EFH is designated throughout the entire Arctic FMP management area. Saffron cod EFH is also designated based on Level 1 general distribution information but EFH is not designated much east of Point Barrow.

The general summer distribution of saffron cod and Arctic cod extends across Prudhoe Bay into the Point Thomson portion of the Project area, with saffron cod and Arctic cod being documented in summer study programs within the area (NMFS, 2005; Williams and Burril, 2011). During winter, Arctic cod are the primary species in the Prudhoe Bay region, although in low densities (Tarbox and Thorne, 1979).

Table 11: Arctic EFH Species EFH Life Stages Present in the Project Area

Arctic FMP Fish Species	Life History Stages			
	Eggs	Larvae	Late Juvenile	Adult
Arctic Cod	-	-	√	√
Saffron Cod	-	-	√	√[a]

[a] Found in very few numbers

3.1.3.1 Arctic Cod

As summarized in Fechhelm et al. (2011), Arctic cod have a circumpolar distribution and are ubiquitous in marine waters throughout the Beaufort Sea and the Arctic FMP management area (Figure 6). Arctic cod are an important food item in the diets of marine mammals, birds, and fish, and are considered to be a primary component of the Arctic marine food chain. Arctic cod is one of the most abundant fish species collected in coastal waters and is typically associated with highly productive transition layers that separate cold marine bottom water and warm brackish surface water. The onshore movement of such layers is an important factor in coastal aggregations of fish. Arctic cod do not actively move into freshwater or low-salinity habitats. The movement of large schools into coastal areas can be dramatic and can be either short-lived or sustained. The occurrence of Arctic cod schools in any particular area is both unpredictable and ephemeral.

EFH Description – Arctic Cod – Eggs, Larvae, and Early Juveniles
Insufficient information is available to determine EFH for Eggs, Larvae, and Early Juveniles.

EFH Description – Arctic Cod – Late Juveniles
EFH for late juvenile Arctic cod is the general distribution areas for this life stage located in pelagic and epipelagic waters from the nearshore to offshore areas along the entire shelf (0 to 200 meters) and upper slope (200 to 500 meters) throughout Arctic waters and often associated with ice floes that may occur in deeper waters.

EFH Description – Arctic Cod – Adults
EFH for adult Arctic cod is the general distribution area for this life stage located in pelagic and epipelagic waters from the nearshore to offshore areas along the entire shelf (0 to 200 meters) and upper slope (200 to 500 meters) throughout Arctic waters and often associated with ice floes that may occur in deeper waters.

3.1.3.2 Saffron Cod

Saffron cod are found in brackish and marine waters of the Beaufort Sea east to Bathurst Inlet in Canada (Fechhelm et al., 2011). They frequently enter rivers and may go considerable distances upstream. Saffron cod may be found both nearshore and offshore during summer. Saffron cod have been reported from studies throughout the Beaufort Sea, but saffron cod is the least abundant of the marine species that move shore during summer. Saffron cod have been reported from studies throughout the Beaufort Sea, but it is the least abundant of the marine species that are regularly caught by fyke nets in the Prudhoe Bay region during summer. Saffron cod EFH is designated by general distribution data and does not extend much beyond Point Barrow, Alaska (Figure 6). Therefore, based on their distribution relative to PTU and West Dock Project information, this species is not discussed further.

EFH Description – Saffron Cod - Eggs, Larvae, Early Juveniles, and Late Juveniles
Insufficient information is available to determine EFH for Eggs, Larvae, and Early Juveniles.

EFH Description – Saffron Cod – Late Juveniles
EFH for late juvenile Saffron cod is the general distribution area for this life stage, located in pelagic and epipelagic waters along the coastline, within nearshore bays, and under ice along the inner (0 to 50 meters) shelf throughout Arctic waters and wherever there are substrates consisting of sand and gravel.

EFH Description – Saffron Cod – Adults
EFH for adult Saffron cod is the general distribution area for this life stage, located in pelagic and epipelagic waters along the coastline, within nearshore bays, and under ice along the inner (0 to 50 meters) shelf throughout Arctic waters and wherever there are substrates consisting of sand and gravel.

3.2 EFH Species within the Cook Inlet/Beluga Crossing and Liquefaction Facility Areas

All five species of Pacific salmon use marine waters in the vicinity of the Beluga crossing and the temporary MOF area near Nikiski (Figure 5) and use rivers or streams on the northern Kenai Peninsula for migration, spawning, and rearing (Figure 13). Most notable are the Kenai and Kasilof rivers, located approximately 9.5 and 19 miles south of the temporary MOF area (Johnson and Litchfield 2015c). The Catalog of Waters important for the Spawning, Rearing and Migration of Anadromous Fishes shows the nearest freshwater salmon habitat is located near the mouth of the Kenai River, south of the temporary MOF area (Figure 13). Parsons Lake and the upper reaches of Bishop Creek, located approximately 3 miles inland to the east of the temporary MOF area, support coho and sockeye salmon (Johnson and Litchfield 2015c). Coho salmon have the greatest amount of freshwater EFH in the study region compared to the other four salmon species, with spawning and rearing habitat in many streams on the peninsula (ADF&G 2015).

FRESHWATER DISTRIBUTION OF ANADROMOUS FISH IN STREAMS NEAR THE MOF AREA

FIGURE 13

ALASKA LNG

LEGEND

- Project Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Anadromous Waters
- Major Highways
- State and Federal Conservation Lands

0 1.5 3 6 Miles

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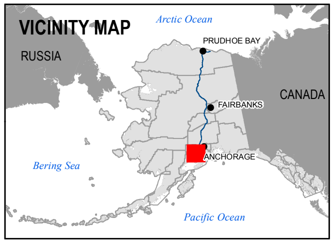


X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 13 Freshwater Distribution of anadromous fish in streams near the MOF area.mxd

3.2.1 Chinook Salmon

Chinook salmon spawn in rivers throughout Interior and Southcentral Alaska, including the Yukon River and its tributaries, and the Susitna, Little Susitna, Beluga, Theodore, and Chuit rivers in Upper Cook Inlet and rivers and streams near Nikiski, such as the Kenai, Kasilof, and Swanson rivers, and Bishop Creek. Figure 14 shows the distribution of Chinook salmon in freshwaters in the Cook Inlet area of the Project. Females may deposit 2,000 to 17,000 eggs in gravel beds. Chinook fry hatch in spring and most juvenile Chinook remain in freshwater until the following spring when they begin to move toward marine habitats as age-1 smolt.

Information from the Susitna and Kenai rivers indicates Chinook salmon leave that system as both age-0 and age-1 fish (Roth and Stratton 1985; King et al. 1994, 1996). Age-0 outmigrants leave the system from mid-May through June, with some level of outmigration continuing through summer, while age-1 smolt leave the system after mid-June (Figure 15). Chinook smolts feed on plankton and insects in freshwater. After migrating to sea, young Chinook salmon initially feed in shallow nearshore areas along the coast. As they grow, they gradually move offshore and into deeper water. Chinook remain within the coastal area throughout their marine phase. Prey initially include a variety of marine plankton, including copepods, amphipods, euphausiids, and small fishes. With increasing size, fish become the dominant food item, with Pacific herring (*Clupea pallasii*) and Pacific sandlance (*Ammodytes hexapterus*), as well as squid and crustaceans, providing a high percent of the diet.

FRESHWATER DISTRIBUTION OF CHINOOK SALMON IN THE MOF VICINITY

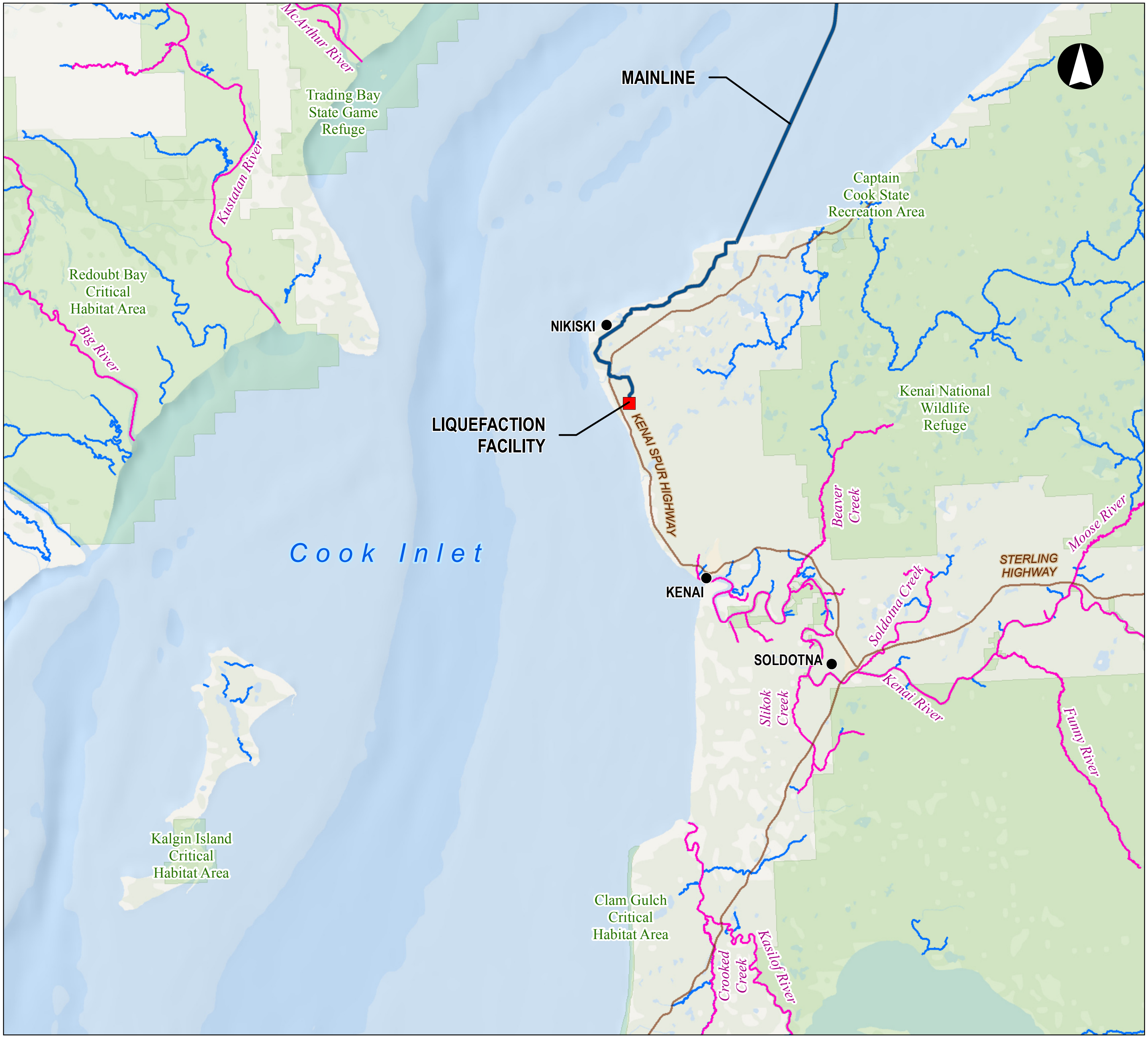
FIGURE 14

ALASKA LNG

LEGEND

- Project Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Anadromous Waters - Chinook Salmon
- Anadromous Waters
- Major Highways
- State and Federal Conservation Lands

0 1.5 3 6 Miles



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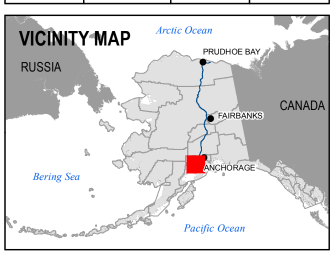
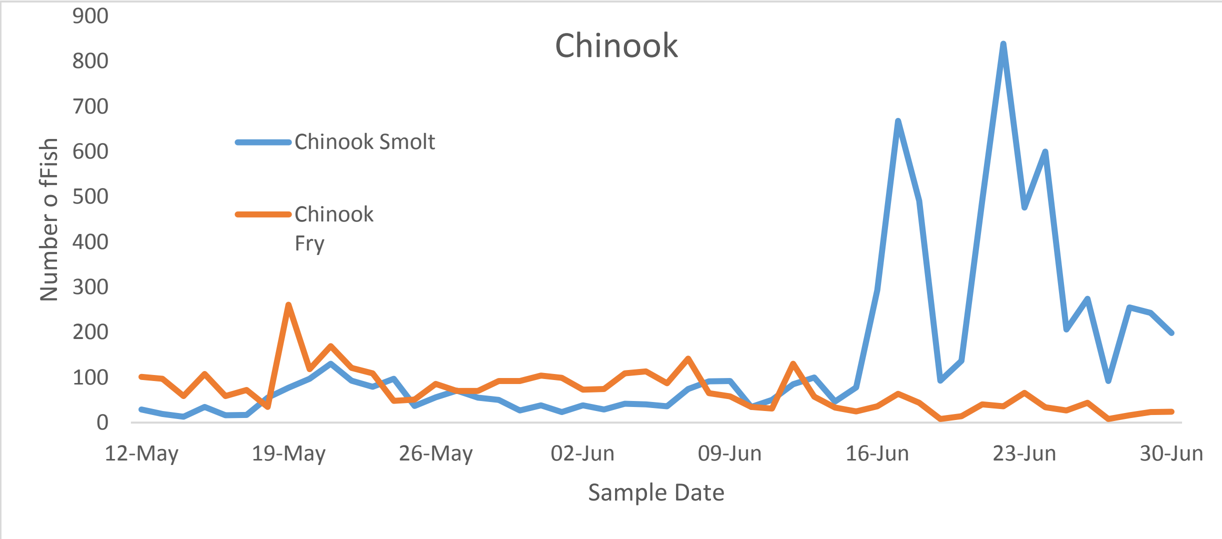


X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 14 Freshwater distribution of Chinook salmon in the MOF vicinity.mxd

Figure 15: Timing of Chinook Salmon Outmigration from the Kenai River, 1994 (King et al. 1996).

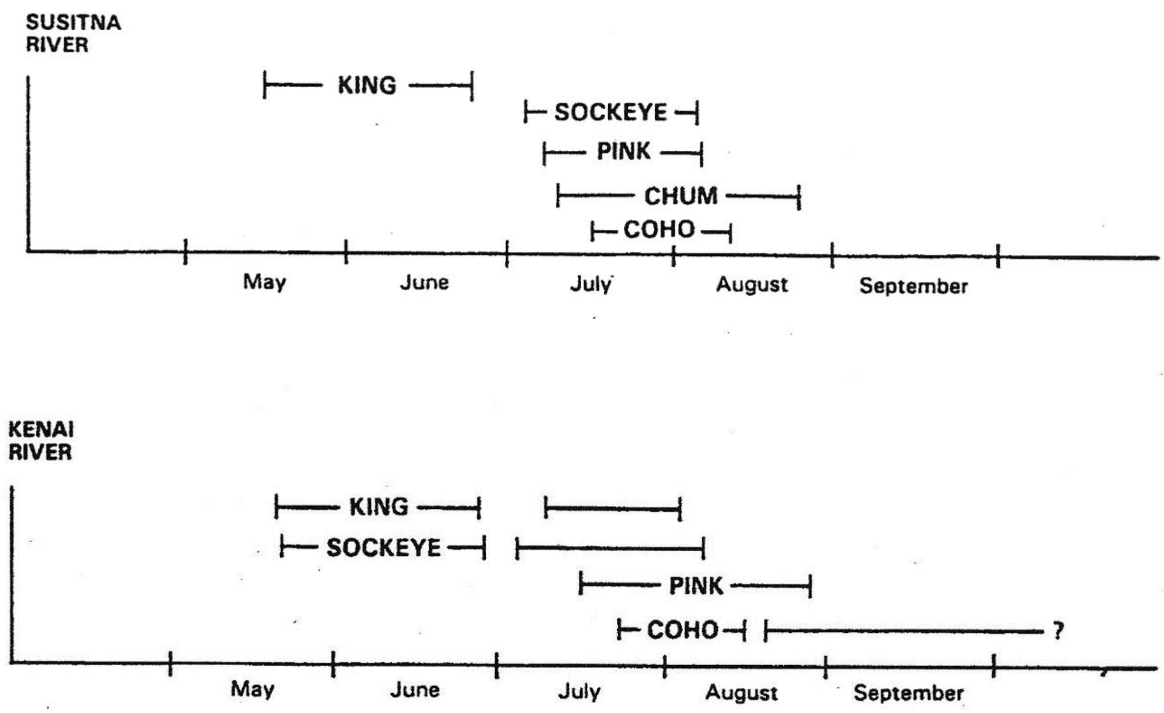


Moulton (1997) captured juvenile Chinook salmon smolts along the northwestern shore of Upper Cook Inlet in the Susitna, Tyonek, and Trading Bay regions. Catch rates peaked in mid-June and mid-July, and no Chinook smolts were caught in September. In Knik Arm, Chinook salmon comprised 25.6 percent of all juvenile salmon captured from April to July 2005 (Houghton et al., 2005a). Peak abundance occurred in June and no significant difference in the catch per unit effort occurred among stations throughout the Knik Arm. In April, most of the Chinook were age-0 fish from 30 to 40 millimeters in length. Beginning in May, fish greater than 61 millimeters dominated the catch, many of which appeared to be of hatchery origin. Multiple cohorts were also present in tow-net samples collected in May. Chinook smolt abundance declined in Knik Arm in mid- to late summer.

Adult Chinook salmon enter tributaries on the western side of the Susitna River in May and June, continuing until August, with peak recreational harvests occurring at the mouth of Alexander Creek during the first week of June, and at the mouth of the Deshka River during mid-June (Ivey and Sweet, 2004). Catches from commercial setnets along the western side of northern Cook Inlet, between 2001 and 2005, indicate that 90 percent of the catch occurs between May 25 and June 18.

Adult Chinook salmon enter the Kenai River in two pulses; the first from mid-May through late June, and the second from early July into early August (Figure 16, Tarbox, 1988). In 2013, adult Chinook salmon returning to the coastal area near the Kasilof and Kenai rivers occupied depths from 0.5 to 14 meters, with a median depth of 4.85 meters (Welch et al. 2013).

Figure 16: Run Timing of Major Salmon Stocks Within Cook Inlet (Taken from Tarbox 1988).



3.2.2 Sockeye Salmon

Sockeye salmon is an important commercial, sport, and subsistence fish throughout Cook Inlet, with major runs to the Kenai, Susitna, Swanson, and other rivers in the region. Figure 17 shows the distribution of sockeye salmon in freshwaters of the Project area. Sockeye typically spawn in lakes or rivers associated with lake systems, although they can occur in river systems without lakes. Female sockeye salmon deposit 2,000 to 4,500 eggs in gravel nests. When lakes are available, sockeye fry may spend one to three years in freshwater before entering the ocean.

Sockeye juveniles normally leave freshwater and enter marine waters during the summer of their second or third year. In the Kenai River, sockeye were observed to leave the system at age-0, 1, 2 and 3 (King et al., 1996). In 1994, age-0 sockeye outmigrated from the Kenai River from mid-May through June. The peak outmigration of age-1 to 3 smolt extended from late May to late June (Figure 18). King et al. (1996) report that age-2 smolt tended to leave the Kenai River earlier than age-1 smolt, which was similar to patterns reported in other Alaskan systems.

Figure 17: Freshwater Distribution of Sockeye Salmon in the MOF Vicinity (Streams Highlighted in Pink) (Johnson and Litchfield 2015).

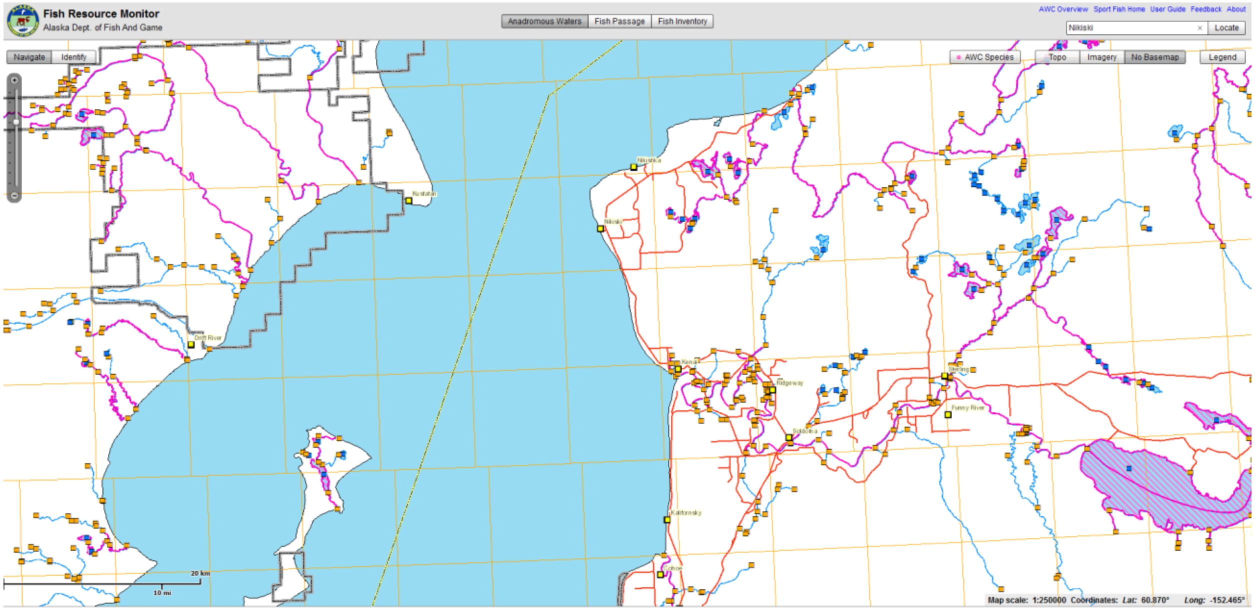
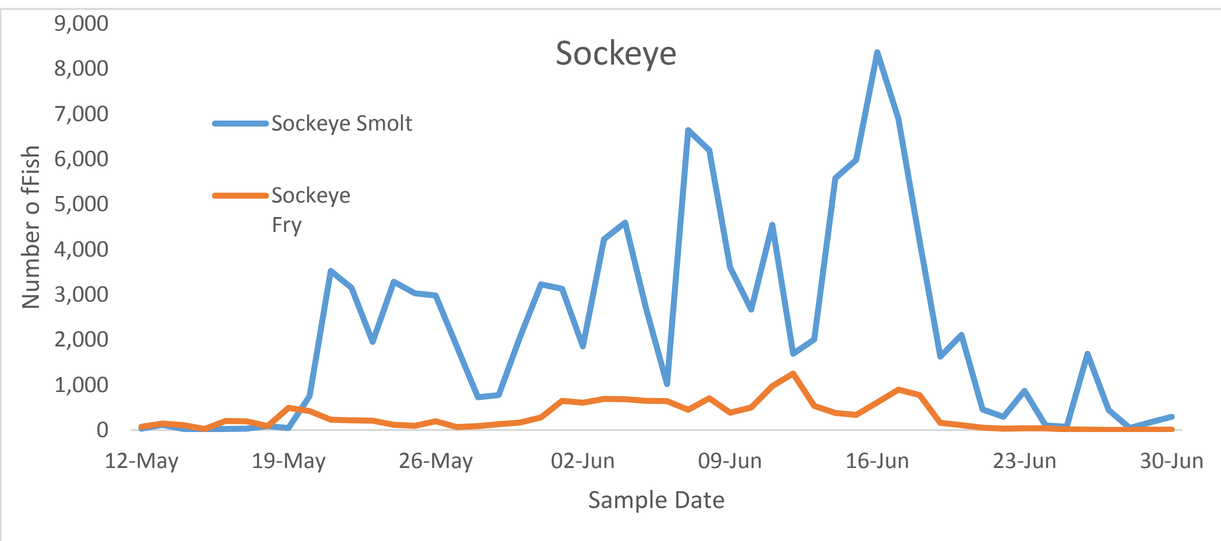


Figure 18: Timing of Sockeye Salmon Outmigration from the Kenai River, 1994 (King et al. 1996)



Juvenile sockeye salmon were caught in Upper Cook Inlet in June and July, but in limited numbers (Moulton, 1997). During June, juvenile sockeye were caught throughout the study area in Upper Cook Inlet; in July, they were caught mostly in the eastern and middle portions of Moulton's (1997) study area. Age-1 was dominant in the June tows, but ages-0 and -1 were caught in equal numbers in July. No juvenile sockeye salmon were caught in September and low numbers encountered in mid-May suggest that numbers would be low or juvenile sockeye absent in March and April.

In Knik Arm in 2004, juvenile sockeye were the most frequently caught salmon during beach seining from July to November (Houghton et al., 2005a, b). Catches peaked in August 2004. In 2005, juvenile sockeye catches were low in April and May, peaked in June, and continued in July. Based on length measurements, two cohorts of sockeye (ages-0 and -1) were present in Knik Arm during both years. Juvenile sockeye in Knik Arm appear to have substantial body growth from July through September 2004.

Adult sockeye salmon are present from June to October in Upper Cook Inlet waters (Johnson and Coleman 2014) with a historic peak return to the southern boundary of Upper Cook Inlet marine waters around July 15 (Shields and Willette, 2005). Approximately 50 percent of Susitna River sockeye are thought to be produced in the Yentna River tributary (Ivey and Sweet, 2004). Catches from commercial setnets along the western side of northern Cook Inlet between 2001 and 2005 indicate that 90 percent of the catch occurs between July 1 and 31, although they are present from early June into early August.

Adult sockeye salmon are present in the Nikiski region from mid-May until mid-August (Tarbox 1988). As with Chinook salmon, there are two major pulses into the Kenai River, one from mid-May into late June and another from early July into early August. In 2013, adult sockeye salmon returning to the coastal area near the Kasilof and Kenai rivers occupied depths from 0.0 to 12 meters, with a median depth of 1.82 meters (Welch et al. 2013).

3.2.3 Coho Salmon

Coho salmon is a popular commercial and sport fish, occurring in most river systems within Cook Inlet, and are found within the Kenai and Swanson rivers near Nikiski and the Susitna River in western Cook Inlet. Coho salmon spawn in many types of freshwater habitats and are known to migrate up the Yukon River to the Alaska/Canada border.

Figure 19 shows the distribution of coho salmon in freshwaters of the Project area. Adult coho salmon return to spawn later than other species and may be found in spawning streams from July through November. Females deposit 2,000 to 4,500 eggs into gravel beds.

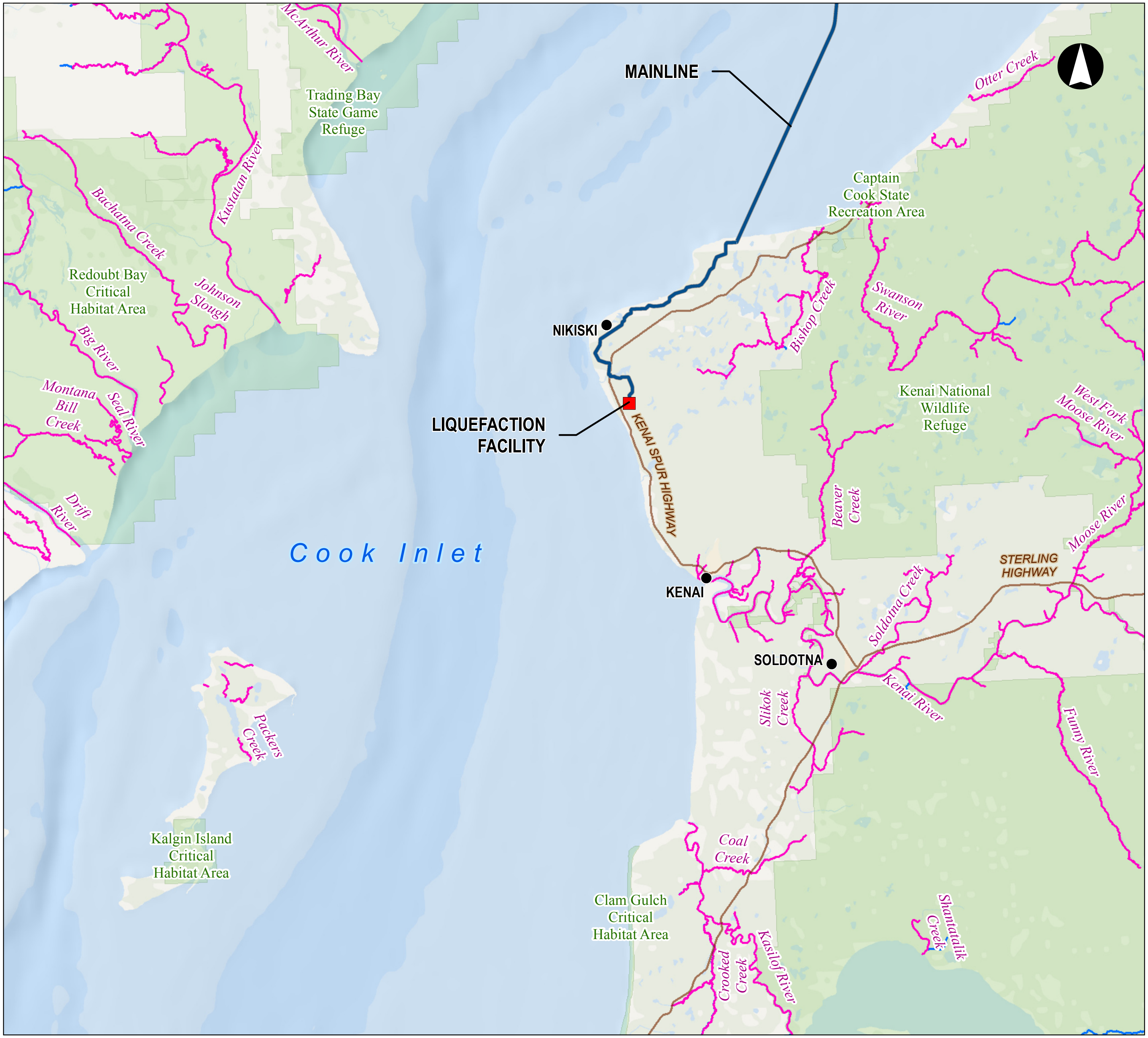
Juvenile coho salmon usually rear from one to three winters in freshwater (Johnson and Litchfield 2015a). In the Susitna and Little Susitna rivers, most of the returning adults have spent either one or two summers in freshwater, migrating out as smolts the following summer. Juvenile coho salmon can establish winter territories in freshwater pools and lakes, and may move between brackish estuarine water during spring and summer for feeding and move back to freshwater in fall.

Juvenile coho in northern Cook Inlet streams spend from one to three years in the freshwater streams. In 1994, coho smolt left the Kenai River from early June until the end of the study on June 30, however the study was focused on sockeye smolt and may have missed a substantial portion of the coho outmigration (Figure 20). Migration of smolts out of the Susitna River to marine waters occurs from mid-May to September. Age 0 smolts left the Susitna River in late July through August in both 1984 and 1985 (Roth and Stratton, 1985). In 1984, ages-1 and -2 showed a similar outmigration pattern, while in 1985, the older smolts outmigrated in June and early July. Upon entry into the marine waters, coho tend to remain near shorelines where they feed on planktonic crustaceans, pink and chum salmon fry, and juveniles and larvae of other fishes. As they grow, they move into deeper, offshore waters and are eventually distributed across the North Pacific Ocean and into the Bering Sea. As the coho grow, their diet shifts to larger pelagic prey.

FRESHWATER DISTRIBUTION OF COHO SALMON IN THE MOF VICINITY

FIGURE 19

ALASKA LNG



LEGEND

- Project Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Anadromous Waters - Coho Salmon
- Anadromous Waters
- Major Highways
- State and Federal Conservation Lands

Source:
Johnson and Litchfield 2015

0 1.5 3 6 Miles

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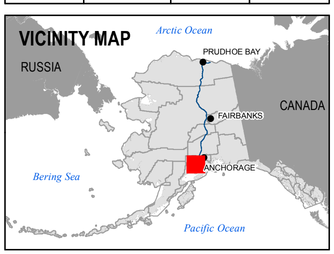
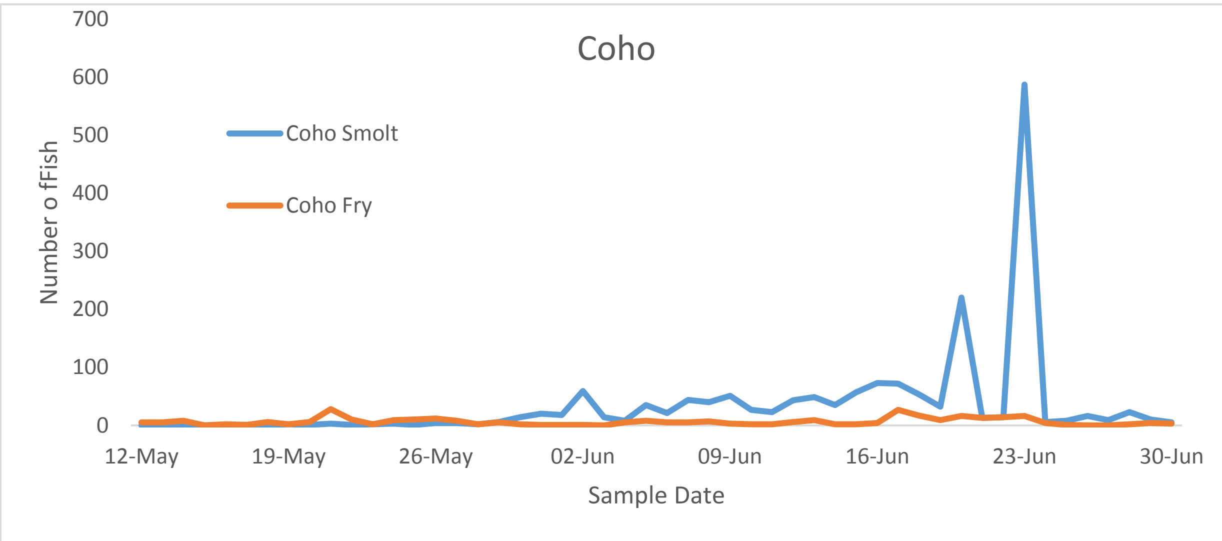
VICINITY MAP



X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 19 Freshwater distribution of Coho salmon in the MOF vicinity.mxd

In Knik Arm, juvenile coho salmon was the second-most-abundant juvenile salmon species captured in beach seines in 2004, and the most abundant species in 2005 (Houghton et al., 2005a). Coho salmon smolts were captured as early as April and were present in Knik Arm into late November. In both 2004 and 2005, catches of juvenile coho peaked in July, but continued into August. In 2005, coho salmon were distributed throughout Knik Arm but were more abundant on the western side (Houghton et al., 2005a). Several cohorts were present throughout the study period and a relatively high frequency of 101- to 140-millimeter coho captured in June 2005 may have resulted from the smolt release from Ship Creek hatcheries.

Figure 20: Timing of Coho Salmon Outmigration from the Kenai River, 1994 (King et al. 1996)



Houghton et al. (2005a) reported that adult coho comprised 0.9 percent of the total beach seine catch and that most adult coho were captured in July with smaller numbers in August. In northern Cook Inlet, catch rates of juvenile coho salmon were highest in mid-June and mid-July, and the greatest numbers were caught near the Susitna River delta (Moulton, 1997). Juvenile coho were the only salmon caught in September. The peak of the run in the west-side Susitna area, an early-run stock, is generally in the last week of July (Ivey and Sweet, 2004). The Little Susitna River has proven to be a good indicator of coho run strength throughout the region, and the Susitna River drainage supports the largest coho stock in Upper Cook Inlet. The greatest recreational harvest of coho salmon generally occurs in the Knik and Eastside Susitna Management Units, followed closely by the Westside Susitna Unit (Ivey and Sweet, 2004). Lake Creek is the greatest contributor to sport fish catches in the Westside Unit. Catches from commercial setnets along the western side of northern Cook Inlet between 2001 and 2005 indicate that 90 percent of the catch occurs between July 12 and August 15, although they are present from early July into late August. Adult coho salmon are well represented throughout Upper Cook Inlet with runs to the Kenai River beginning in late July and continuing into October (Figure 16, Tarbox 1988).

3.2.4 Pink Salmon

Pink salmon are the smallest of the Pacific salmon, with a maximum length of 76 centimeters and weight of 6.4 kilograms (Mecklenburg et al., 2002). Adult pink salmon return to rivers and streams throughout Upper Cook Inlet. Pink salmon use at least the lower reaches of many rivers in the Marine Terminal area but are most widely distributed in the Kenai and Kasilof rivers. Figure 21 shows the distribution of pink salmon in freshwaters of the Project area. They are harvested in commercial and subsistence fisheries, but usually in the course of effort directed at other species.

Females may deposit as many as 1,500 to 2,000 eggs in a gravel nest in freshwater or occasionally in intertidal areas. The eggs hatch during winter and the developing fish, or alevins, remain in the gravel using their yolk sacs for nourishment. Fry emerge from the gravel in late winter or early spring and immediately move downstream to marine waters.

Because pink salmon spawn at 2 years of age, two separate lines of unrelated fish develop in alternating odd- and even-year cycles. In some locations one line may be dominant over the other in abundance. In the Cook Inlet region, larger pink salmon runs occur during even years (ADF&G 1994).

Pink salmon emerge from gravel substrate in April and May, and immediately migrate downstream to the estuary. During 1985, pink salmon left the Susitna River throughout June, with the outmigration essentially finished by the first week in July (Roth et al., 1986). Outmigrating pink salmon averaged 37 millimeters, with a maximum of 48 millimeters. In 1993, pink salmon fry were encountered at the onset of smolt sampling in the Kenai River on May 17, so outmigration had been initiated prior to this date (King et al., 1994). Only 21 pink salmon outmigrants were caught during smolt sampling in 1994 compared to over 86,000 in 1993, (King et al., 1994, 1996) reflecting the difference in odd- versus even-year abundance. The time spent in freshwater varies, depending on the distance the juveniles must travel, and average stream velocities they encounter along the way. Freshwater residence of a few hours to a few days is typical. Feeding does not normally occur during this downstream migration. Because 2015 was an off-peak year for returning pink salmon adults, there should be few fry outmigrating from the Kenai River in spring 2016 when the Project is being conducted.

Juvenile pink salmon were the most abundant salmon reported by Moulton (1997) during tow-net sampling in Upper Cook Inlet in June and July of 1993, comprising 16.5 percent of the total catch. Pink salmon were caught in 92 percent of the tows in June, comprising approximately 25 percent of the total catch. Pink salmon numbers decreased in July, when they occurred in only 70 percent of the tows. Pink salmon were abundant throughout the study area from the East and West Forelands to Fire Island near Anchorage, but were most abundant in mid-June near the mouth of the Susitna River. However, a large number of pink salmon was also caught in a single mid-channel tow in mid-July in the eastern portion of the study area.

In the ocean, juvenile pink salmon smolt feed on plankton and larval fish, and may reach 100 to 150 millimeters in length by their first winter. They spend the next year in the open ocean, returning the following fall to spawn in their natal streams. This life cycle of the Pacific salmon is generally the shortest (two years from hatching to spawning) (ADF&G 1994). Pink salmon from northern Cook Inlet likely move to the GOA during the late summer and early fall (ADF&G 1994).

During 1985, pink salmon left the Susitna River throughout June, with the outmigration essentially finished by the first week in July (Roth et al., 1986). Outmigrating pink salmon averaged 37 millimeters, with a maximum of 48 millimeters. Adult pink salmon return to the Kenai River from mid-July to late August (Figure 16, Tarbox 1988). As indicated, Upper Cook Inlet pink salmon runs are even-year dominated, thus returning adult pink salmon should be abundant in 2016.

FRESHWATER DISTRIBUTION OF PINK SALMON IN THE MOF VICINITY

FIGURE 21

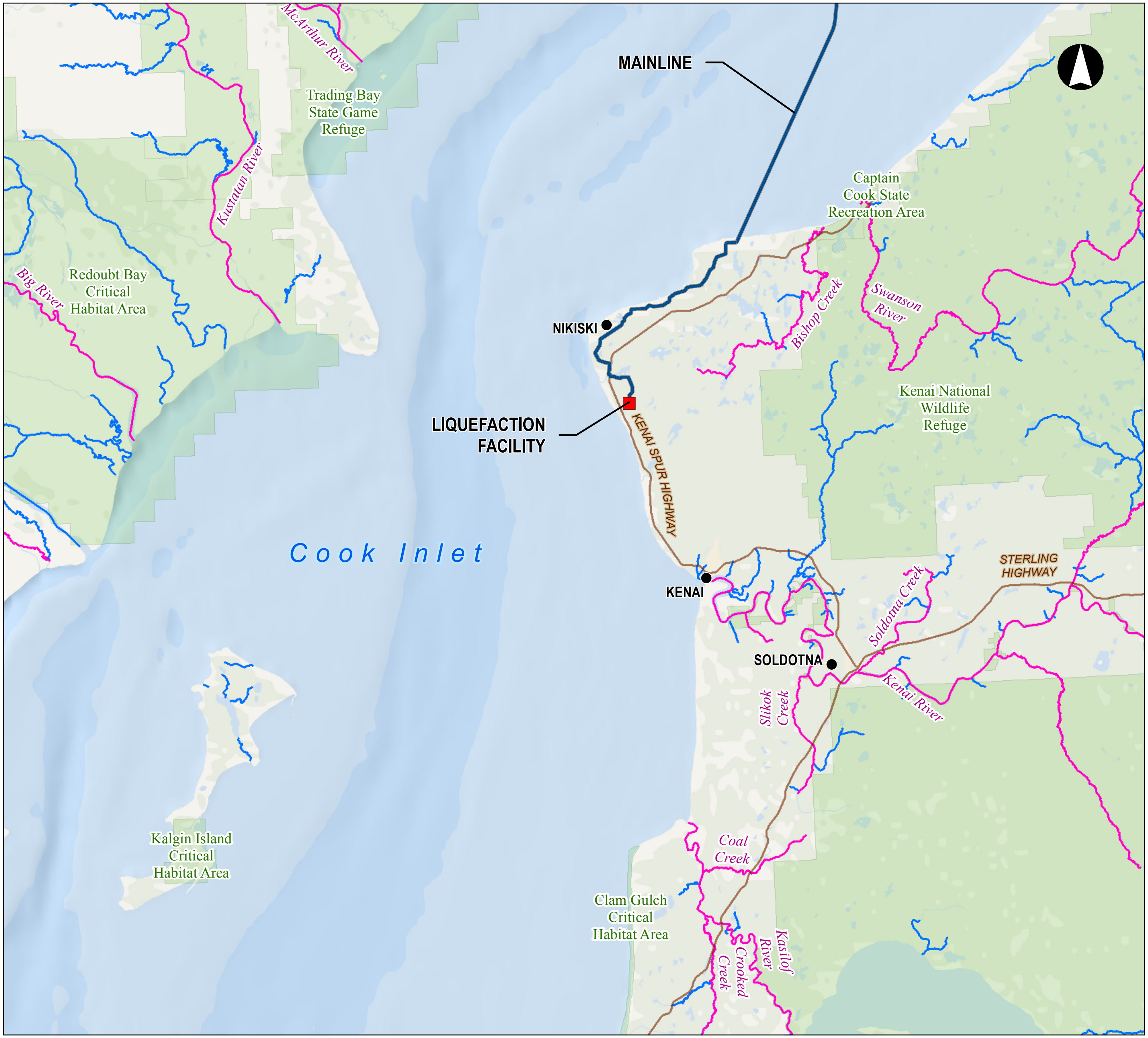
ALASKA LNG

LEGEND

- Project Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Anadromous Waters - Pink Salmon
- Anadromous Waters
- Major Highways
- State and Federal Conservation Lands

Source:
Johnson and Litchfield 2015

0 1.5 3 6 Miles



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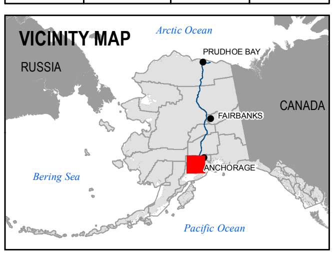
VICINITY MAP



X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 21 Freshwater distribution of Pink salmon in the MOF vicinity.mxd

3.2.5 Chum Salmon

Chum salmon in Upper Cook Inlet are most abundant in the Susitna River, although they occur in other rivers as well, including the Kenai River. Figure 22 shows the distribution of chum salmon in freshwaters of the Project area. Chum salmon spawn in coastal streams and intertidal areas, but may also travel great distances inland. Females may lay up to 4,000 eggs.

Chum fry move toward marine waters soon after hatching, usually shortly after ice breaks up from their natal rivers. Chum may not feed before reaching saltwater, thus making marine food resources of special importance. Juvenile chum in Cook Inlet are thought to enter marine water from late May through July. By their first winter, Cook Inlet chum salmon have moved into the Gulf of Alaska and spend three to four years in the ocean before returning to natal streams (Johnson and Coleman 2014). Chum salmon outmigrants were not reported from smolt sampling in the Kenai River in 1993 and 1994, thus few are likely produced in this system King et al., 1994, 1996), and few are likely to encounter the Project area.

Juvenile chum salmon emerge from the streambed in spring and immediately begin moving downstream to the sea. The duration of this migration depends on the total distance traveled, and water velocities encountered. In most cases, the downstream migration takes a few hours to a few days. Little or no feeding occurs in streams where the downstream migration is completed in a small time after emergence. In the Susitna River, chum leave during June through early July at a mean size of 42 to 43 millimeters. In both 1984 and 1985, chum salmon between 50 and 60 millimeters were caught in the river, which was interpreted to indicate growth prior to outmigration. While in the Kenai River, chum leave during April and May at a mean size of 42 to 43 millimeters with fry lingering and foraging in the intertidal area at the head of bays (ADF&G 1994).

Chum salmon smolts were the second-most-abundant salmon reported by Moulton (1997) in Upper Cook Inlet and comprised 10.2 percent of the total catch. Chum salmon showed a steady increase in size through the study period with weekly mean lengths increasing from 43.6 millimeters in early June to 57.7 millimeters in mid-July. The growth rate of chum smolt appeared to be greater in July than in June and may have been related to warmer temperatures or to a decrease in the numbers of smolt emigrating from freshwater (Moulton, 1997).

Once in the estuary, juveniles form schools and normally remain close to shorelines for several months to feed and grow prior to moving onto the high seas. Fish larvae and insects were important components of juvenile chum diet in northern Cook Inlet during June, while insects became dominant in July (Moulton, 1997). Prey studies often describe harpacticoid copepods as dominant food item. By late summer, juvenile chum salmon move to offshore waters.

Adult chum salmon are not well represented in the west-side Susitna drainages of the Upper Cook Inlet or the Kenai River and timing of entry into these regions is not well known (Figure 16). Their peak run timing in northern Cook Inlet is mid-July through mid-August; however, their run continues into September (Salo 1991).

FRESHWATER DISTRIBUTION OF CHUM SALMON IN THE MOF VICINITY

FIGURE 22

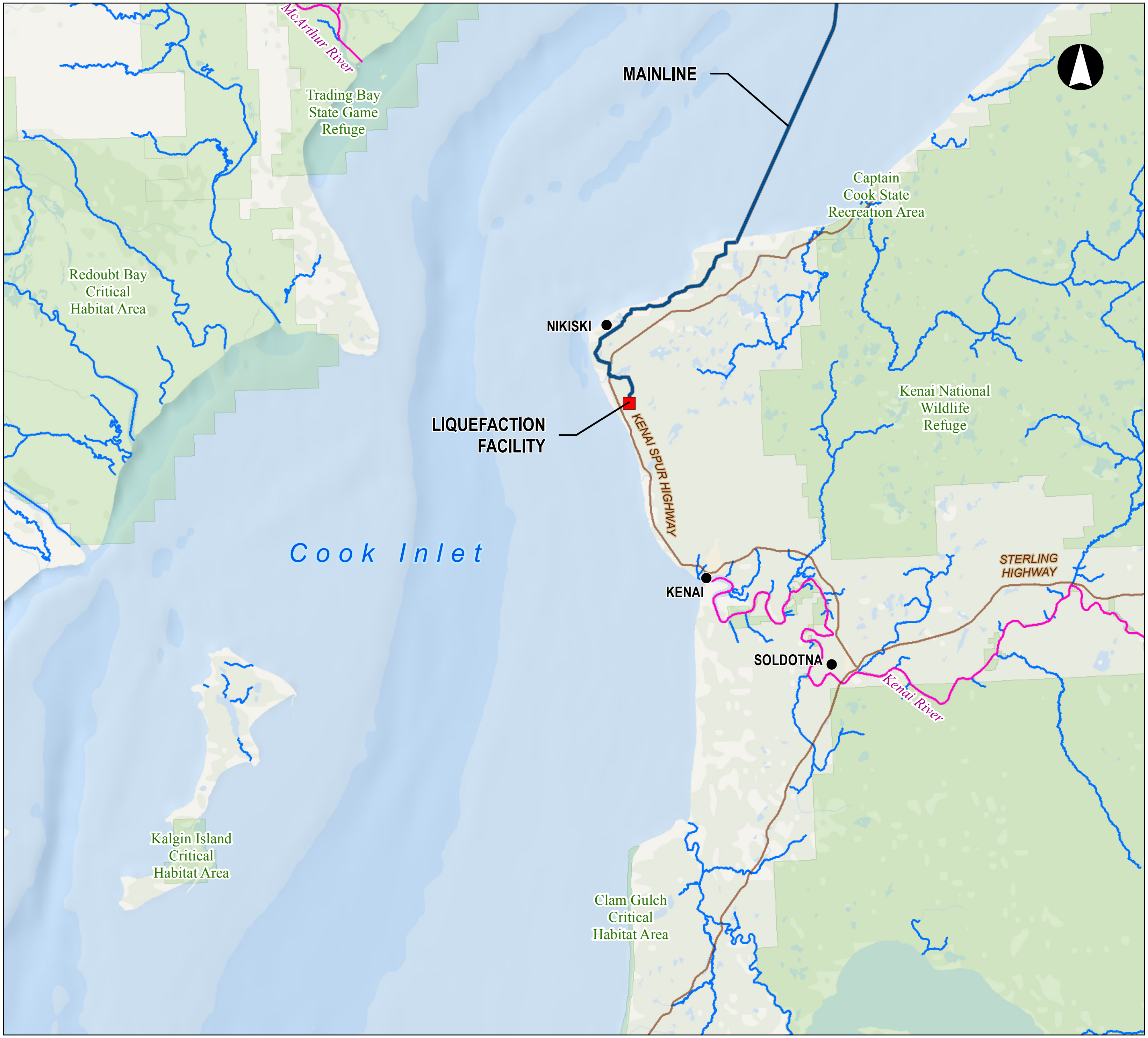
ALASKA LNG

LEGEND

- Project Facility
- Alaska Place Names
- Alaska LNG Rev C2 Route
- Anadromous Waters - Chum Salmon
- Anadromous Waters
- Major Highways
- State and Federal Conservation Lands

Source:
Johnson and Litchfield 2015

0 1.5 3 6 Miles



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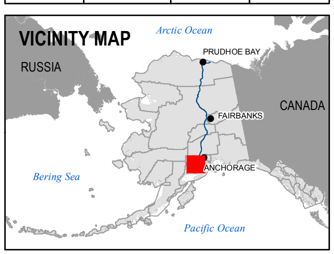
VICINITY MAP



X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 22 Freshwater distribution of Chum salmon in the MOF vicinity.mxd

3.3 EFH SPECIES WITHIN THE ARCTIC WATERS EVALUATION AREA

The Arctic Region activities primarily include dock modifications at Prudhoe Bay and the PTTL. Prudhoe Bay is located at the Project's northern terminus and consists of largely open bays with limited barrier island protection. Mapping of fisheries resources within the Project footprint is provided in Appendix A of Resource Report No. 3.

Prudhoe Bay abuts the Beaufort Sea, which is nominally covered by ice for approximately nine months of the year between late summer and the following July. During the summer months, ice on the Beaufort Sea will retreat from 10 kilometers to 100 kilometers offshore (National Oceanic Atmospheric Administration [NOAA], 2010). Due to the combination of meltwater from the sea ice and overland flow from the rivers, a stratified water column can develop with more saline waters below a layer of fresher water. As summer progresses, the waters can become less stratified and more well mixed, returning to marine conditions (URS, 1999). Although gravel makes up the substrate around the bases of several of the barrier islands, the overlying sediment covering most of Prudhoe Bay and nearby coastal waters consists primarily of fine silt and fine sand (Busdosh et al., 1985).

In addition to the above, the PTTL would cross the Sagavanirktok and Shaviovik rivers, both of which support small runs of salmon.

Fish populations of the nearshore region of the Beaufort Sea provide an important subsistence resource for local residents (Craig, 1989) and support commercial and sport harvests (Bureau of Land Management [BLM], 1998, 2004, 2014; Howe et al., 1998). Fish populations near existing and planned developments related to oil exploration and extraction, and the effects of these developments on fishes and fish habitat, have been extensively investigated since the mid-1970s. Summaries of those studies are included in reviews and other documents, including the United States Army Corps of Engineers (USACE) (1980, 1984), ARCO Alaska et al. (1997), BLM (1998), Truett and Johnson (2000), Logerwell et al. (2010), Williams and Burril (2011), and Fechhelm et al. (2011).

3.3.1 Pacific Salmon

Prudhoe Bay is located near the limit of salmon use in the Alaskan Arctic. Chum and pink salmon are the only species of salmon with confirmed presence in the Sagavanirktok River, the primary tributary into Prudhoe Bay (ADF&G 2011; Carothers et al. 2013). Both of these species are likely to occur in the vicinity the proposed dock modifications in Prudhoe Bay during their marine stages of life. Chinook salmon have been confirmed as present in Fish Creek (Johnson and Litchfield 2015a), and are occasionally found in the Colville River (George et al. 2009), but there is no confirmed presence as far east as Prudhoe Bay. Other than anecdotal reports by locals (George et al. 2009), there are few confirmed records of sockeye or coho salmon in the Alaskan Beaufort Sea watersheds (Johnson and Litchfield 2015a; Carothers et al. 2013). Chinook, sockeye, and coho salmon are, therefore, unlikely to occur within the vicinity of the proposed dock modifications in Prudhoe Bay and are not discussed further for the Arctic FMP EFH.

3.3.2 Groundfish

Marine species commonly encountered include Arctic cod (*Boreogadus saida*), saffron cod (*Eleginus gracilis*), Arctic flounder (*Pleuronectes glacialis*), and fourhorn sculpin (*Myoxocephalus quadricornis*) (Fechhelm et al., 2011). Anadromous fish commonly occurring in the Beaufort Sea in the vicinity of oil production areas include Dolly Varden, Arctic cisco, least cisco, humpback whitefish, broad whitefish, and rainbow smelt. Although these anadromous species occur in the Beaufort Sea, they can include both anadromous and freshwater populations.

The marine fish discussed in the following sections are the primary species that are expected to occur in the Project area.

3.3.2.1 Arctic Cod

As summarized in Fechhelm et al. (2011), Arctic cod have a circumpolar distribution and are ubiquitous in marine waters throughout the Beaufort Sea. Arctic cod are an important food item in the diets of marine mammals, birds, and fish, and are considered to be a primary component of the Arctic marine food chain. Arctic cod is one of the most abundant fish species collected in coastal waters and is typically associated with highly productive transition layers that separate cold marine bottom water and warm brackish surface water. The onshore movement of such layers is an important factor in coastal aggregations of fish. Arctic cod do not actively move into freshwater or low-salinity habitats. The movement of large schools into coastal areas can be dramatic and can be either short-lived or sustained. The occurrence of Arctic cod schools in any particular area is both unpredictable and ephemeral.

3.3.2.2 Saffron Cod

Saffron cod are found in brackish and marine waters of the Chukchi and Beaufort seas east to Bathurst Inlet in Canada (Fechhelm et al., 2011). They frequently enter rivers and may go considerable distances upstream. Saffron cod may be found both nearshore and offshore during summer. Saffron cod have been reported from studies throughout the Beaufort Sea, but it is the least abundant of the marine species that moves along the shore during summer. While saffron cod have been reported from studies throughout the Beaufort Sea, it is the least abundant of the marine species that are regularly caught by fyke nets in the Prudhoe Bay region during summer.

4.0 HABITAT AREAS OF PARTICULAR CONCERN (HAPC)

There are no Habitat Areas of Particular Concern (HAPC) proximate to any of the Project components outside of shipping routes. Within the GOA Groundfish FMP management area, two general HAPCs are identified: the Alaska Seamount Habitat Protection Areas and the Gulf of Alaska Coral Habitat Protection Areas (Figure 23). The Alaska Seamount Habitat Protection Area includes 15 seamounts all of which are east and south of the Aleutian trench and the Smith Escarpment in the GOA, far outside of Cook Inlet and far from Nikiski and Beluga, Alaska. In addition, three HAPCs within the Gulf of Alaska Coral Habitat Protection Areas are identified—Cape Ommaney and Fairweather North and South. All are located off the Alexander Archipelago east of Yakutat Bay, far outside Cook Inlet and far from Nikiski and Beluga, Alaska. The Salmon FMP includes the HAPCs listed and adds the Bowers Ridge and Ulm Plateau HAPCs (Figure 23). Both HAPCs lie north of the southern arch of the Aleutian Islands and separate the Bowers and Aleutian basins of the Bering Sea. Both HAPCs are far from the Project area.

HABITAT AREAS OF PARTICULAR CONCERN IN THE GULF OF ALASKA

FIGURE 23

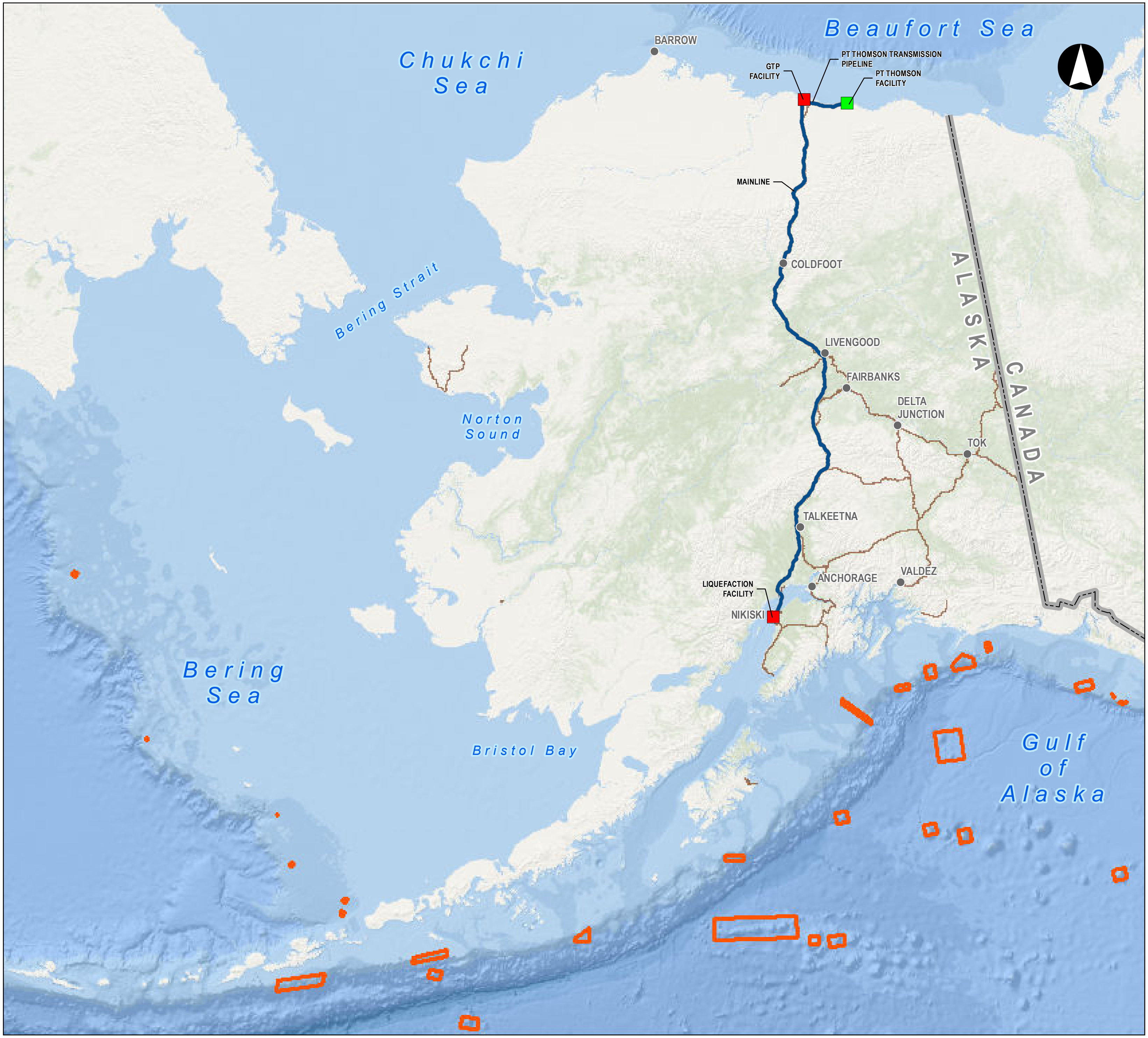
ALASKA LNG

LEGEND

- Project Facility
- Existing Facility
- Alaska LNG Rev C2 Route
- Major Highways
- Habitat Areas of Particular Concern

Source:
NPFMC, 2012
NPFMC, 2013

0 50 100 200 Miles



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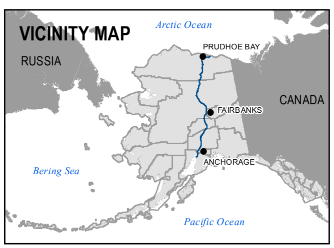
VICINITY MAP



X:\AKLNG\Resource Reports\RR03\Appendix D\Figure 23 Habitat Areas of Particular Concern in the Gulf of Alaska.mxd

5.0 POTENTIAL EFFECTS TO EFH AND EFH SPECIES

The Project could have both short-term construction and long-term operational effects on EFH and EFH species. Effects are often described generally for fish and apply to juvenile and adult salmon migration, juvenile rearing and overwintering, as well as salmon egg survival.

5.1 POTENTIAL EFFECTS ON FRESHWATER EFH AND EFH SPECIES

5.1.1 Effects on Freshwater EFH and EFH Species from Project Construction

The primary construction-related activities that could affect freshwater EFH and EFH species include the construction of pipeline stream crossings, associated gravel and ice road work pads, equipment stream crossings, development of material sources, and water withdrawals. Temporary impacts to fisheries and fish habitat from Project construction could include:

- Surface water use (e.g., vessel traffic), including water withdrawals (e.g., hydrostatic testing, ballast water management, cooling water).
- Discharges (run-off, hydrostatic testing).
- Releases of sediment and turbidity (e.g., dredging, construction).
- Scouring.
- Habitat loss, including shoreline and in-stream cover loss and loss or sedimentation of critical spawning habitat.
- Interruption of fish spawning migrations;
- Spills of fuels, lubricants, or solvents; and
- Material source development impacting habitat and/or producing sedimentation.

Best management practices (BMPs) would be designed and implemented to reduce or otherwise mitigate potential impacts. This includes the measures and guidance provided in the following Project-specific plans:

- Applicant's *Upland Erosion Control, Revegetation, and Maintenance Plan* (Applicant's *Plan*) (Appendix D of Resource Report No. 7).
- Applicant's *Wetland and Waterbody Construction and Mitigation Measures* (Applicant's *Procedures*) (Appendix N of Resource Report No. 2).
- *Blasting Plan* (Appendix B of Resource Report No. 6).
- *Fugitive Dust Control Plan* (Appendix J of Resource Report No. 9).
- *Gravel Sourcing Plan and Reclamation Measures* (Appendix F of Resource Report No. 6).
- *HDD Inadvertent Release Plan* (Appendix L of Resource Report No. 2).
- *Waste Management Plan* (Appendix J of Resource Report No. 8).
- *Site-Specific Waterbody Crossing Plans* (Appendix I of Resource Report No. 2).
- *Spill Prevention, Control, and Countermeasure* (SPCC) Plan (Appendix M of Resource Report No. 2).
- *Stormwater Pollution Prevention Plan (SWPPP)* (Appendix J of Resource Report No. 2).
- *Water Use Plan* (Appendix K of Resource Report No. 2).
- *Unanticipated Contamination Discovery Plan* (Appendix I of Resource Report No. 8).
- *Noxious/Invasive Plant and Animal Control Plan (*Appendix K of Resource Report No. 3).

5.1.1.1 Direct Mortality

Some components of Project construction could lead to direct mortality of EFH species. Excessive overpressures from blasting in or near waterbodies could have lethal effects on fish and some blasting for ROW preparation and material source development would be needed. Water withdrawal during construction of ice roads and for pipe hydrostatic testing could lead to fish mortality through either impingement or entrainment at water intake points or through dewatering of fish-bearing habitats. Development of shallow scrape material sites within floodplains could also lead to the entrapment of fish after high-water events that flood the site and ultimately lead to mortality of trapped fish as water levels recede, isolating and potentially drying out the site. Pipeline construction methods could dewater some reaches of stream at the time of construction leading to mortality. As noted previously, numerous construction mitigation plans have been developed that would reduce the potential for direct mortality on fish and avoid or reduce the likelihood of these impacts.

The potential for construction mortality would be of short duration and would not extend beyond the active period of construction at any given fish-bearing site for most potential causes. Shallow gravel sites in active floodplains could have more persistent potential to cause mortality if not addressed. The significance of any mortality events would be dependent on the location and level of fish use at the time of the occurrence. For example, during winter on Alaska's North Slope, and some drainages north of the Yukon River, significant proportions of a fish population may be concentrated in relatively few riverine pools or reaches making any mortality event potentially significant to that population. EFH habitats and species within the majority of the Project area are not distributed as described above so overall, the potential significance to EFH species at the population or stock level would be minor. Any mortality that occurs during Project construction is not expected to cause significant, long-term effects to EFH.

5.1.1.2 Pipeline Stream Crossings

Stream crossing pipeline construction methods could affect EFH and EFH habitats. Construction of pipeline stream crossings would use one of several modes dependent on the conditions at the site and fish use during construction (see Resource Report No. 2). Proposed crossing methods based on each waterbody's characteristics and site-specific conditions would be identified as follows (see also Applicant's *Procedures* in Resource Report No. 2):

- If the waterbody is dry or frozen to the bed, cross the waterbody using an open-cut crossing method.
- If the waterbody is flowing, assess the type of fish and fish habitat present within the affected reach and determine whether an open-cut timing window is available.
- If the potential fisheries impact is rated as acceptable, and if an open-cut timing window is available and the in-stream work can be completed within the timing window, proceed with the installation using the open-cut crossing method.
- If an open-cut timing window is not available or is too short to complete the in-stream work, consider the use of isolated (dry ditch) crossing methods.
- If the potential fisheries impact is rated as not acceptable and if isolated crossing methods are not feasible or appropriate, consider using a buried trenchless crossing method such as horizontal directional drill (HDD) (a minimum practical length of 1,700 to 1,900 feet on level terrain is required for using the HDD method with large-diameter pipe), direct pipe, boring, or aerial crossing.

Crossing installations would be performed in accordance with construction specifications and all terms and conditions included in each crossing permit. If local conditions at the time of the planned installation dictate that the method is not feasible, a site-specific crossing plan would be developed for review and approval by the corresponding authorities.

A list of the proposed stream crossings is provided in Appendix H of Resource Report No. 2. Streams with identified EFH are listed in Appendix A (Table A-1). Sixty-seven of the fish-bearing stream crossings have been identified as having EFH; 40 have documented salmon spawning habitat either at the proposed crossing location or upstream, and 30 crossings occur within habitats identified by the Anadromous Waters Catalog (AWC) as important for salmon spawning. Appendix Table A-1 provides a summary of EFH species stream crossings by milepost and provides information on spawning habitats, stream crossing construction season, and method.

Pipeline construction at waterbody crossings would include open-cut and frozen open-cut crossings at waters anticipated to be dry, lack surface flow, or not require dry-ditch construction during the season of construction. Seventeen would occur in streams with EFH; only 2 would occur during periods of flow (summer) (Appendix Table A-1). Streams crossed that have flow would be limited to a 24-hour in-water work window for minor streams and a 48-hour in-water work window for intermediate streams.

Pipeline construction of waterbody crossings either when frozen or dry would be constructed similar to all upland pipeline installation in the spread and would include trench excavation, pipeline installation, and then trench stabilization. Construction impacts to EFH and EFH species are not anticipated from his mode of construction as fish would not be present and there would be no water flow. This method of construction could be employed at all classes of waterbody provided the crossing is dry.

Isolation-cut methods would be employed in both winter and summer and would be applied to flowing waterbodies, unless appropriate state and federal agencies determine that dry-ditch installation would not be needed based on the fish resources at the crossing location. Isolation-cut construction would occur at 44 streams with identified EFH species. Approximately half of the isolation-cut method crossings would be constructed during winter in anadromous and EFH streams (Appendix Table A-1).

Isolation-cut methods would include dam and pump or flume crossing methods to move water around the excavation work to avoid sedimentation and turbidity and maintain downstream flow. Dam and pump methods would only be used in cases where sensitive fish species passage during the construction window has not been specified or indicated though resource agency guidance. In addition to the above dry-ditch methods, in braided systems with multiple channels, or in dynamic systems characterized by frequent and common channel shifts, diversions could be constructed to move flow to a historic channel, or newly created channel within the active floodplain. In all cases there would be potential for short-term impacts to fish EFH and EFH species in the immediate vicinity of the construction area. Fish passage could be impeded or inhibited during this timeframe which, if during critical migration periods, could lead to delayed or eliminated access to spawning habitats. Crossing locations in or upstream from spawning areas could dewater spawning gravels and kill eggs or larval fish depending on the timing of installation. These crossing methods could also result in increased release of sediments and increase turbidity and sedimentation in the immediate Project area, potentially resulting in decreased stream productivity during construction within the influence of the release. However, various mitigation measures, referenced previously, and more fully described in Section 6.0, would reduce the potential for significant adverse effects. The primary potential for impacts during installation of pipeline crossings using this method would be associated with spawning migrations and spawning habitat impacts. Timing of installations has already been designed to avoid sensitive periods of the year to avoid these impacts as possible. However, identification of anadromous fish spawning habitat is not comprehensive in Alaska (and along the alignment), and additional spawning areas that are not currently identified are likely to be present at some streams.

Winter crossings of sensitive overwintering areas on the North Slope could have minor to major effects on fish wintering at the crossing location, and depending on the density of fish, could have longer-term impacts if mortality were to occur. The winter isolation-cut construction of the PTTL across the east channel of the Sagavanirktok River crosses in a sensitive overwintering area and a likely spawning area for anadromous broad whitefish. In addition, pink salmon spawning is documented within the reach. It is anticipated that planning and permitting for this site would identify mitigation measures to reduce the potential for significant adverse effects on EFH species, and other species dependent on this location for spawning and overwintering. Similarly, isolation-cut methods proposed to install the Chatanika River crossing upstream from Minto Flats could impact overwintering northern pike that winter downstream from the crossing, however, this reach of the Chatanika River is a migratory corridor for EFH species and other anadromous fish species and spawning has not been documented near the crossing.

If significant proportions of a population are in a wintering area that is affected during construction, numerous age classes of fish could be affected and killed. No EFH is designated for any such crossings with the exception of the East (Main) Channel of the Sagavanirktok River. Cataloging of fish overwintering areas along the alignment generally has not occurred. Most streams crossed would not have viable fish overwintering areas, but some would. Documentation of adequate under-ice water volume of high enough quality to overwinter fish would be needed to fully assess impacts and would provide information to ensure adequate mitigation methods are employed.

Some stream crossings would be constructed aerially, where the pipeline would be suspended over the waterbody. For purposes of this analysis, aerial modes include VSM-supported pipeline crossings typical to the North Slope, as well as single-span, multi-span, and cable suspension bridges with and without in-stream supports. Ninety-eight crossings would be constructed in the aerial mode, almost all of which would be constructed on the North Slope and associated with the PTTL. Aerial crossing methods would have minimal potential for impact to fish or fish habitat. VSM or aerial bridge support installation within a waterbody could have short-term effects on fish species depending on the timing of installation. North Slope installations would occur during winter with limited to no fish presence (and no EFH species present) and pile installation would tend to avoid most waterbodies. Pile driving associated with larger aerial crossings of water bodies could disturb fish and could produce sound pressure levels (SPLs) high enough to lead to mortality in the absence of mitigation. No such installations are proposed in EFH or anadromous streams. Eleven aerial crossings of anadromous streams would occur along the PTTL; all streams would be dry during winter construction with the exception of the crossing of the West Channel of the Sagavanirktok River, which would be constructed on existing/modified support structures (no in-water work is proposed).

Five river crossings—the Middle Fork Koyukuk, Yukon, Tanana, Chulitna, and Deshka rivers—would be constructed using buried trenchless methods where the pipeline would be installed beneath the rivers. Most potential impacts to EFH and EFH species are avoided using this method because this method does not involve open cut across the stream bed or banks. There would be some potential for loss of drilling muds into the rivers during installation, which would result in short-term increases in turbidity near the discharge location and possibly some increased sedimentation of proximate stream bed habitat. Depending on the magnitude of mud loss and whether or not drilling muds escaped the river beds into the water column, there could be some potential for sedimentation of substrates for some distance downstream from the release site. While unlikely, some loss of productivity and spawning habitat could occur within the clear water systems crossed with this method. The *HDD Inadvertent Release Plan* (Appendix L of Resource Report No. 2) has been developed to reduce the potential for a release to occur and provide mitigation measures should one happen. Significant impacts to fish, EFH species, and EFH are not anticipated. If buried trenchless crossings prove infeasible, alternative methods of crossing construction would be employed and potential effects have been addressed above (aerial or trenched).

Table 12: Summary of EFH Stream Crossings by Class and Construction Method

Stream Class	Crossing Method	EFH Streams		
		Crossings	Winter	Summer
Minor	Buried Trenchless	0	0	0
	Aerial	0	0	0
	Open/Frozen Cut	26	12	14
	Isolation Cut	12	8	4
Intermediate	Buried Trenchless	0	0	0
	Aerial	0	0	0
	Open/Frozen Cut	4	1	3
	Isolation Cut	12	7	5
Major	Buried Trenchless	5	0	5
	Aerial	1	1	0
	Open/Frozen Cut	5	4	1
	Isolation Cut	0	0	0
Total		65		

<u>Restoration</u>

In accordance with the Applicant's *Procedures* and the Project *Restoration Plan*, restoration of the waterbodies following construction would include:

- Use of clean gravel or native cobbles for the upper 1 foot of trench backfill in all waterbodies that are subject to ADF&G Title 16 fish passage requirements.
- For open-cut crossings, stabilizing waterbody banks and installing temporary sediment barriers within 24 hours of completing instream construction activities. For dry-ditch crossings, complete streambed and bank stabilization before returning flow to the waterbody channel;
- Returning all waterbody banks to preconstruction contours or to a stable angle of repose as approved by the Environmental Inspector.
- Installing erosion control fabric or a functional equivalent on waterbody banks at the time of final bank recontouring. Limiting the use of synthetic monofilament mesh/netted erosion control materials in areas designated as sensitive wildlife habitat unless the product is specifically designed to reduce harm to wildlife. Anchor erosion control fabric with staples or other appropriate devices.
- Use of riprap for bank stabilization in compliance with the USACE, or its delegated agency, permit terms, and conditions.
- Unless otherwise specified by state permit, limiting the use of riprap to areas where flow conditions preclude effective vegetative stabilization techniques such as seeding and erosion control fabric.
- Revegetating disturbed riparian areas with native species of conservation grasses, legumes, and woody species, in accordance with site-specific performance standards developed in consultation with federal and state regulatory agencies.
- Installing a permanent slope breaker across the construction ROW at the base of slopes greater than 5 percent that are less than 50 feet from the waterbody, or as needed to prevent sediment

transport into the waterbody. In addition, install sediment barriers as outlined in the Applicant's *Plan*.

- In some areas, with the approval of the Environmental Inspector, an earthen berm may be suitable as a sediment barrier adjacent to the waterbody.

5.1.1.3 Material Source Development

Mainline and associated facilities construction would need materials for access roads, camp pads, storage yards, facilities pads, and the construction ROW. As much material as possible would be sourced from hilltop and ROW cuts. Numerous floodplain material sites would either be developed or continue to be developed to provide the additional material needed. Refer to the *Gravel Sourcing Plan and Reclamation Measures* (Appendix F of Resource Report No. 6) for site specific material source development and reclamation measures. Potential material sites proximate to anadromous fish-bearing waters, including some with potential EFH, are identified in Appendix Table A-3 of Resource Report No. 3. A review of all potential material sources indicates that up to 58 sites are within or near enough to influence drainages that could affect anadromous fish, although, given final site selection and mining plans, it is anticipated that fewer would be within EFH. Currently, only six primary material sites fall within 300 feet of a waterbody designated with freshwater EFH. Future Project planning would refine the list of floodplain material sources that would ultimately be developed.

Construction of material sources within floodplains could have a variety of effects on EFH and EFH species. Material extraction sites studied in Arctic and Subarctic floodplains in Alaska have demonstrated adverse and some beneficial effects on fish and fish habitat (Joyce et al. 1980, Ott et al 2014). The effects of gravel extraction from floodplains on fish and fish habitat is dependent on many factors including the type and size of the river, type of material extraction employed, and the amount of material extracted. Material site development can lead to destabilization of river channels, river channel capture, floodplain widening, increased erosion and sedimentation, increased water velocities, reduced water quality and can lead to aquatic habitat shifts, and in some instances has been documented to cause surface flows into the gravels creating a barrier to fish passage (Joyce et al 1980). Fish habitat changes then lead to changes in fish distributions in terms of fish species and age class distributions within the altered habitats. Material sites that alter the hydrologic regime of a stream can have long-term deleterious effects on fish and their habitats (Joyce et al 1980). The study determined that active channel mining should be avoided as possible, particularly when important spawning or wintering habitats were nearby. Fish entrapment potential was also documented at some sites where extraction sites left depressions in flood plains that were later flooded at high water and then became isolated as water dropped.

However, the study identified configurations where specific mining methods of specific floodplain features, limitations of gravel removed specific to stream type and size, and location of removal sites that could produce habitat enhancements and reduce the potential for stream altering processes to be initiated. Some benefits to local fish populations including the creation of wintering habitats and productive feeding habitats have been identified. Ott et al. (2014) summarizes fish use of several gravel mine sites, most constructed as pits that were subsequently connected to nearby drainages, on Alaska's North Slope. While some sites took many years to be used by appreciable numbers of fish, most were used for overwintering. Gravel extraction sites in that study provided a habitat that is in limited quantities in the Arctic. Several of the sites studied had been rehabilitated primarily to provide for fish overwintering, but also had productive shallow water habitats incorporated in their design to foster both productivity and enhanced overwintering habitat.

Alaska specific guidelines for floodplain material site development have been prepared. A companion document to Joyce et al 1980, provides detailed guidelines for gravel removal from Arctic and Subarctic river systems (Joyce et al 1980b). In addition, McClean (1993), conducted a review of material source development and, building from Joyce et al (1980b), produced decision matrices and associated gravel mining guidelines for Alaska's North Slope. The guidelines are applicable throughout Alaska.

Material site development could have long-term adverse effects on EFH and EFH species that could have minor to significant effects if sites are developed within EFH. However, site-specific mining plan design and reclamation would reduce the potential for adverse impacts and could enhance fish habitats in some drainages.

Upland material sites could also affect EFH and EFH species primarily by mobilization of sediments at the material site into proximate EFH. Application of appropriate BMPs and stormwater runoff plans should reduce the potential effects to EFH and EFH species from upland material site development. Any effects to EFH and EFH species would be anticipated to be short-term and minor, as any offsite transport of sediments would be controlled once identified.

Mitigation measures that would be implemented in material site development are discussed in Section 6.0.

5.1.1.4 Water Withdrawal and Hydrology

The *Water Use Plan* (Appendix K of Resource Report No. 2) has been developed to provide the estimated water requirements of the Project and potential sources. Water sources would be distributed along the Project footprint and would include a mix of surface water sources including roadside impoundments, streams, lakes, and groundwater wells. Potential water sources include those with documented freshwater EFH (Appendix Table A-4's highlighted entries).

Mainline and PTTL construction would require approximately 1.86 billion gallons of water over a three- to four-year period. Approximately 90 percent of that demand would be from surface water sources spread throughout the Project. Demands would fluctuate by year of construction but generally demand would be highest for any given spread during hydrostatic testing. The exception would be along the North Slope, where demands would be highest during ice pad construction. Spread 1, from the GTP to near the Dietrich River, would account for over 50 percent of the total freshwater demand for Mainline construction.

The potential water sources selected are preliminary at this time and would be finalized with ADF&G and existing water rights holders. A more-detailed review of specific impacts to potential EFH and EFH species would be conducted if necessary as sites are selected for permitting. However, the following assessment would still be applicable for each site.

Peak demands from EFH sources would occur in summer months. Water withdrawal activities can affect fish in multiple ways. Fish could be entrained or entrapped within the pumping system itself or become impinged on the intake structure at the point of withdrawal. Excessive withdrawal from any given site could also have impacts to fish and habitat including EFH and EFH species. Water withdrawal during winter can lead to water levels that reduce habitat quality including inadequate volume to resist freezing, and inadequate volume to retain high enough dissolved oxygen concentration for survival of fish. Winter withdrawal could lead to reduced flows in small streams and could affect spawning beds and fish eggs within the gravel as well as impede fish passage to and between important overwintering habitats. Fish overwintering areas, particularly in the two northernmost construction spreads of the Mainline (Spreads 1 and 2, see Resource Report No. 1) can exist as isolated pools or stream reaches that would be highly sensitive to water removal. Summer season withdrawal can also have similar affects to fish and fish habitat if volume removal is too high. Reductions in water levels and flows can increase water temperatures to beyond the thermal tolerances of some fish species, but could also increase productivity for juveniles of others. Any withdrawal that leads to discontinuous surface flows within a creek or lake outlet would trap fish. During winter, effects of water withdrawal could be major, and would likely persist for the entire winter construction season. Summer withdrawals would have less potential for adverse effects on fish and fish habitat but excessive withdrawal could still lead to minor to moderate short-term impacts depending on the timing of the withdrawal.

The proposed mitigation measures (see Section 6.0) are anticipated to reduce potential effects from water withdrawal on fish and fish habitats. Impacts to fish are anticipated to be minor. For fish-bearing waterbodies proposed for use as a water source, screened intake devices designed to reduce the velocity at the intake to below the maximum swimming speeds of the most-sensitive fish life stages likely to be present would be employed, and also would be required by state and federal agencies. Water withdrawal from fish-bearing sites would also likely be limited such that adequate water would remain for fish overwintering and fish passage. Another mitigating factor is the overall low rates of water withdrawal required for the Project and the availability of many sources. For example, Spread 1 would have the highest peak flow needs at about 17 cubic feet per second (cfs), split between seven sources (2.4 cfs per site). Relative to availability, water needs are relatively low for much of the year. However, during winter, as rivers essentially cease to flow on the North Slope, and to a lesser extent in the Interior, water availability would likely be limited to roadside material sites and lakes. Hydrostatic testing is planned for the summer and fall (shoulder season).

Specific effects to hydrology from water withdrawals would be more fully assessed as final water sources are selected. However, as presented previously overall removal from any one source would likely be low relative to overall availability. Effects to the hydrology of a stream are anticipated to be minor and short-term and would not persist beyond construction. Water withdrawal would be conducted consistent with the *Water Use Plan* and all applicable state and federal permits.

5.1.1.5 Blasting

Areas along the Mainline may require the use of explosives for ditch construction as identified in the *Blasting Plan* (Appendix B of Resource Report No. 6). Material site development may also require blasting. Use of explosives proximate to occupied fish habitat can produce in-water overpressures and in-gravel particle velocities that could injure or kill fish and kill fish eggs in spawning gravels. In 2013, Kolden and Aimones-Martin, conducted a literature review of research conducted on the effects of various overpressures and particle velocities on fish and fish eggs. They found that the slowest LD10 particle velocity occurred with Chinook salmon eggs at 5.8 inches per second, with other salmon species showing considerably faster particle velocities required to achieve an LD10; coho at 9.1 inches per second, chum at 16.4 inches per second, pink at 24.5 inches per second, and sockeye at 33.0 inches per second. Their review also found that the lowest SPL identified, using modern measuring equipment, to injure fish was 10.0 pounds per square inch. The report ultimately recommended that blast-related overpressures and peak particle velocities in fish-bearing water should be set at some point below those thresholds known to injure fish and kill eggs. In 2013, the ADF&G adopted revised blasting standards to be applied to projects where the impacts of blasting on fish and embryos in fish-bearing waterbodies cannot be avoided or mitigated. The revised standards limit the in-water instantaneous pressure rise in the water column on rearing habitat and migration corridors to no more than 7.3 pounds per square inch where and when fish are present and specified peak particle velocities in spawning gravels are limited to no more than 2.0 inches per second during the early stages of embryo incubation before epiboly completion (Timothy 2013).

Sound-related behavioral effects can also be caused by explosives use near fish-bearing waterbodies, however, explosives are not likely to be used at one location for long enough to have persistent effects on fish behavior.

Blasting could occur proximate to fish-bearing waters along the Mainline and could occur in and near EFH. Site-specific blasting plans have not yet been developed but it is anticipated that required standards would be met and that effects to fish and fish habitat would be avoided.

5.1.1.6 Impeded Fish Passage

Access road stream crossings can impede the free and efficient passage of fish. Any condition that increases water velocity, decreases water depth, decreases flow or causes flow to go subsurface, or blocks a watercourse would impede fish passage. The effects of fish passage can range from minor to significant depending on the timing and duration of the blockage. Blockages to fish passage in habitats used only for rearing of juveniles would have the lowest potential effect on fish. Many of the streams crossed by the Project have only “presence” or “rearing” identified as their use of the stream suggesting temporary blockages to fish passage would be of minor impact and would only persist during the period of blockage, typically less than a few days. However, during spawning migrations, blockages could be more significant depending on the duration of blockage. Blockages of short periods to EFH species passage moving to spawning areas would likely have minor impacts to EFH species because spawning runs for most salmon species in the Project area are fairly prolonged. Blockages that occur during migrations to juvenile salmon overwintering habitat that prevent fish from gaining access to viable wintering habitat would affect fish survival. Blockages to fish moving into wintering areas could have minor to moderate effects, however, most drainages crossed by the Mainline are small systems that likely provide rearing habitat for only small overall components of a drainage’s population of fish and rearing EFH species. Effects would most likely be of short duration and there would not likely be significant effects on any population of fish. Blockages of large drainages could have longer-term, more-intense effects on fish and EFH species; however, such blockages are not anticipated.

Adherence to mitigation measures in the Applicant’s *Plan* and *Procedures*, as well as state and federal permit conditions, would significantly reduce the potential for adverse effects to fish from blockages to passage. All access road stream crossings would be constructed to pass the highest anticipated flow during the period of use, which would provide for adequate fish passage during most flows. Any permanent stream crossings of access roads would be constructed to allow for the passage of fish and maintain fish habitats as required by any state and federal permits.

5.1.1.7 Ice Road Construction

The primary potential effects of ice road construction would be associated with water withdrawal for road bed construction. The potential impacts from water withdrawal are discussed in Section 5.1.1.4. Other potential effects of ice roads on fish and fish habitat are primarily associated with two major factors— freeze-down of fish overwintering areas and impedance of breakup flows during spring. Ice road crossings over deep-water riverine pools, typically isolated from one another on the North Slope of Alaska, can reduce habitat volume by additional freeze-down of the thawed water below the natural ice, and can all serve to alter the temperature regimes of the pools potentially fostering a slushing condition of the entire overwintering pool. Similarly, ice road crossings of flowing waters that freeze down into the substrates can stop subsurface flow, forcing it above the ice. If subsurface flow is impeded, downstream wintering habitats and eggs, if spawning habitats are nearby, can be dewatered or degraded leading to mortality. During breakup when river water levels rise dramatically each spring in most of Alaska, ice roads within floodplains can dam breakup flows and lead to erosion of stream banks and stream beds. Stream bed and bank erosion can be most pronounced at ice road crossings of incised streams. Ice road crossings of streams with persistent winter flow have the potential to scour the stream bed below the ice road as the channel is constricted from freeze-down; however, the ice would likely erode faster than the stream bed minimizing the effects to fish habitats. Most ice road stream crossings would occur on the North Slope and would occur over streams with limited to no flow by late winter. Crossings of deeper rivers would maintain water below the ice as freeze-down to the bed would likely be prohibited for most. Ice roads can also divert sheet flow during breakup potentially affecting natural recharge to lakes on the downgradient side of the road. Ice road crossings of EFH would be constructed. Various state and federal permits would authorize construction of ice roads, and permits would be conditioned to reduce the impacts described.

5.1.1.8 Spills

Spills could affect EFH and EFH species and could occur at various locations along the Project during construction but most would be associated with fuel and hydraulic systems of construction equipment. An outline of a *SPCC Plan* (Appendix M of Resource Report No. 2) has been developed for Project construction and would reduce the potential for spills and the severity of any that could occur. Fuel containment and contingency plans would be in place for all Project components dealing with potentially hazardous materials including fuel oils. Fuel spills that fail to be contained prior to reaching waterbodies with fish and fish habitat would be affected. Effects would depend on the season of the spill, size of the spill, and the aerial extent of the spill. Spills would be expected to have acute effects on fish proximate to the spill location and potentially would lead to avoidance of the area by fish. Large spills that move appreciably downstream from the spill location would have a higher potential to affect more fish and more habitat over a longer distance.

Only in the event of a large uncontrolled spill would any long-term major impacts be anticipated. Stream productivity could be affected by large spills for a number of years if the contaminant entered local waterbodies. Activities with such spill potential like bulk fuel storage would be kept away from freshwater fish habitat and EFH as is practicable.

5.1.1.9 Ditch Stabilization

Post-construction, and into operations, destabilization of the Mainline ditch could affect fish and habitat including EFH and EFH species. The ditch would bisect sheet flow during periods of snowmelt and rainfall runoff events, and the linear nature of the ditch could concentrate flow along the ROW and increase erosion. While the ditch is being constructed there is potential for mobilization of loose soils along the ditch and transport to nearby streams. Any significant erosion events along the ditch during construction could erode portions of the ditch, thereby delivering higher sediment loads to fish habitats. Areas of ditch that are either above or below grade would be most likely to channelize water and would therefore have higher potential for erosion. As discussed below, sediment and increased turbidities that persist can have short- and long-term effects on stream productivity and channel morphology and could alter fish habitats.

It is anticipated that portions of the Mainline installed along ice-rich soils would be the most likely areas to experience some potential for erosion. Mitigation measures and stabilization plans would reduce the potential for erosion to relatively short distances and adherence to the *Stormwater Pollution Prevention Plan* (Appendix J of Resource Report No. 2) would reduce the potential for sediment release to streams. Sections of the Mainline constructed through ice-rich soils, and deep active layer wetlands, would be the most likely areas to experience some potential for slower ditchline stabilization after construction. Likely effects to fish and fish habitat from construction ditch stabilization are anticipated to be minor and short-term because post-construction monitoring would rapidly identify any areas of concern and rehabilitation action that would take place.

5.1.1.10 Erosion, Sedimentation, Alteration of Stream Channel, Water Quality

Cumulatively, the Project components discussed could increase erosion and sedimentation and could alter stream channels and water quality. Adherence to the mitigation measures in the Applicant's *Plan* and *Procedures* would significantly reduce the potential for adverse effects to fish. Most construction activities in fish habitat would be of short duration and have limited effects on fish and fish habitat. If stream bank and bed stabilization efforts are initially unsuccessful there would be a more prolonged period for potential erosion, sedimentation, and alteration of downstream channel configurations. Stream channel stabilization would be most challenging for sites constructed in streams confined by ice-rich banks and terrain. Effects of longer-term destabilization of stream channels can lead to shifts in substrate type typically to a finer sediment type or high embedment ratios of larger stream substrate that can degrade feeding and spawning habitats. Shifts in aquatic invertebrate communities and loss of stream complexity could also affect overall fish use of a stream. Post-construction monitoring would be important to identify crossing locations that require additional rehabilitation work to reduce the period of fish habitat degradation. As discussed previously, effects to fish and fish habitat could range from minor to moderate but would typically be of short duration with the exception of any sites that take longer to stabilize.

Turbidity associated with erosion could also have adverse effects on fish and potentially some EFH juveniles. Section 5.2.1.13 provides detailed analyses on the potential effects of increased turbidities on fish. However, impacts would be similar to those described, and would be short-term and localized.

Material source development within active floodplains can have similar affects to fish habitat and fish to those described. Material sites that are oversized for a stream can similarly lead to long-term stream channel destabilization and reduced stream productivity. Spawning reaches could be degraded in the long term. Site-specific material source siting and mining plans would need to be developed because large material site-caused destabilization would be difficult to reverse. Generally, effects are anticipated to be minor. Material site development would be reliant on upfront planning to avoid any significant adverse effects.

Ditch excavation would produce a substantial quantity of material along sections of the Mainline that could not be used as backfill in the ditch. Handling of excess ditch material could also increase overall construction-related sediment inputs to local streams depending on the mode of disposal. Disposal plans including discharge of waste material into excavated upland material sites would mitigate the potential for sediment mobilization into streams and EFH.

Any erosion and resulting sedimentation of adequate magnitude to cause stream channel alterations would have the potential for adversely affecting fish and fish habitat, including EFH and EFH species along the Mainline. Expected adverse effects would be short term and localized and no population-level effects to fish would be anticipated.

5.1.1.11 Invasive Plants and Aquatic Organisms

Equipment and supplies for construction of the Project would be shipped from locations within the United States and foreign locations with known populations of species non-native to Alaska. In addition, equipment could work within areas with known aquatic invasive species and mobilize organisms to unaffected locations. Similarly, water withdrawal activities could mobilize some species of aquatic invasives to previously uninhabited locations. The ADF&G has identified a number of aquatic nuisance species (ANS), some of which are already present in the Project area (Table 13). In addition to the species listed, Nuttall's waterweed (*Elodea nuttallii*), a non-native species of pondweed, has been identified in locations near the Project in Interior Alaska. Adherence to the *Noxious/Invasive Plant and Animal Control Plan* (Appendix K of Resource Report No. 3) would reduce the potential for the spread of non-native species by reducing the potential for contaminated equipment to move among spreads or in-water work locations in different drainages.

Table 13: Alaska ANS Plan High-Priority Threat Species

Type	Common Name	Scientific Name	Present in Project Area[b]
Fish	Atlantic salmon	*Salmo salar*	No
Fish	Brook Trout	*Salvelinus fontinalis*	No
Fish	Northern pike	*Esox Lucius*	Yes
Fish	Oscar	*Astronotus ocellatus*	No
Crustacean	Chinese mitten crab	*Eriocheir sinensis*	No
Crustacean	Green crab	*Carcinus maenas*	No
Crustacean	Signal crayfish	*Pacifastacus leniusculus*	No
Mollusk	New Zealand mudsnail	*Potamopyrgus antipodarum*	No
Mollusk	Zebra mussel	*Dreissema polymorpha*	No
Marine Invertebrate	Golden star tunicate	*Botryllus schlosseri*	No
Marine Invertebrate	Violet tunicate	*Botrylloides violaceous*	No
Marine Invertebrate	Glove leather tunicate	*Didemnum vexillum*	No
Marine Invertebrate	Common sea squirt	*Ciona intestinalis*	No
Marine Invertebrate	Pacific transparent sea squirts	*Ciona savignyi*	No

Source: Based on Appendix I of the ADF&G Aquatic Nuisance Species Management Plan (ADF&G, 2002)
Notes:

[a] Based-on query of United States Geological Survey (USGS) Nonindigenous Aquatic Species mapped occurrences: http://nas.er.usgs.gov/queries/SpSimpleSearch.aspx (USGS, 2013)

5.1.1.12 Loss of Fish Habitat

During construction of the Project there would be a temporary loss of fish habitat. Habitat losses would be restricted to the immediate location of construction, which includes pipeline crossings located in EFH. Crossings would be rehabilitated back to near preconstruction conditions after one open-water season post-construction. Loss of fish habitat is not anticipated to extend beyond one season for most crossings, and there would be no loss of fish habitat for buried trenchless crossings.

Stabilization of some stream crossings could take a longer period to be achieved. Streams in ice-rich soils common to the North Slope and the northern portion of the Interior spreads could take additional seasons of rehabilitation efforts to stabilize stream banks and the ditch. Loss or alteration of fish habitats would then persist for a longer period indirectly reducing habitat downstream over time. However, it is likely that any habitat losses would remain limited in extent to the immediate area of construction.

Material site development, if active channel mining is determined applicable, would similarly eliminate associated fish habitat for the period of mining. Details on specific potential effects to fish and fish habitats of material site development are presented in Section 5.1.1.3.

5.1.2 Effects on Freshwater EFH and EFH Species from Project Operation

Operation of the Project could have both short- and long-term effects to freshwater EFH and EFH species. The primary operational risks to EFH and EFH species would be associated with stream crossings, material sources, water withdrawals, and spills.

5.1.2.1 Erosion

Erosion related to stream crossings, and erosion of the ditch line could affect fish and fish habitat, including EFH and EFH species as described in Section 5.1.1. Adherence to mitigation measures in the Applicant's *Plan* and *Procedures* would significantly reduce the potential for adverse effects to fish. Erosion potential through operations of the Mainline would be associated with the same activities described for construction and would include pipeline stream crossings, material sites, and ditch stabilization that may take place over the life of pipeline operations. Potential effects to fish and habitat would be much more limited during operations than initial construction because activities are not widespread during operations.

Over the life of the Project, flood events and maintenance at crossings could lead to similar short-term, minor impacts as described in Section 5.1.1.

Operation of a chilled pipe and associated frost bulb could locally alter water movement at some sites during winter and summer and lead to erosion by constricting the area available below the stream bed to move water, resulting in increased water velocity and erosion. Mainline insulation methods would be employed to reduce the influence of the freeze bulb within streams as appropriate.

5.1.2.2 Water Temperature

Operation of a chilled Mainline in the substrates of smaller streams are likely to affect local water temperatures within streams because the USACE would require a minimum 5-foot burial depth below the stream bottom.

Winter water temperature reductions would pose a higher potential risk particularly at stream crossings with low but persistent winter flows. On the North Slope, crossings of sensitive over-wintering areas that remain just above freezing all winter could freeze during exceptionally cold winters with the added thermal drop associated with the below-freezing pipeline. Small drainages with persistent low flows of cool water during winter, most common between the Brooks Range and the Alaska Range, would be most susceptible to winter reductions in water temperatures. If crossings were to freeze, solid water would be forced to the surface as aufeis and downstream overwintering and spawning habitats could be dewatered. Most streams located within the Project area that would be potentially impacted along the Project area are not heavily used for spawning or overwintering so effects to fish would be anticipated to be minor and infrequent. Most drainages used for summer, fall, and winter spawning by EFH and other fish species would be large enough to be unaffected, and coupled with the minimum burial depth, are unlikely to be impacted by the chilled pipeline.

5.1.2.3 Barriers to Fish Passage

Barriers to fish passage through operation of the Mainline are not anticipated to be a consistent effect of the Project because of burial depth and accommodation for lateral stream migration. Alterations to stream breakup could affect upstream movement of Arctic grayling to spawning habitats during spring if ice dams associated with new aufeis production, or enhanced ice thickness at Mainline crossings were to occur. Arctic grayling often move to spawning areas during periods of breakup in the presence of surface and shelf ice, so they likely would be able to negotiate any Mainline crossings. However, delays in excess of a few days could affect overall spawning success at some locations.

Persistent erosion, sedimentation, and channel alteration within fish-bearing streams could alter fish passage depending on the extent of the channel changes. Conditions leading to impeded fish passage would be identified quickly and rehabilitation of the causal mechanisms would occur. If barriers to fish passage were to occur during operations, the effects would likely be short-term and minor in most cases. Barriers to passage that may occur during spawning and overwintering migrations could have minor to moderate effects on local populations but would likely persist for only one season.

5.1.2.4 Hydrological Changes

Work pads and access roads that remain during operations could have longer-term effects on stream hydrology than during construction if they intercept surface flow within drainages and are able to redirect flow outside the drainage. Such situations likely would be remedied quickly through installation of additional cross drainage to ensure road integrity. Any effects would be short term and minor, and few would occur in EFH.

5.1.2.5 Stream Channel Alteration

The potential for stream channel alterations during Project operations would be minimal and limited to those discussed for construction. Stream channel alterations associated with prolonged erosion, sediment inputs, and any condition that alters the ability of a stream to move bedload under its design flow regime (stream type) would change the stream type and alter geomorphic processes. Habitat quality could be degraded and fish use altered. Alterations of critical habitats such as spawning and overwintering would have longer-lasting moderate effects on fish and potentially EFH species.

5.1.2.6 Invasive Plants and Aquatic Organisms

Potential for spread of aquatic invasive plants and organisms would be much lower during operations because overall activity levels in and near waterbodies would be minimal and limited to locations where additional site restoration/stabilization would occur.

5.1.2.7 Spills

Any potential LNG spill during Project operations would not occur near freshwater EFH. However, release of natural gas could occur in EFH and could have localized effects on any fish resources near the release. Potential impacts would include acute mortality of fish proximate to the release or exposure to low-temperatures just downstream from the release, possibly resulting in death. Depending on the mode of release, stream banks and beds could be significantly disturbed resulting in many of the effects described in the preceding sections including increased turbidity and sedimentation as well as impacts to fish passage, and adverse impacts to spawning and overwintering habitats. Stream stabilization in concert with repair of the pipeline would occur. Likely potential impacts to EFH and EFH species would be short-term and primarily direct. Somewhat longer-term effects similar to those described for construction could occur during repair.

5.2 POTENTIAL EFFECTS ON MARINE EFH AND EFH SPECIES

Construction of the Marine Terminal in Cook Inlet would not affect designated marine EFH for groundfish in Cook Inlet but could affect groundfish EFH species, including walleye pollock. Salmon EFH and species could also be affected by construction and operation of the facilities. Dredging and backfill of trenches for pipeline placement could have temporary impacts to salmon EFH and species depending on the timing of the activities. Construction of DH 4 at the Seawater Treatment Plant location at West Dock could affect designated marine EFH for Arctic cod, pink, and chum salmon. Potential mechanisms for impacts to marine EFH and the different life stages of EFH species from Project construction could include:

- Turbidity and sedimentation (e.g., dredging, in-water construction).

- Underwater noise.
- Habitat loss.
- Surface water use and discharge (e.g., hydrostatic testing).
- Spills of fuels, lubricants, or solvents.

Quantification of impacts to marine EFH and EFH species is difficult, regardless of Project location. Salmon EFH within Cook Inlet is based on migratory corridors along the shoreline for adults and juveniles with limited residency in the area. Also, detailed descriptions of the EFH for the GOA forage fish complex are not available. The only species with high juvenile presence in Upper Cook Inlet with adequate information detailing EFH is walleye pollock and EFH is only designated in Cook Inlet up to a location just north of Kachemak Bay, depending on the life history stage. For the PTU and West Dock, within the Arctic FMP, only Arctic cod has designated EFH in the area of the West Dock and PTU Expansion. There would be a temporary loss of approximately 47 acres of EFH for Arctic cod at West Dock due to the West Dock modifications, DH 4 modifications, and PTU Expansion project. dock expansion.

If necessary maintenance dredging of the berthing basin for the PTU expansion would be conducted in the summer using small portable hydraulic dredge with a pipeline to dispose of the sediment at an approved location. Dredged material disposal would be at designated, beneficial use near shore disposal sites.

Minor dredging at the PTU docks (approximately 5,000 cubic yards) would have temporary impacts to salmon and Arctic cod EFH, again depending on the timing of the activity.

About 14 acres would be lost temporarily (but long-term) due to the construction and use of the temporary MOF in Cook Inlet. Dredging at the east and west sides of Cook Inlet for the Mainline crossing would result in the temporary disturbance of approximately 50 acres or more. Depending on the timing of dredging, this activity—while short in duration—could disrupt migration of EFH species.

As discussed in Section 5.1.1, site-specific BMPs would be designed and implemented to reduce or mitigate potential impacts. For marine EFH mitigation measures could include:

- Schedule the timing of in-water construction to avoid peak periods of migration for EFH species.
- Maximize in-water construction work during low tide.
- Utilization of “soft-start ramp-up” procedures prior to impact and/or vibratory pile driving in shallow nearshore waters (as required for ESA and Marine Mammal Protection Act {MMPA} compliance).

5.2.1 Construction

Potential direct effects to marine EFH and EFH species from Project construction could include increased short-term turbidity in the water column, removal of benthic substrates and marine invertebrates, and spills.

5.2.1.1 Trenching, Dredging

Pipelay Trenching

Dredging for the pipeline would begin at the shoreline crossings on both sides of Cook Inlet using the open-cut method. In Cook Inlet the pipeline would be installed in a trench and buried from the shoreline out to a water depth of 35 to 45 feet and represents a distance of about 8,800 feet at the Shorty Creek crossing and 6,600 feet at the Boulder Point crossing.

This trench would be excavated with a combination of TSHDs and amphibious excavators during low tides. Following pipeline installation, the trench is expected to naturally backfill. The entire area of dredging would be 13 acres (118,000-218,000 cubic yards) and 36 acres (155,000-289,000 cubic yards) for the Boulder Point and Shorty Creek crossings, respectively.

Marine Terminal Dredging

Dredging and seabed preparation at the Marine Terminal would be completed during April through October during the first construction season using a dredging barge (barge-mounted crane, clamshell) and hydraulic dredge operating for approximately 206 days. Dredging of the temporary MOF would be the most extensive excavation with an estimated 28-acre footprint ranging from -5 to -32 feet MLLW. Substrates within these proposed dredge areas are primarily medium dense sandy silt and sand overlying hard sandy clay. Cobbles and boulders of varying sizes are also present. Seabed preparation would be completed by backfilling the dredged area with gravel and rock. .

The following factors contribute to the extent of plume dispersion during dredging: dredging method, barge type/ size, current speed, salinity, temperature, grain size and density of dredged material, tides and if dredging occurs in summer or winter (NOAA, 2017). The impact of the dredge operation would be limited in extent for the duration of the activity. During dredging activities, the upper water column would be affected for up to 20 minutes, while most clumps and fine sand would settle to the bottom within the first 10 minutes and the existing ambient total suspended solids concentration of .6 g/L would be achieved within 1 hour in the bottom 10 ft of the water column. During that time, the plume from the upper water column could extend up to 7200 ft in the worst case scenario, if traveling 6 ft/s for 20 minutes. The plume from the lowest water column could extend for 3,600 ft, traveling 1ft/s for 1 hr. Maintenance dredging may be required in subsequent years to maintain depths depending on the rate of sedimentation

Because of the high natural turbidity in Upper Cook Inlet, it is unlikely that dredging and dredge disposal would exceed background water turbidity more than 2700 feet (worst case scenario) from these activities. It is unlikely that dredge operations would occur during this worst case scenario, and tide and wave action would likely dilute the concentration, thereby decreasing the potential area of impact.

West Dock Modifications

Sediments near the proposed West Dock and DH 4 construction area consist of alternating layers of silty sand and sandy silt with occasional occurrences of clay with a few lenses of black fibrous organic peat (Houghton 2012). Water depths in the construction area range from about -4.5 to -9 feet MLLW.

There would also be increased turbidity and mobile species would be expected to avoid the area due to both turbidity and sound associated with the equipment/vessels. Direct impacts from in-water construction would be annual disturbance/loss of substrate and invertebrates within the area. There would also be intermittent and localized increases in turbidity during in water construction and barges ballasting in front of DH 4. The potential effects to fish and fish habitat, including EFH and EFH species, would be minor and temporary.

Barge Bride Modifications

The existing bridge across the 650-foot-long breach between Dock Head 3 (DH 3) and the new DH 4 is limited to single-lane light vehicle traffic. A bridge crossing with the capacity to support the module weight would be required for a successful offload and transport from DH 4. A temporary barge bridge consisting of two barges ballasted to the sea floor to bridge the gap would be used. The barges would be placed at the beginning of the open-water season prior to each sealift. The barges would be removed at the end of each sealift. Movement of Arctic cod in and out of Prudhoe

Bay would not be adversely affected by the temporary barge placement because the species is not restricted by salinity conditions.

PTU Expansion

Dredging would also be conducted at the PTU dock facility. The volume is expected to be approximately 5,000 cubic yards. Temporary displacement of Arctic cod and some salmon species would be expected during dredging activities. As with other dredging locations, the method does not involve long-term impacts to EFH or EFH species.

5.2.1.2 Release of Contaminants

Disturbance to the benthic substrate could release any chemicals and metals that may be tied up in the substrate. Substrate samples are currently being analyzed and could result in modification of the plan as more data are received. Pending that evaluation, contamination through mobilization of contaminated materials is not anticipated. No impaired waterbodies have been identified for any of the freshwater stream crossings (see Resource Report No. 2).

5.2.1.3 Turbidity

Increased short-term, localized turbidity in the water column would occur during dredging. The amount of turbidity created would depend on the material type being excavated and the type of dredge used. Project-related dredging is not expected to result in more than temporary exceedance of water quality criteria farther than several hundred yards down-current, given the sands and gravel expected to be removed (Hayes 1986).

Suspended solids in estuarine waters have been reported to injure juvenile salmon and could reduce their ability to sight-feed on surface and near-surface invertebrates at higher concentrations (USACE 2008). At lower concentrations, juvenile salmon may use turbid waters to hide from predators. Effects of turbidity and suspended solids on juvenile salmon are summarized in a comprehensive compilation by Bash et al. (2001). The effects of high suspended solids concentrations on salmonids have been reported to include mortality, reduced survival, reduced growth, reduced feeding, stress, disease, avoidance, displacement, change in body color, alerted behavior, and reduced tolerance to salt water (Lloyd 1987). Potential severity of effects is related to: duration of exposure, frequency of exposure, toxicity, temperature, life stage of fish, angularity of particles, size of particles, type of particles, severity and magnitude of pulse, natural background turbidity, time of occurrence, other stressors and general condition of biota, and availability of and access to areas with less suspended material. Much of the research on juvenile salmonids and turbidity was done in laboratory settings. Applicability to field situations has not been thoroughly verified. Other research applies to headwaters and systems that are normally clear except for seasonal and infrequent sediment. Furthermore, turbidity values reported by some research may not be a consistent and reliable tool for determining the effects of suspended solids on salmonids. Bash et al. (2001) concluded that, "salmonids encounter naturally turbid conditions in estuaries and glacial streams," but this does not necessarily mean that salmonids in general can tolerate increases of suspended sediments over time. Relatively low levels of anthropogenic turbidity may adversely affect salmonid populations that are not naturally exposed to relatively high levels of natural turbidity (Gregory 1992). Bash et al. (2001) also noted that managers are interested in learning whether there is something inherent in "natural" turbidity sources that make them somehow less harmful to fish than are anthropomorphic sources of turbidity because it is apparent that salmonids are able to cope with some level of turbidity at certain life stages. Evidence of their ability to cope is illustrated by the presence of juvenile salmonids in turbid estuaries and local streams with high natural levels of glacial silt (Gregory and Northcote 1993). Feeding efficiency of juvenile salmonids has been shown to be impaired by turbidity levels in excess of 70 Nephelometric Turbidity Units (NTUs), well below typical and persistent levels in Cook Inlet (Houghton, 2005).

The increased short-term turbidity from material excavation and fill placement in Cook Inlet is likely to be negligible, given Cook Inlet's naturally high levels of turbidity (400–600 NTUs) and the location of the Project area, which is characterized by significant turbulence and mixing due to currents and tides.

Similarly, potential impacts from turbidity caused by dredging of the navigation channel and turning basin at the PTU are anticipated to be negligible. Initial dredging is expected to occur during the winter months, partially through bottom-fast ice, minimizing the potential for turbidity. Turbidity resulting from maintenance dredging in the summer would be expected to be localized and temporary.

5.2.1.4 Removal and/or Burial of Organisms

Upper Cook Inlet experiences some of the most extreme tides in the world, demonstrated by a mean tidal range from 4 meters at the Gulf of Alaska end to 8.8 meters near Anchorage (USACE 2013). Tidal currents reach 2 meters per second (3.9 knots) (Mulherin et al. 2001) in Upper Cook Inlet, increasing to 3 to 4 meters per second (5.7 to 7.7 knots) near the Forelands (just north of the temporary MOF area) where the inlet is constricted. Each tidal cycle creates significant turbulence and vertical mixing of the water column in the Upper Inlet (USACE 2013), and are reversing, meaning that they are marked by a period of slack tide followed an acceleration in the opposite direction (Mulherin et al. 2001).

The removal of seafloor substrates and benthic invertebrates as a result of material excavation is often considered to be negligible depending on the size and duration. However, depending on the timing of excavation, there could be long-term impacts to juvenile salmon, migrating salmon, and spawning forage fishes such as eulachon and capelin. While the areas where excavation and fill placement would occur are small when compared to the overall habitat, their duration could create overlapping windows with migrating and spawning fishes.

Because of scouring, mixing, and sediment transport from the currents in Upper Cook Inlet, the marine invertebrate community overall is very limited (Houghton 2005). Of the 50 stations sampled by Saupe et al. (2005) in Southcentral Alaska, the Upper Cook Inlet station had, by far, the lowest abundance and diversity of marine invertebrates. The fish community of Upper Cook Inlet is characterized largely by migratory fish—eulachon, capelin, and Pacific salmon—returning to spawning rivers, or outmigrating salmon smolts. Most of these fishes are not focused on feeding, but on spawning, and therefore the temporary disruption of prey resources would not have lasting impacts on the fish species.

5.2.1.5 Disposal

The effects of dredge spoil placement on overall water quality are expected to be short-term and minor. Material resuspension during tidal variation would result in localized increased turbidity.

5.2.1.6 Noise

Overview

Noise generated by Project construction could have negative impacts on fish, including EFH species. Potential impacts of sound exposure on fish could include physical damage to the ear region, physiological stress responses, and behavioral responses such as startle response, alarm response, avoidance, and a potential lack of response due to masking of acoustic cues. Noise sources associated with the Project include impact and vibratory pile driving, dredging/trenching, and vessel noise (especially tugs while anchor handling for pipe lay).

The greatest concern for fish with regards to anthropogenic noise sources associated with construction of the Project resides with pile driving, because noise levels associated with pile driving often exceed 180 decibels and have the potential to injure juvenile salmon. It is expected that all fishes within the areas of pile-driving activities would leave and/or avoid the areas completely. Within Prudhoe Bay, pile driving is expected to occur during the winter through bottom-fast ice and therefore no fish are expected in the region. The BMPs expected to be implemented for the West Dock modification would include winter-time construction and a soft-start/ramp-up process prior to impact or vibratory pile-driving activities. Furthermore, the use of sound attenuation measures in ice-free areas have the potential to reduce noise levels by up to 5–20 decibels depending on the methods used and the timing of the activities around slack tide. Tidal flow can reduce the effectiveness of some types of sound attenuation measures but these types of measures would be investigated for use.

There are three primary underwater noise sources that would potentially affect fish:

- Pile driving.
  - Impact sheet-pile-driving associated with the Marine Terminal and DH 4 construction.
  - Vibratory pile-driving associated with the Marine Terminal and DH 4 construction.
- Vessels – Propeller cavitation during anchor handling and bow thruster operation during dynamic positioning both associated with Mainline pipe laying across Cook Inlet.
- Dredging (and trenching) activity in Cook Inlet (Mainline MOF and temporary MOF).

Fish Hearing

Fishes in general use sound to process their environment, both abiotic and biotic sources. Abiotic sources include wave action, tidal movement, substrate movement, geological events and even rain dropping on the water’s surface. Biotic sources include marine mammals and invertebrates. Therefore, the addition of anthropogenic noise to the biome can result in substantial effects to the local fish population depending on the intensity and duration of the noise events.

Injury in Fishes from Noise

A fundamental issue of concern with regard to fishes is what constitutes “injury” in the sense of the marine mammal literature (see Southall et al. [2007]) and the MMPA. For marine mammals, permanent hearing loss is considered injury, but is not likely to occur in fishes. All evidence for temporary hearing loss shows that fishes recover quickly from this loss.

The question therefore is when does “injury” start in fishes and what is the nature of physiological effects that can lead to injury. In the very limited literature on interim criteria for regulation of exposure of fishes to pile-driving sound (regulations have not been promulgated for other sound sources), the concern is for the onset of physiological effects, but this is not clearly defined. In a recent study by Halvorsen et al. (2011a,b) on effects of pile-driving sounds on Chinook salmon (and similar studies by Casper et al., 2011, 2012 on striped bass, tilapia, and juvenile salmon), it has become clear that there are some effects that have the potential for impacting the survival of fishes (e.g., burst swim bladder, massive internal bleeding), whereas other effects have no more impact on survival than does a small cut on the arm of a human (e.g., external bleeding at the base of fins).

Therefore, until a better definition of “injury” is available and agreed upon for fishes, an injury will be defined as an effect on the physiology of the animal that leads to immediate or potential death for the purposes of this report. In contrast, behavioral effects, such as moving from a site of feeding, would not be considered an injury.

Impacts of anthropogenic noise on fish can range from mortality to disturbance. Continuous sound exposure and loud sounds can temporarily affect the auditory sensitivity of fish by causing an upward shift in auditory threshold. This effect is known as temporary threshold shift (TTS). The duration of TTS varies depending on the nature of the stimulus, but by definition, there is generally recovery of full hearing over time (Hastings and Popper 2005). Extended and continuous sound exposure and loud sounds can also cause permanent hearing loss or permanent threshold shift (PTS) often the result of acoustic trauma (Hastings and Popper 2005). The impacts from PTS often result in physical damage to the fish's auditory structures that in turn reduce the natural ability to detect predators and therefore become easy prey.

Potential impacts of sound exposure on fish could include barotrauma—physical damage to the fish due to concussive noise impacts; TTS; PTS; physical damage to the ear region; physiological stress responses; and behavioral responses such as startle response, alarm response, avoidance, and a potential lack of response due to masking of acoustic cues (Halvorsen et al. 2012).

Other potential impacts of sound exposure on fish include physical damage to the swim bladder, liver, gills, physiological stress responses, and behavioral responses such as startle response, alarm response, avoidance, and a potential lack of response due to masking of acoustic cues.

Most of these impacts are either temporary or intermittent and it is unlikely that they would impact fish at the population level. Federally managed fish and shellfish are mobile and would be expected to avoid the construction area due to the noise. This would reduce potential physiological effects on fish.

Physiological Effects on Fishes from Noise

Several general points can be made with reference to effects on fish physiology and mortality of intense sounds.

1. There is little evidence for immediate mortality other than when fishes are very close to intense sound sources, such as pile driving for very large piles. There are no data on any other sound source. Substantial study needs to be put into questions of immediate mortality.
2. Physiological effects that are sufficient to potentially kill fishes over time appears to have some correlation with the total amount of sound exposure. A few non-quantified studies have shown no damage to non-auditory tissues as a result of seismic airgun exposure (Popper et al., 2005; Song et al., 2008) or to any tissue after exposure to high intensity low-frequency and mid-frequency sonars (Halvorsen et al., 2006; Popper et al., 2007). A quantified study of pile driving (Halvorsen et al., 2012) demonstrates a range of effects that increase in likely impact on the animals, but the fishes seem to recover from these effects in a few days (Casper et al., 2011, 2012). There are some data that suggest that some seismic airgun signals, under certain acoustic conditions, may damage sensory cells of the ears (McCauley et al., 2003), but that there is no effect on other species under different acoustic conditions (Song et al., 2008).
3. There are very few data documenting effects of any intense sound source on eggs and larvae. Far more data are needed before any preliminary conclusions can be reached on the effects of sound on eggs and larvae, and studies need to include, in addition to mortality, effects on growth and body tissues.
4. It is possible that exposure to loud sounds or increased background noise can result in increased stress levels and effects on the immune system. However, such effects have never been documented for fishes, and the only long-term study (Wysocki et al., 2007) of increased ambient noise showed no effect. It is critical to note that lack of effect may be more a function of not enough study rather than being the actual result. Future studies are needed to ask questions of such effects.

Current Sound Energy Level Criteria for Adverse Effects of Noise on Fish

There is considerable concern about effects of anthropogenic sound on marine organisms, including fishes (see Popper and Hawkins {2012}). However, despite the concerns, there is actually very little in the way of recommendations for regulatory levels of sound. In fact, the only known criteria, which are clearly labeled "interim," arose on the U.S. West Coast out of concern about effects of pile driving on fishes (reviewed in Woodbury and Stadler, 2008; Stadler and Woodbury, 2009). These criteria are for the onset of physiological effects and say nothing about behavior.

The current interim criteria are dual in nature. That is, they state that physiological onset may occur if the peak sound level of a pile driving strike is 206 dB re 1 µPa or have an SEL_{cum} of 187 dB re 1µPa2 -s for fishes above 2 g (0.07 oz) or 183 dB re $1µPa^2$ -s for fishes below 2 g (0.07 oz) (for explanation of these criteria, see also Popper et al. (2006) and Carlson et al.(2007). NMFS also considers sounds of 150 dB re $1µPa^2$ -s to represent the threshold for affecting fish behavior.

Salmonid Hearing

There are several sources of in-water noise associated with the Project that can cause impacts to salmon and fishes in general. These include impact and vibratory pile-driving, dredging, vessel noise, etc. The effects of pile driving on salmon are the most problematic and represent the widest and most severe range of injuries that can result from prolonged exposure to these noises.

Salmonids overall (including the five species of Pacific salmon) are considered hearing "generalists"—they have a narrow range of hearing—falling between 0.03-0.4 kHz and a threshold of 110-135 re 1 µPa (Popper and Hastings 2009). Therefore, cumulative sound exposures above threshold levels have the potential to result in impacts (behavioral changes/stress/physical damage) to those fishes within the zones of ensonification.

Halvorsen et al. (2012) conducted as series of controlled laboratory experiments on juvenile Chinook salmon to test the threshold levels of injury from impulsive sound on these fish. Observed injuries ranged from mild hematomas at the lowest sound exposure levels to organ hemorrhage at the highest sound exposure levels (SELs). Frequency of observed injuries were used to compute a biological response weighted index (RWI) to evaluate the physiological impact of injuries at the different exposure levels. As single strike and cumulative sound exposure levels (SEL_{ss}, SEL_{cum} respectively) increased, RWI values increased. Based on their results, tissue damage associated with adverse physiological costs occurred when the RWI was greater than 2. In terms of sound exposure levels, a RWI of 2 was achieved for 1920 strikes by 177 dB re 1 $µPa^2·s$ SEL_{ss} yielding a SEL_{cum} of 210 dB re 1 $µPa^2·s$, and for 960 strikes by 180 dB re 1 $µPa^2·s$ SEL_{ss} yielding a SEL_{cum} of 210 dB re 1 $µPa^2·s$. These metrics define thresholds for onset of injury in juvenile Chinook salmon.

Cumulative impacts of sound exposure levels (SEL_{cum}) above 180 dB re 1 $µPa^2·s$ @ 1 meter (960 hammer strikes) have been shown to result in injury threshold in juvenile Chinook salmon in laboratory studies (Halvorsen et al. 2012). A noise that exceeds an SEL of 180 dB re 1 $µPa^2·s$ or greater is therefore considered to be a threshold value for avoiding permanent damage and/or mortality. SELs approaching 180 dB are most problematic for juvenile salmon that are unable to fully avoid areas of pile driving due to strong tides and/or currents in the region. These noise sources are of serious concern during pile placement for the duration of construction and vessel operations for the life of this Project.

Pile Driving

Impact pile driving is likely to be the loudest noise component associated with facilities construction. Impact pile drivers place the pile by hammering it into place, which creates impulse noise that may be repeated many times before the pile reaches the desired depth. The expected SELs for the Knik Arm Crossing project for the piles driven with impact hammers are presented in Table 14 along with the estimated distances from the source to the acoustic harassment threshold level of 160 decibels referenced at 1.0 micropascal root mean square (1 µPa rms) for impulse sounds.

A vibratory pile driver works by applying downward pressure to the top of the pile by vibrating a weight, which creates a continuous signal. Table 15 presents the estimated SEL and distance to the acoustic harassment threshold of 125 decibels for 24-inch-diameter piles placed using the vibratory method. The sound level from vibratory pile driving is less than that for impact-driven piles for piles of the same diameter, by approximately 20–35 decibels.

The duration of pile driving may be considerable and is a function of the desired depth and resistance to penetration, which are determined by substrate characteristics and the diameter of the pile (Caltrans 2007). Placement of a 24-inch-diameter temporary pile is estimated to require 15 minutes of vibratory hammer and one hour of impact hammer. Placement of a 48-inch-diameter temporary pile is estimated to require 30 minutes of vibratory hammer and 90 minutes of impact hammer. Vibratory removal of 24-inch- and 48-inch-diameter piles is estimated to require one and two hours, respectively.

Impact Pile Driving – Impulsive Underwater Noise

Impulsive underwater noise has the potential to injure salmon when it exceeds 180 decibels referenced at 1.0 dB re 1 μPa rms. Impulsive noise sources that may be employed during the construction phase of the Project include impact hammers for pile driving. Pile driving is planned for construction of the temporary MOF, PLF trestle, in the Marine Terminal area, the Mainline MOF on the west side of Cook Inlet, and expansion of West Dock in Prudhoe Bay. Presumably, most of these piles would be installed with an impact hammer, but some may be installed with vibratory systems. A variety of pile types and sizes would be used.

Illingworth & Rodkin (2007) compiled measured data on near-source (10-meter) sound pressure levels from impact pile driving for pile sizes ranging in diameter from 12 to 96 inches (Table 14). Near-source values ranged from 170 decibels re 1 μPa (24-inch concrete pile) to 195 decibels re 1 μPa (96-inch cast-in-steel shell pile), and distances to the 180-decibel injury threshold for salmon ranged between 4 and 178 meters.

Table 14: Summary of Nearshore (10 meters) SELs from Impact Pile Driving

Pile Type	Pile Size (inch)	Approx. Water Depth (feet)	Average SEL (rms)[a]	180-decibel Radius (feet)
Steel H-type	12	16.4	170	49.2
Steel Sheet	24	49.2	180	105.0
Concrete	24	16.4	160	13.1
Concrete	24	49.2	166	23.0
Steel Pipe	12	16.4	167	26.2
Steel Pipe	14	49.2	174	52.5
Steel Pipe	24	49.2	178	167.3
Steel Pipe	24	16.4	177	105.0
Steel Pipe	36	16.4	190	105.0
Steel Pipe	36	32.8	183	147.6
Cast-in-Steel Shell	60	16.4	185	187.0
Cast-in-Steel Shell	96	32.8	195	584.0

[a]Measured values converted to 10-meter values using 20 Log (r) for common comparison. Reference for SEL is 1 μPa^2 –sec.

Note: Compiled by Rodkin & Pommerenck (2014); radii to threshold values calculated using 20 Log (r).

URS (2007) conducted a test pile-driving program at Anchorage in 2007 in association with the Port of Anchorage's Marine Terminal development project. The firm evaluated the sound pressure levels associated with both impact and vibratory driving of sheet and H piles. The results of this study are directly applicable to planned construction at the Project Marine Terminal, and indicate that for vibratory pile driving the radial distance to the 120-decibel isopleth was about 800 meters, while the distance to both the 190- and 180-decibel isopleths were less than 10 meters. URS found, as did Blackwell (2005), that noise levels emanating from vibratory pile driving in the silty nearshore waters of Cook Inlet drop off rapidly.

The results of the URS (2007) impact hammer analysis showed that the distance to the 160-decibel isopleth was about 350 meters, while the distances to the 190- and 180-decibel isopleths were less than 10 meters and 20 meters, respectively. These values were based on measured sound pressure levels of 160 dB re 1 µPa (rms) at 300 meters and 177 dB re 1 µPa (rms) at 19 meters, and are much less than what Blackwell (2005) measured during impact hammer pile driving at Port Mackenzie. However, the difference is attributed to the size and length of the piles. The URS study measured the driving of 14-inch H piles (more representative of Project construction), while Blackwell measured the deep driving of 36-inch pipe.

Vibratory Pile-driving – Non-Impulsive Underwater Noise

Vibratory pile drivers may also be used for construction at the Marine Terminal and West Dock. Vibratory pile drivers use a system of counter-rotating eccentric weights to transmit vertical vibrations into the pile. These vibrations "liquefy" the contacted sediments allowing the piles to easy gravitational sinking into the sediment bed, facilitated by the heavy-weighted hammer.

In 2005, Laughlin (2010a) collected underwater noise measurements associated with vibratory driving of 24-inch steel piles at a ferry terminal in Puget Sound, and recorded a near-source (10 meters) SPL of 162 dB re 1 µPa (rms) with dominant frequencies between 800 and 1,000 hertz. In 2009, Laughlin (2010b) again measured underwater noise associated with the vibratory hammering of 30-inch steel piles at a second ferry terminal. Here, average SPLs ranged between 160 and 169 dB re 1 µPa (rms) at distances between 11 and 16 meters from the source, with a maximum value of 169 dB re 1 µPa (rms) at 11 meters. Laughlin (2010b) also measured sound levels at 790 and 806 meters from the source and recorded SPLs of between 126 and 131 dB re 1 µPa (rms). Measured transmission losses ranged between 29 and 43 dB re 1 µPa (rms) and averaged 34 dB re 1 µPa (rms) over the approximate 800-meter range between source and received levels. Laughlin (2010b) concluded that the observed transmission loss was most accurately modeled by a logarithmic spreading loss of about 20 Log (r).

In 2004, Blackwell (2005) measured underwater sounds associated with the vibratory driving of two 36-inch piles at the Port MacKenzie dock in Cook Inlet, Alaska, and recorded mean SPLs of 162 and 164 dB re 1 µPa (rms) (at 56 meters from the source) depending on microphone depth (1.5 and 10 meters, respectively). Dominant frequency ranged between 400 and 2,500 hertz. Blackwell also characterized the sound propagation associated with hammering and calculated a logarithmic transmission loss of about 21.8 Log (r) for the deeper hydrophone and about 28 Log R for the shallower hydrophone.

Carr et al. (2006) assessed underwater noise impacts associated with development of the Cacouna Energy Liquefied Natural Gas terminal in Haro Strait, British Columbia. They measured transmission loss of experimentally transmitted sounds (at the center of the 1/3 octave bands ranging from 200 to 2,000 hertz) from six locations at distances between 834 and 3,248 meters from the sound source. Using vibratory hammer source data from Nedwell and Edwards (2002) (the loudest measurement was 151 dB re 1 µPa (rms) at 80 meters from the source; pile size not given but the photographs suggest 36-inch steel), Carr et al.'s (2006) modeled distance to the 120 dB re 1 µPa (rms) isopleth was 1.6 kilometers.

The results of this study would be directly applicable to planned construction at the Marine Terminal, and indicate that for vibratory pile driving, the radial distance to the 120 dB isopleth was about 800 meters, while the distance to both the 190- and 180-decibel isopleths were less than 10 meters (URS 2007). URS found, as did Blackwell (2005), that noise levels emanating from vibratory pile driving in the silty nearshore waters of Cook Inlet drop off rapidly.

SFS (2009) measured vibratory pile driving activity the Port of Anchorage and found maximum source (1 meter) levels to range between 161 and 198 dB re 1 μPa (rms) depending on pile type. Average source values ranged between 158 and 187 dB re 1 μPa (rms). Sheet pile placement generated the greatest noise levels, with the average distance to the 120-decibel threshold estimated at 2.3 kilometers and the maximum distance estimated at 8.2 kilometers. The maximum distance measurement occurred during a high tide and was considered a worst-case event.

In the above studies, distances to the 190-decibel and 180-decibel injury thresholds were less than 10 meters in all cases.

Table 15: Summary of Near-Source (10 meters) Unattenuated SELs for In-Water Pile Installation using Vibratory Driver/Extractor

Pile Type	Pile Size (inches)	Relative Water Depth (feet)	AverageSEL[1] (rms)
Steel Pipe	12	<16.4	155
Steel Pipe	36	~16.4	175
Sheet Pile	24	~49.2	167

[1]Measured values converted to 10-meter values using 20 Log (r) for common comparison. Reference for SEL is 1 μPa^2 –sec.

Note: Compiled by Rodkin & Pommerenck (2014)

Dredging

Dredging and trenching activities associated with construction of the Project would generate underwater noise. None of the noise sources associated with these activities are impulsive, but some of the sources, such as backhoeing and dumping, are also not continuous. Regardless, none of the noise-producing activities associated with dredging are expected to cause injury to migrating fishes. In fact, USACE dredging activities were monitored at the Port of Anchorage (URS 2007) and showed that none would have exceeded 180 decibels at the source. In fact, URS (2007) found that noise levels ranged between 136 and 141 dB re 1 μPa (rms) at distances ranging between 39.4 and 62.3 feet, respectively from the source. Representative noise levels and distances to the 120-decibel threshold are found in Table 16.

Table 16: Representative Underwater Noise Levels from Other Proposed Activities Generating Underwater Noise

Activity	Sources	SPL Documented	SPL Ref. to 32.8 feet	Distance to Threshold (feet)	Source
Dredging	Clamshell dredge of mixed coarse sand/gravel	113 decibels at 492 feet	136.5 decibels	223	Dickerson et al. (2001)
	Clamshell dredge in soft sediments	107 decibels at 33 feet	107 decibels	10	Dickerson et al. (2001)
	Winching in/out	117 decibels at 492 feet	140.5 decibels	351	Dickerson et al. (2001)

Activity	Sources	SPL Documented	SPL Ref. to 32.8 feet	Distance to Threshold (feet)	Source
	Dumping into barge	109 decibels at 492 feet	132.5 decibels	141	Dickerson et al. (2001)
	Empty barge at placement site	109 decibels at 1037 meters	139 decibels	295	Dickerson et al. (2001)
	Clamshell dredge at the Port of Anchorage	141 decibels at 39 feet	142.6 decibels	443	URS (2007)
Underwater trenching	With backhoe in shallow water	125 decibels at 328 feet	145 decibels	584	Greene et al. (2007)
Underwater grading	With dozer in shallow water	114 decibels at 328 feet	134 decibels	167	Greene et al. (2007)

Noise associated with dredging at the MOF would have the potential to affect (behavioral) the local fauna. Activities associated with dredging generate relatively low frequency ranges (20 to 1,000 hertz) that diminish with increased distance from the point source, resulting in the SPL (dB rms) decreased from 15 to 30 dB re 1 μPa-m at 150-m and 5,500-meter distances, respectively (Dickerson et al. 2001). An underwater sound characterization study conducted by the U.S. Army Engineering Research and Development Center (ERDC) and Dredging Operations and Environmental Research (DOER) Program established baseline data (Table 16) for mechanical dredging activities in Cook Inlet.

As mentioned, Cook Inlet is known for its extreme environmental conditions (especially the large tidal fluctuations), noise from relatively high current flow, and sedimentation displacement during tidal actions. These conditions create a relatively "loud" ambient noise background. A recent study (May 2011) in Knik Arm showed that ambient noise levels ranged from 105 to 148 dB re 1 μPa, with a mean of 124 dB re 1 μPa. Thirty-eight percent of ambient noise measurements were above 125 dB re 1 μPa (Knik Arm Bridge and Toll Authority {KABATA} 2011).

A comparison of the noise values in Table 16 and the mean value of ambient noise from the KABATA study shows that the peak SPL (decibels) of the loudest dredging activity (124 dB re 1 μPa) is at or below that of mean ambient noise levels. This is not consistent with Dickerson et al. (2001), which shows a much quieter mean ambient noise level (60 dB re 1 μPa). However, the KABATA study and the Dickerson study were done in different locations and different times of the year (May/July 2011 versus September 1999/August 2000), respectively, and the KABATA study measured ambient noise during multiple tidal cycles. Both studies used a "drift" technique to record ambient noises. Therefore, differences between the ambient noise levels of these two studies may be due to technique.

Furthermore, there is no indication that noise, both natural and from dredging at the Port of Anchorage are affecting salmon migration. Salmon regularly return to Ship Creek, which terminates adjacent to the Port of Anchorage, and to other area streams.

There is the potential that ambient noise conditions in and around the temporary MOF would not be as "loud" as those at Knik Arm and be closer to the ambient levels reported in Dickerson et al. (2001). However, given the apparent lack of significant effect of noise on salmon at the Port of Anchorage—which is consistent with the literature—indicates there would be a similar lack of effect in the temporary MOF area.

Finally, noises higher than ambient noise levels generated by the excavation of any Project area would be focused in a small location, when compared to the entire ecosystem. The noise values presented by the KABATA and Dickerson et al. (2001) reports are within the range of hearing for salmonids (Popper and Hastings 2009). However, migrating fishes (juveniles and adults) within the majority of the construction areas are able to freely avoid the activities and would avoid harmful exposure. This, coupled with mitigation measures that are intended to avoid migration of juvenile/adult salmon, would further reduce this effect.

Vessel Noise

Construction vessel traffic would create noise that could potentially be perceived by fish and would result in behavioral affects. Vessel noise would be short-term and any potential effects to EFH species would be discountable.

5.2.1.7 Hydrostatic Test Water Intake and Discharge (LNG Tanks)

Hydrostatic testing of each of the LNG tanks would require approximately 27,000,000 gallons of water over a 14-day period, with an average fill rate of about 1,400 gallons per minute. The planned source of the hydrostatic test-water for the LNG tanks is Cook Inlet. Hydrostatic test water intake would result in the entrainment and impingement of juvenile fish, fish eggs, and larvae, and pelagic invertebrates resulting in 100 percent mortality. If salt water is used, the intake within Cook Inlet would be screened and the intake rate reduced to the extent practicable to reduce the potential for entrainment and impingement of marine life. Uptake of sea water and testing can be mitigated by scheduling testing during periods outside of spawning and/or migration of local fish assemblages. With planned timing, the impacts of hydrostatic test water uptake are anticipated to be localized, minor, and temporary.

Discharge of the hydrostatic waters could create thermal refugia for larval, juvenile, and adult fishes. These thermal refuges could concentrate prey resources and have more dramatic impacts to the fauna of the region. BMPs typically used in these situations are to ensure discharge water temperatures match the ambient temperatures of the outflow area. No biocides would be used.

5.2.1.8 Habitat Displacement

Habitat displacement of fish due to the physical actions of dredging and the associated increased turbidity and noise would be temporary and localized. In Cook Inlet, the proposed action would occur prior to juvenile salmon outmigration into Cook Inlet and in-migration of spawning adult eulachon and salmon, but possibly around the onset of capelin movements into the area for spawning. Most mobile organisms would be able to move to adjacent habitat during the short time during which material is excavated. The Marine Terminal is a small percentage of the total EFH in Cook Inlet and following construction, any displaced individuals would be anticipated to rapidly return to the area.

Houghton (2005) and other sources indicate that returning adult salmon tend to occupy shallow water, probably to reduce predation by beluga whales. Welch et al. (2013) reported that returning Chinook adults were at a median depth of 4.85 meters, while returning sockeye adults had a median depth of 1.82 meters. Dredging would occur along the margins of this depth contour; however, adult salmon would not be concentrated in the Project area during the proposed timeframe for the dredging.

As noted, the area of initial dredging in Prudhoe Bay would be partially frozen. Arctic cod would not be in the bottom-fast ice area and would be expected to temporarily move from the area of disturbance associated with non-bottom-fast dredging. Following dredging, any displaced individuals would be anticipated to rapidly return to the area.

Habitat displacement due to the presence of the barge bridge between the existing causeway bridge would also be temporary and localized. As noted, the barges would be removed at the end of each sealift, any displaced individuals would be anticipated to rapidly return to the area. While the barge bridge is in place, restriction of fish movement between habitat areas would not be anticipated. The barge bridge would offer three areas for fish passage: the area between the barges and two areas between each barge and the dock bulkheads.

5.2.1.9 Spills

Minor releases of hydrocarbons (e.g., diesel fuel, lubricants) could result in short-term and minor adverse impacts on juvenile and adult fish, including death or chronic effects. The impacts of hydrocarbons are caused by either the physical nature of the oil (physical contamination and smothering) or by its chemical components (toxic effects and bioaccumulation). It is anticipated that the immediate response reaction of fish would be avoidance.

Minor releases of hydrocarbons could also result in short- or long-term adverse impacts on EFH species eggs and food sources. The impacts would depend on the depth of the spill and the type of hydrocarbon that is spilled. It is likely that any oil spills at the surface would tend not to sink below depths of 35 feet (MMS 2002a, 2002b). When oil sinks to depths around 35 feet, it is at concentrations several orders of magnitude lower than those demonstrated to have an effect on marine organisms (MMS 2002b). Based on the amounts of hydrocarbons stored on the vessels and the fact that all vessels are generally designed with features to reduce the potential for spills, any impacts from an inadvertent spill are generally anticipated to be localized, minor and short-term.

5.2.2 Operations

5.2.2.1 Seawater Intake and Cooling Water Discharge

LNGCs calling at the Marine Terminal would be carrying ballast water (sea water) upon arrival to Cook Inlet. The ballast water would have been exchanged in international waters according to international convention. As LNG is loaded onto the LNGCs at the Marine Terminal, the LNGCs would release the ballast water, thereby replacing the sea water with LNG product as ballast to maintain stability of the LNGC in the water. Approximately 2.9–3.2 billion gallons of ballast water would be discharged per year from LNGCs during LNG loading operations at the Marine Terminal, with the range in annual discharge volume due to varying LNGC sizes and number of voyages that may call at the Marine Terminal. The water discharged would be approximately 0-25 °F warmer than ambient water temperature in Cook Inlet. Ballast water discharged in Cook Inlet would be treated according to U.S. regulations.

Approximately 1.6–2.4 billion gallons of sea water per year may be taken in and discharged by LNGCs as cooling water while at the Marine Terminal. The water would undergo minimal filtration upon intake and supports a heat exchange process to provide cool water needed for the LNGC integrated cooling systems for equipment onboard such as main engines and diesel generators. The range in intake/discharge volumes account for the varying LNGC sizes and estimates of the number of LNGC calls at the Marine Terminal. The water discharged could be approximately 5 °F warmer than ambient water temperature in Cook Inlet.

The ballast and cooling water discharge is not expected to reach the seafloor. Therefore, demersal fish and benthic shellfish would not be affected. An increase in temperature could result in adverse behavioral and physiological impacts on fish. Because the discharge water plumes compose a relatively small area, impacts are expected to be minor. Additionally, pelagic fish would be expected to avoid the water discharge. Overall, long-term, minor, and localized impacts on pelagic fish would result from the ballast and cooling water discharge.

Water discharge could create thermal refugia for larval, juvenile, and adult fishes. These thermal refuges could concentrate prey resources.

Seawater intake often occurs through one of two upper or lower sea chests each measuring 1.5 meters by 2.0 meters (4.9 feet by 6.6 feet). Average water velocity through the lattice screens at the hull side shell would not exceed 0.5 feet per second (USCG and MARAD, 2009).

Direct impacts of the seawater intake could include entrainment of fish and invertebrate eggs and larvae passing through the intake screen. Mortality of juvenile salmon and forage fish eggs/larvae in the LNGCs' seawater intakes is assumed to be 100 percent. Most salmon juveniles (with the exception of chum salmon) would have short-term residence in the Project area with greatest potential exposure occurring in June to late July (Moulton 1997). Impacts to forage fishes would have the greatest impact to eggs and larvae during spawning/hatching time periods. No long-term impacts to either the juvenile salmon or forage fish species would be expected.

It is anticipated that the impacts on fisheries resources and EFH would be minor given the small scale of the LNGCs' intakes when compared to the entire area of Cook Inlet.

Both screens on the seawater intake structure and a seawater intake velocity of 0.5 feet per second would prohibit most juvenile and adult fish from being entrained in the seawater intake. Indirect impacts would occur because planktonic fish and shellfish serve as a source of food for some juvenile and adult fish species. While some juvenile salmon and/forage fish species could become impinged/entrained, it is expected that those numbers would be minor and no impacts on fish populations would be anticipated. Long-term and minor adverse impacts on fish and shellfish would result from the seawater intake associated with port operations.

5.2.2.2 Noise Disturbance

Noise generated by LNGC engine/boiler operations could have negative impacts on fish, including EFH species. As discussed previously, potential impacts of sound exposure on fish could include physical damage to the ear region, and physiological stress responses. However, the primary impact to fishes would be behavioral responses such as startle response, alarm response, avoidance, and a potential lack of response due to masking of acoustic cues. Noise from routine operations would be associated with ship transits, loading when moored to the port, and LNGC maneuvering activities. Because fish are mobile organisms, only localized behavioral effects would be expected to occur during operations.

5.2.2.3 Change of Hydrological Regime

Localized changes to the hydrological regime would be expected in the immediate vicinity of the in-water marine structures. Structural components of the facilities within the region would redirect currents away from the structures and may force fish farther offshore where they may become more susceptible to predation by marine mammals (seals, porpoise, and belugas).

5.2.2.4 Habitat Modification/Loss

The presence of the Marine Terminal and Mainline would result in a minor amount of long-term modification and loss of marine benthic habitat in Cook Inlet, including shading from overwater structures. The permanent structures for the Marine Terminal would cover approximately 20.2 acres of nearshore habitat. While forage fish, juvenile groundfish, and salmon would be in the area, no specific EFH is described for the Project location. The region is a migratory corridor and structures would force migrating fishes to move into deeper nearshore waters thereby increasing predation potential.

5.2.2.5 Spills

As discussed for Project construction, minor releases of hydrocarbons (e.g., diesel fuel, lubricants) could result in impacts on EFH species and food resources. Based on the amounts of hydrocarbons stored on the vessels and the fact that all vessels would be designed with features to reduce the potential for spills, any impacts from an inadvertent spill are generally anticipated to be localized, minor, and short-term.

Large releases of LNG could result in seawater cooling and freezing of surface layers. Potential impacts would include exposure to low-temperature LNG at the water surface, possibly resulting in frostbite or death. These impacts would likely occur in the immediate vicinity of the spill location; the timeframe of the impact would be limited. This would result in potential impacts to fish near the surface, through either behavioral avoidance of colder waters or physiological effects. In addition, there could be impacts on eggs and food sources at the surface. Impacts would be anticipated to be localized, short-term, and minor.

5.2.2.6 Decommissioning

Decommissioning activities would cause localized removal, turnover, and disruption of sediments, which could potentially displace, bury, or crush benthic organisms. Impacts on benthic communities from decommissioning could also cause individual fish to avoid feeding in the area for a short period. It is anticipated that displaced fish would return to normal feeding life styles within weeks after decommissioning activities cease. Overall, any potential impacts to EFH and EFH species from Project decommissioning activities are anticipated to be less than those of construction, short-term, and minor.

6.0 SUMMARY OF MITIGATION

The timing of stream crossing construction activities has been developed based on agency coordination regarding known periods of fish use for spawning and overwintering, the most sensitive periods for most fish species. Because most potential for impacts to fish and fish habitats associated with the Project are short-term in duration and construction-related, scheduling construction timing for non-sensitive low use periods of the year has been accommodated as possible. Most stream crossing construction would occur during winter when fish use is less dispersed and when most seasonal use habitats are absent of fish. As discussed in Section 5.1.1, the Applicant's *Plan* and *Procedures,* BMPs have been designed to reduce or otherwise mitigate potential impacts. A summary of potential impacts and mitigation measures is provided in Table 17.

Agency coordination has been an integral part of determining when and how construction should proceed at specific stream crossing locations. Agency coordination would continue and site-specific stream crossing plans developed during permitting for all crossings of streams where fish would be present during construction or where sensitive periods cannot be avoided. Permit conditions would be developed from these applications that would be implemented during construction.

Table 17: Summary of Potential Mitigation Measures

Activity	Potential Impact	Mitigation
CONSTRUCTION OF FACILITIES, ROADS, AND PIPELINES		
General Construction	Disruption of habitat that may lead to direct and indirect mortality and a decrease in mobility Increase in dust deposition	• Follow the BMPs in the Applicant's *Plan* and *Procedures*. • Follow construction techniques as outlined in Resource Report No. 2, including any site-specific crossing plans. • Keep construction activities within the proposed limits of disturbance. • Use temporary bridges and matting for transportation of construction equipment and materials across waterbodies. • Reduce the number of waterbody crossings to the greatest extent possible. • Identify stream crossing locations with the use of ROW signage.
Pile Driving	Serious injury and mortality of EFH species	• Follow the BMPs in the Applicant's *Procedures*. • Time activity to avoid migration of EFH species. • Use ramp-up procedures to alert fish of impending noise (e.g., as required for marine mammals).
Dredging	Disturbance of habitat and the disruption of the migration of EFH species	• Follow the BMPs in the Applicant's *Procedures*. • Time activity to avoid migration of EFH species.

Activity	Potential Impact	Mitigation
Waterbody Crossings	Disruption of habitat, fish mobility, and downstream sediment transport	• Follow the BMPs in the Applicant's *Procedures*. • Use site-specific crossing methods to reduce length of in-stream work (open-cut, dam and pump, or flumed crossing). • Construction windows would be timed to occur outside of sensitive time periods, especially near identified important fish habitats (i.e., spawning and wintering) or sensitive waterbodies to the maximum extent practicable. • Construct crossings as "tie-in" locations and use "tie-in" crews to take advantage of optimal crossing windows. • Design ice roads and bridges with adequate culverts per ADF&G requirements and in accordance with NMFS guidelines. • Backfill streams with native material. • Follow Applicant's *Plan* and *Project Restoration Plan*. • Construct pipeline crossing during low-flow or frozen times of the year as practicable. • Keep temporary bridges clear of excessive mud and debris.
Grubbing/Grading	Vegetation removal can lead to thermal impacts and increased sedimentation. Increase in dust deposition, due to construction equipment	• Follow the BMPs in the Applicant's *Plan*. • Minimizing unnecessary removal of riparian vegetation. • Institute a "no-grubbing" zone within 50 feet of each stream crossing, until crews and materials are on site and ready to be installed, to the extent practicable. • Avoid additional temporary work space areas within 50 feet of waterbodies to the extent practicable. • Restore disturbed banks upon completion of each crossing or as soon as practical, following Applicant's *Procedures* and Project *Restoration Plan*.
Floodplain Material Source Development	Stream channel changes, altered productivity, fish entrapment, barriers to fish passage Habitat enhancement, deep overwintering habitat	• Follow permit conditions for material site use. • Limit equipment use and the placement of structures within the floodplain. • Follow Applicant's *Plan* and *Procedures* and restore material site per landowner requirements. • Design site development to accommodate spring floods and avoid fish entrapment.
Blasting	Sedimentation, noise, vibrations, and alteration in stream morphology	• Follow *Blasting Plan* and obtain all necessary permits. • Avoid blasting during sensitive times of the year (spawning, wintering, etc.) to the extent practicable.
Access Roads (Temporary)	Habitat disruption, barrier to fish passage, change in stream morphology, increased dust deposition, and thermal impacts	• Use existing roads and the construction ROW travel lanes to the greatest extent possible. • Limit vegetation removal to tree trimming instead of removal as practicable. • Install proper-sized flumes and equipment bridges. • Follow *Dust Abatement Plan*. • Restore temporary roads per landowner agreements.
Contamination	Degradation in water quality	• Follow Project-specific *SPCC Plan*. • Identify "no fueling" areas with ROW signage.

Activity	Potential Impact	Mitigation
Water Withdrawal, Discharge, and Dewatering Activities	Impingement and entrainment of small fish, larvae, and eggs. Degradation in water quality and stream morphology.	• Follow the BMPs in the Applicant's *Plan* and *Procedures* and *Water Use Plan*. • Comply with water withdrawal and discharge permit requirements. • Assume water withdrawals use appropriately sized fish screens and other state and federal guidelines for fish protection. • Discharge of waters in a manner that does not create downstream scour or excessive bed and bank erosion. • Avoid dewatering sediment laden water directly in to waterbodies; use dewatering structures or filter bags.
OPERATION and MAINTENANCE ACTIVITIES		
Pipeline Maintenance and Inspections	Thermal impacts, Erosion and sedimentation, and increased public access to otherwise secluded waterbodies	• Follow the BMPs in the Applicant's *Plan* and *Procedures*. • At waterbody crossings, the riparian zone would be allowed to permanently vegetate. • Any required maintenance in and around streams would implement BMPs in the *Plan* and *Procedures* and any permit requirements. • Implement ROW patrolling, no-trespassing signs and the installation of gates, chains, or placement large boulders at pubic road and trail crossings.
Access Roads (Permanent)	Increase in impervious areas and stormwater run-off	• Structural BMPs to be installed as part of the overall facility design and SWPPP. • Design culverts and bridges to accommodate fish passage and flooding events.
Vessel Traffic	Noise, vessel movement, potential spills, and introduction of non-native nuisance species	• Ballast water would be treated according to U.S. regulations. • Vessels would only be allowed to travel within designated shipping lanes. • Implement a Spill Response Plan and train onsite spill response personnel.
Stormwater Discharge from the GTP and Liquefaction Facilities	Water quality and thermal impacts due to operational discharge	• Adhere to permit conditions outlined in any facility-specific Alaska Pollutant Discharge Elimination System Permit (if required). • Perform daily, weekly, and monthly monitoring and sampling of discharge out falls as required by permits

7.0 SUMMARY OF EFFECTS DETERMINATION

The potential direct and indirect effects of Project construction and operation on marine EFH and EFH species would be minor. This is due to the minor, localized nature of the proposed actions in Prudhoe Bay and Cook Inlet, the temporary nature of the impacts in each construction season, and the implementation of the mitigation measures.

Freshwater EFH and EFH species such as Pacific salmon would be encountered most commonly in the southern portion of the Project area. This is also the area where ice-rich soils are less common and surface water sources necessary for construction are more available throughout the year. Short-term, localized effects during construction are likely but most seasonally sensitive habitats would be avoided through the timing of winter construction. This would include implementation of out-of-sequence stream crossing construction at some sites to ensure construction occurs during the most benign period of the year for fish resources. Perturbation to sensitive fish overwintering and spawning areas could have longer-term effects of increased magnitude. Identification of important spawning and overwintering habitats through continued coordination with agency personnel and resource specialists would further identify sensitive habitats. Once overwintering areas are identified in relation to proposed crossing locations, appropriate mitigation measures would be developed.

Overall, impacts of greatest potential to effect EFH species are in-water noise disturbance from pile driving and perturbation of the substrate due to dredging (both during construction and for maintenance) in Cook Inlet.

Impacts to EFH species due to noise from pile driving (regardless of location) would be behavioral and short-term since most species would avoid the areas and/or are transiting through this region. Implementation of BMPs such as timing of pile placement, use of ramp-up methods, and the potential use of sound attenuation measures would also reduce any direct impacts to EFH species.

Modifications at West Dock would result in the direct, temporary but long term loss of 31 acres of EFH in Prudhoe Bay. An additional 16 acres would be impacted by seabed preparation for the berthing basin and barge bridges. These impacts would be minor compared to the subtidal shoreline habitat all around West Dock, temporary and short term for the period of construction. Arctic cod are highly mobile within the West Dock area and would move out of the areas of greatest impacts. Additional loss of approximately 5,000 cubic yards would be lost for dredging at the PTU.

Dredging activities associated with the Project would result in the direct temporary but long term loss of approximately 50 acres of EFH at the temporary MOF in Cook Inlet. Overall, EFH species within Cook Inlet would not be impacted in a negative manor since fishes there are in transition zones; fishes would, however, be forced into deeper waters (Cook Inlet) due to the loss of nearshore habitat during dredging and as a result of the facility structures. Timing as a result of mitigation (e.g., winter operations at West Dock) could further decrease potential impacts by conducting the dredging for the PTU expansion project outside migration windows (May–September; Cook Inlet) and would avoid potential direct impacts to all migrating fishes.

Additionally, there is a potential that dredge spoils could release toxic contaminants into the water column; however, the dynamic nature of both locations should flush any contaminants and therefore turbidity out of the area during each tidal cycle. Some sediment sampling and laboratory analyses have been conducted in or near the proposed dredging location in Cook Inlet and at the former Alaska Pipeline Project proposed dredge disposal site in Prudhoe Bay sediments at both locations have been found to be uncontaminated and to meet environmental standards for dredging projects. The results of the sediment analyses are summarized in Section 2.3.1.1.4 and Section 2.3.1.2.3.4 in Resource Report No. 2 and Resource Report No. 3, Section 3.2.7.3.2.2 (GTP Associated Infrastructure- Dock Head 4).

Table 18 provides a summary of the potential effects to EFH and EFH species during construction and operations of the Project, and summarizes their anticipated duration, extent, and significance to fish populations. After review of this draft assessment by agency personnel, a meeting would be held to discuss comments and a path forward to finalizing the mitigation requirements for EFH impacts from Project construction and operations.

Table 18: Summary of Major Potential Effects to EFH and EFH Species During Construction and Operation of the Project

Activity/Effect Category	Potential Impact	Effect	Potential Duration	Potential Extent of Impact	Significance	Significance with Mitigation and Known Habitats
CONSTRUCTION:						
Mainline Stream Crossings – including access roads						
Dry/Frozen Streambed – open cut	No fish present	NA	NA	NA	NA	NA
Wetted Stream bed – isolation cut	Temporary loss of habitat under flume	Temporary loss of habitat under flume	Short-term, duration of crossing	Minor, limited to flume length	Minor	Minor
Winter	Dewater/sediment input to overwintering areas/spawning gravels	Reduced habitat quality/mortality	Short-term, one season	Limited to crossing location, and downstream habitats in same stream	Dependent on fish use, could have population level effects in some instances	Minor
Summer	Reduced or blocked fish passage	Delays in migration for feeding and spawning	Short-term	Local at crossing location	Population level effects not anticipated	Negligible
	Increased sediment input/turbidity	Reduced stream productivity/Reduced feeding success	Short-term, during construction activities	Local at crossing location and a short downstream distance in summer construction	Population level effects not anticipated	Negligible compared to total reach of stream
Wetted Stream bed – aerial/buried trenchless	Increased turbidity	Reduced feeding success	Short-term, during construction activities	Localized for summer construction, not applicable for winter construction	Population level effects not anticipated	Negligible compared to total reach of stream
	Behavioral Disturbance	Reduced feeding success	Short-term, during construction activities	Localized for summer construction and 24 to 48 crossing disturbance	Population level effects not anticipated	Negligible compared to total reach of stream

Activity/Effect Category	Potential Impact	Effect	Potential Duration	Potential Extent of Impact	Significance	Significance with Mitigation and Known Habitats
Material Source Development – floodplain sites	Changes in stream morphology and sediment transport regime/reduced water quality	Reduced habitat quality, reduced fish passage to feeding, overwintering and spawning habitat	Long-term	Local stream reach	Dependent on stream and fish use of available habitat types, locally significant	Negligible to Minor
	Fish entrapment	Mortality	Long-term	Localized to material site location if unmitigated	Population level effects not anticipated	Negligible with BMPs to avoid entrapment
	Overwintering habitat creation	Increased winter survival	Long-term	Local stream/proximate streams	Population level effects could be seen in some areas	NA
Water Withdrawal	Fish entrapment/entrainment/ impingement	Mortality	Short-term, during construction activities	Localized to intake location	Population level effects not anticipated	Negligible, BMPs employed in Procedures and Permit conditions
Winter	Reduction in flow/habitat	Mortality	Short-term, winter season	Local, potentially extending to downstream habitats	Dependent on fish use, could have population level effects in some instances	Negligible
Summer	Reduction in flow/habitat/reduced fish passage	Change in productivity, reduced access to upstream habitats	Short-term during construction	Local, potentially extending to downstream habitats	Unlikely to have population level effects	Negligible
Blasting	Excessive overpressures	Mortality of fish and eggs/behavioral avoidance	Short-term, during construction activities	Localized	Population level effects are not anticipated	Negligible with BMPs (scare charges, sound attenuation measures) used to prevent fish impacts

Activity/Effect Category	Potential Impact	Effect	Potential Duration	Potential Extent of Impact	Significance	Significance with Mitigation and Known Habitats
Habitat Removal	Permanent loss of 67 acres of EFH (Arctic cod) at West Dock, and 34 acres of EFH (salmon) at the Liquefaction Facility MOF, additional salmon EFH loss at the site of the Mainline MOF	Change in movement of fishes depending on area and can increase mortality due to predation	Long-term – Life of the Project	Localized	Unlikely to have population level effects	Minor – structures would be colonized with new fauna – predation of migrating salmon at MOF could become an issue
Spoils Placement	Burial of organisms – release of toxins	Mortality of fish and eggs	Short-term, during construction activities	Localized	Unlikely to have population level effects	Negligible if no toxins are found in spoils materials
Dredging	Increased sedimentation/turbidity	Decreased productivity and feeding success – Mortality of fish and eggs/behavioral avoidance	Short-term, during construction activities	Localized	Population level effects are not anticipated.	Minor, see above on BMPs employed; timing of operations would reduce effects
Pile Driving	Severe – serious potential for injury and mortality	Mortality of juvenile fishes and the potential for adult salmon	Short-term, during construction activities	Localized	Unlikely to have population level effects	Minor, see above BMPs employed; timing of operations would reduce effects
OPERATIONS:						
Erosion – ditchline, stream crossings, material sites	Increased sediment and turbidity	Decreased productivity and feeding success	Long-term	Local stream	Unlikely to have population level effects	Minor
	Decreased fish passage	Reduced access to feeding areas and important spawning and overwintering areas	Long-term	Local stream	Unlikely to have population level effects	Minor

Activity/Effect Category	Potential Impact	Effect	Potential Duration	Potential Extent of Impact	Significance	Significance with Mitigation and Known Habitats
Chilled Pipeline/Frost Bulb	Decreased fish passage	Reduced access to feeding areas and important spawning and overwintering areas	Long-term	Local stream	Unlikely to have population level effects	Minor
	Decreased water temperature	Decreased stream productivity	Long-term	Local	Unlikely to have population level effects	Negligible
		Reduction in overwintering habitat, via freezing/mortality	Short- to long-term, if alternate habitats are available, effect would be short-term	Local	Dependent on location- could have local population level effects	Minor
Barriers to Fish Passage	Decreased access to feeding habitat	Lower growth rates, more competition	Long-term	Local	Population level effect not anticipated	Minor
	Decreased access to spawning habitats	Lower fish production	Long-term	Local	Population level effects not anticipated	Negligible
	Decreased access to overwintering habitat	Lower winter survival	Long-term	Local to river-wide depending on location	Dependent on fish use, could have population level effects in some instances	Minor
	Force migratory fish into deeper waters	Increased risk of predation of migrating fishes	Long-term	Local	Population level effects not anticipated but should be investigated	Minor

Activity/Effect Category	Potential Impact	Effect	Potential Duration	Potential Extent of Impact	Significance	Significance with Mitigation and Known Habitats
Hydrological/Stream Channel Changes	All of the above	All of the Above	Long-term	Most likely restricted to local stream	Dependent on fish use, could have population level effects in some instances	Minor
Vessel Traffic	Noise	Area avoidance	Long-term	Intermittent and localized	Population level effect not anticipated	Minor
Ballast and Cooling Water Management	Fish, marine invertebrates, zooplankton, and ichthyoplankton, entrapment/entrainment/impingement, Thermal plumes	Mortality, area avoidance – increased predation	Long-term	Intermittent and localized	Population level effect not anticipated	Minor
LNG Spills	Rapid temperature reduction	Direct mortality of individuals	Short-term, depending on location and timing, and fish passing area of spill. LNG vaporizes quickly (lighter than air) and would only impact localized layers of the water column near the surface.	Local to across portions of Cook Inlet	No population level impacts	Minor
DECOMMISSIONING:						
Removal of Structures – MOF	Destruction of habitat structure and removal/burial of local fauna	Direct mortality of individuals	Immediate and short in duration	Loss of diversity in the region with eventual reintroduction of resident species	No population level impacts	Minor

8.0 ACRONYMS AND TERMS

Term	Definition
Abbreviations for Units of Measurement	
°F	degrees Fahrenheit
cfs	cubic feet per second
dB	decibels
ft	feet
NTU	Nephelometric Turbidity Unit
rms	root mean square
SPL	sound pressure level
µg	microgram
µPa	micropascals
Other Abbreviations	
§	section or paragraph
ADF&G	Alaska Department of Fish and Game
ADOT&PF	Alaska Department of Transportation & Public Facilities
AFFI	Alaska Freshwater Fish Inventory
AGDC	Alaska Gasline Development Corporation
AKNHP	Alaska Natural Heritage Program
ANS	Aquatic Nuisance Species
AWC	Anadromous Waters Catalog
BLM	U.S. Department of the Interior, Bureau of Land Management
BMP	best management practices
C.F.R.	Code of Federal Regulations
CGF	Central Gas Facility
CWA	Clean Water Act
DOER	Dredging Operations and Environmental Research
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
ERDC	U.S. Army Engineering Research and Development Center
ERMA	Extended Recreation Management Areas
ESA	Endangered Species Act
FERC	United States Department of Energy, Federal Energy Regulatory Commission
FMC	Fisheries Management Council
FMP	Fisheries Management Plan
FERC	United States Department of Energy, Federal Energy Regulatory Commission
FMC	Fisheries Management Council
FMP	Fisheries Management Plan
GOA	Gulf of Alaska
GTP	gas treatment plant

Term	Definition
HAPC	Habitat Areas of Concern
HDD	horizontal directional drill
KABATA	Knik Arm Bridge and Toll Authority
Liquefaction Facility	natural gas liquefaction
LLC	Limited Liability Company
LNG	liquefied natural gas
LNGC	liquefied natural gas carrier
Mainline	an approximately 800-mile-long, large-diameter gas pipeline
MGS	Major Gas Sales
MLBV	Mainline block valve
MLLW	mean lower low water
MMPA	Marine Mammal Protection Act
MOF	material offloading facility
MP	Mainline milepost
MT	minnow trap
NAS	nonindigenous aquatic species
NEPA	National Environmental Policy Act
NMFS	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
North Slope	Alaska North Slope
PBTL	Prudhoe Bay Gas Transmission Line
PBU	Prudhoe Bay Unit
Project	Alaska LNG Project
PTS	permanent threshold shift
PTTL	Point Thomson Gas Transmission Line
PTU	Point Thomson Unit
ROW	right-of-way
SEL	sound exposure level
SPCC	Spill Prevention Countermeasures and Control
SWPPP	Storm Water Pollution Prevention Plan
TAPS	Trans-Alaska Pipeline System
TBD	to be determined
Applicant’s Plan	Applicant’s Upland Erosion Control, Revegetation, and Maintenance Plan
Applicant’s Procedures	Applicant’s Wetland and Waterbody Construction, and Mitigation Procedures
TSHD	trailing suction hopper dredge
TTS	temporary threshold shift
U.S.	United States
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USGS	United States Geological Survey
VSM	vertical support member

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APPENDIX A

Appendix Table A- 1: Freshwater Essential Fish Habitat Potentially Occurring in the Project Area

MP	Waterbody Name	Class	Proposed Construction Season	Proposed Crossing Method	Anadromous Water Catalog (AWC) Number	AWC Species	Fish Absence or Presence	Alaska Freshwater Fish Inventory (AFFI)**	EFH Species	Anadromous Species Presence	Over-wintering[1]	Spawning at Crossing Location	Species with Documented Spawning Upstream from Crossing
Mainline													
211.1	Middle Fork Koyukuk River	Major	Summer	Trenchless	334-40-11000-2125-3912	CHp, Kp, SFp, Wp	PRESENT – ADFG, TAPS, AFFI	Arctic grayling, slimy sculpin	Yes	Yes	Unknown		
229.1	Minnie Creek	Minor	Winter	Frozen Cut	334-40-11000-2125-3912-4128	Kr	PRESENT – ADFG, TAPS, APP 2010, AFFI	Arctic grayling, slimy sculpin	Yes	Yes	Unknown		
236.5	Marion Creek	Minor	Winter	Frozen Cut	334-40-11000-2125-3912-4112	CHs,Kr	PRESENT – ADFG, TAPS, APP 2010, AFFI	slimy sculpin	Yes	Yes	Yes		CH
241.0	Slate Creek	Minor	Winter	Frozen Cut	334-40-11000-2125-3912-4100	CHp,Kp	PRESENT – ADFG, TAPS	Anadromous stream, fish present	Yes	Yes	No		
261.24	South Fork Koyukuk River	Intermediate	Winter	Isolation Cut	334-40-11000-2125-3740	CHp,COp,Kp,Wp	PRESENT – ADFG, TAPS, APP 2010, AFFI	Arctic grayling	Yes	Yes	Yes		CH, K
272.94	Jim River	Intermediate	Winter	Isolation Cut	334-40-11000-2125-3740-4080	CHs,COp,Ks	PRESENT – ADFG, TAPS, APP 2010	Arctic grayling, slimy sculpin	Yes	Yes	Yes	Yes	CH. K
275.18	Douglas Creek	Minor	Winter	Frozen Cut	334-40-11000-2125-3740-4080-5062	Kr	PRESENT – ADFG, TAPS, APP 2010	Chinook salmon, AFFI point. Fish collected, no species identified	Yes	Yes	Unknown		
281.89	Prospect Creek	Intermediate	Winter	Isolation Cut	334-40-11000-2125-3740-4080-5030	Ksr	PRESENT – ADFG, TAPS, APP 2010, AFFI	slimy sculpin	Yes	Yes	Yes	Yes	K
357.08	Yukon River	Major	Summer	Trench-less	334-40-11000	CHp,COp,Kp,Pp,Sp,SFp,Wp	PRESENT – ADFG, TAPS	Anadromous stream, fish present	Yes	Yes	Yes		
439.14	Chatanika River	Intermediate	Winter	Isolation Cut	334-40-11000-2490-3151-4020	CHp,COp,Kp	PRESENT – ADFG, AFFI	General fish observation, no species information	Yes	Yes	Yes		CH, K
473.58	Tanana River	Major	Winter	Trenchless	334-40-11000-2490	CHp,COp,Kp	NO DATA	NO DATA	Yes	Yes	Yes		CH, CO
476.58	Nenana River (#1)	Major	Winter	Open Cut	334-40-11000-2490-3200	CHp,COp,Kp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes		CH, CO
489.74	Nenana River (#2)	Intermediate	Winter	Isolation Cut	334-40-11000-2490-3200	CHp,COp,Kp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes		CH, CO
505.26	Bear Creek	Minor	Winter	Frozen Cut	334-40-11000-2490-3200-4220	CHs,COs	NO DATA	NO DATA	Yes	Yes	Yes	Yes	CH, CO
	Unnamed Tributary to June Creek				334-40-11000-2490-3200-4220-5005-6016	CHs, COs			Yes	Yes	Yes	Yes	CH, CO
505.47	June Creek	Minor	Winter	Frozen Cut	334-40-11000-2490-3200-4220-5005	CHs,COs	PRESENT - ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CH, CO

MP	Waterbody Name	Class	Proposed Construction Season	Proposed Crossing Method	Anadromous Water Catalog (AWC) Number	AWC Species	Fish Absence or Presence	Alaska Freshwater Fish Inventory (AFFI)**	EFH Species	Anadromous Species Presence	Over-wintering[1]	Spawning at Crossing Location	Species with Documented Spawning Upstream from Crossing
520.14	Little Panguingue Creek	Minor	Winter	Frozen Cut	334-40-11000-2490-3200-4071	COs	NO DATA	NO DATA	Yes	Yes	Yes	Yes	CO
521.51	Panguingue Creek	Intermediate	Summer	Isolation Cut	334-40-11000-2490-3200-4075	COsr	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CH, CO
586.19	Middle Fork Chulitna River	Intermediate	Summer	Isolation Cut	247-41-10200-2381	COs, Ksr	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CO, K
589.65	East Fork Chulitna River	Intermediate	Summer	Isolation Cut	247-41-10200-2381-3260	COp,Ks,Sp	PRESENT – ADFG, AFFI	Anadromous stream, fish present	Yes	Yes	Yes	Yes	K
593.46	Hardage Creek	Intermediate	Summer	Isolation Cut	247-41-10200-2381-3260-4020	Kr	PLANNED – AKLNG 2015, AFFI	High stream gradient, no fish collected or observed	Yes	Yes	Unknown		
598.12	Honolulu Creek	Intermediate	Summer	Isolation Cut	247-41-10200-2381-3240	COpr,Ks	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	K
601.43	Little Honolulu Creek	Minor	Summer	Isolation Cut	247-41-10200-2381-3240-4020	Ks	ABSENT – AKLNG 2014	High stream gradient, no fish collected or observed	Yes	Yes	Yes	Yes	K
612.09	Pass Creek	Intermediate	Summer	Isolation Cut	247-41-10200-2381-3236	CHp,COp,Kp,Pp,Sp	PRESENT – AFFI	Dolly Varden, slimy sculpin	Yes	Yes	Unknown		
614.26	Little Coal Creek	Minor	Summer	Isolation Cut	247-41-10200-2381-3234	CHp	PRESENT – AKLNG 2014	Adult pink, juvenile Coho and Chinook, rainbow trout, Dolly Varden	Yes	CH, CO, K, P	Unknown		
617.79	Horseshoe Creek	Minor	Summer	Isolation Cut	247-41-10200-2381-3220	CHp,COp,Kp,Pp,Sp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes		CO
634.00	Byers Creek	Minor	Winter	Isolation Cut	247-41-10200-2381-3180	CHs,COs,Ks,Sp	PRESENT – ADFG, AFFI	salmonid-unspecified	Yes	Yes	Yes		
637.80	Unnamed Tributary to Chulitna River	Minor	Summer	Isolation Cut	N/A	N/A	PRESENT – AKLNG 2014	Juvenile salmon, adult pinks	P	P	N/A	N/A	N/A
640.59	Troublesome Creek	Minor	Winter	Isolation Cut	247-41-10200-2381-3130	CHs,COs,Ks,Ps	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CH, CO, K, P
641.54	Chulitna River	Major	Summer	Trenchless	247-41-10200-2381	CHs,COp,Kp,Pp,Sp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CH
650.10	Unnamed Tributary to Chulitna River	Minor	Winter	Frozen Cut	247-41-10200-2381-3073	COs,Ps	PRESENT – ADFG, AFFI	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CO, P
654.43	Unnamed Tributary to Chulitna River	Minor	Winter	Isolation Cut	247-41-10200-2381-3051	COp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Unknown		
657.93	Unnamed Tributary to Chulitna River	Minor	Winter	Isolation Cut	247-41-10200-2381-3007	COp	PRESENT – ADFG, AFFI	threespine stickleback, slimy sculpin	Yes	Yes	Unknown		
658.66	Unnamed Tributary to Chulitna River	Minor	Winter	Frozen Cut	247-41-10200-2381-3007-4029	COp		Anadromous stream, fish present	Yes	Yes	Unknown		
659.75	Unnamed Tributary to Chulitna River	Minor	Winter	Isolation Cut	247-41-10200-2381-3007-4017	COp	PRESENT - ADFG	Anadromous stream, fish present	Yes	Yes	Unknown		

MP	Waterbody Name	Class	Proposed Construction Season	Proposed Crossing Method	Anadromous Water Catalog (AWC) Number	AWC Species	Fish Absence or Presence	Alaska Freshwater Fish Inventory (AFFI)**	EFH Species	Anadromous Species Presence	Over-wintering[1]	Spawning at Crossing Location	Species with Documented Spawning Upstream from Crossing
661.19	Drywater Creek	Minor	Winter	Isolation Cut	247-41-10200-2361	COsr,ALp	PRESENT - AKLNG 2014	Coho salmon	Yes	Yes	Yes	Yes	CO
663.46	Trapper Creek	Minor	Winter	Isolation Cut	247-41-10200-2341	COsr,Kr	PRESENT - ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CO
666.35	Unnamed Tributary to Rabideux Creek	Minor	Winter	Isolation Cut	247-41-10200-2291-3049	COsr	PRESENT - ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CO
668.04	Unnamed Tributary to Rabideux Creek	Minor	Winter	Isolation Cut	247-41-10200-2291-3045	COr	NO DATA	NO DATA	Yes	Yes	Unknown		
669.78	Sawmill Creek	Minor	Winter	Isolation Cut	247-41-10200-2291-3041	COsr	PRESENT – ADFG, AFFI	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CO
669.91	Unnamed Tributary to Sawmill Creek	Minor	Winter	Frozen Cut	247-41-10200-2291-3041-4002	COp		Anadromous stream, fish present	Yes	Yes	Unknown		
672.06	Unnamed Tributary to Rabideux Creek	Minor	Winter	Isolation Cut	247-41-10200-2291-3025	COr	PRESENT – AFFI	stickleback-unspecified, lamprey-unspecified, sculpin-unspecified	Yes	Yes	Unknown		
673.17	Queer Creek	Minor	Winter	Isolation Cut	247-41-10200-2291-3011	COr,Kr	PRESENT – ADFG, AFFI	stickleback-unspecified, lamprey-unspecified	Yes	Yes	Unknown		
678.20	Unnamed Tributary of Queer Creek	Minor	Winter	Isolation Cut			PRESENT – AKLNG 2014	Meandering stream with intermittent palustrine scrub-shrub, Coho salmon	CO	CO	Unknown		
704.29	Deshka River	Major	Summer	Trench-less	247-41-10200-2081	CHs,COsr,Kpr,Pp,Spr,ALp,HWp	PRESENT – ADFG, AFFI	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CH, K, P, CO
705.02	Unnamed Tributary of Deshka River	Minor	Winter	Frozen Cut			PLANNED – AKLNG 2015, AFFI	lamprey-unspecified, salmonid-unspecified, Coho salmon	CO	CO	Unknown		
705.71	Unnamed Tributary of Deshka River	Minor	Winter	Isolation Cut			PLANNED – AKLNG 2015	stickleback-unspecified, salmonid-unspecified, Coho, Dolly Varden, slimy sculpin	CO	CO	Unknown		
707.11	Unnamed Tributary of Deshka River	Minor	Winter	Isolation Cut	247-41-10200-2081-3035	COr,Kr	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Unknown		
719.84	Fish Creek	Intermediate	Winter	Isolation Cut	247-41-10200-2053-3020-4015	COr,Kpr,Sp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Unknown		K, CO
720.36	Yentna River	Major	Winter	Open Cut	247-41-10200-2053	CHs,COsr,Kpr,Pp,Spr,OUs	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CH, CO
725.07	Anderson Creek	Minor	Winter	Isolation Cut	247-41-10200-2043	COp,Pp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Unknown		
727.21	Alexander Creek	Intermediate	Summer	Isolation Cut	247-41-10200-2015	COr,Pp,Kp,Sp,CHp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Unknown		K, CO, P
730.27	Pierce Creek	Intermediate	Summer	Isolation Cut	247-41-10200-2015-3019	COr	PRESENT – AKLNG 2014	67 fish-unspecified collected in (minnow trap) MT	Yes	Yes	Unknown		
732.29	Granite Creek (North Fork)	Intermediate	Summer	Isolation Cut	247-41-10200-2015-3017	COsr,Sr	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CO

MP	Waterbody Name	Class	Proposed Construction Season	Proposed Crossing Method	Anadromous Water Catalog (AWC) Number	AWC Species	Fish Absence or Presence	Alaska Freshwater Fish Inventory (AFFI)**	EFH Species	Anadromous Species Presence	Over-wintering[1]	Spawning at Crossing Location	Species with Documented Spawning Upstream from Crossing
733.81	Granite Creek (South Fork)	Intermediate	Summer	Isolation Cut	247-41-10200-2015-3017	COsr,Sr	PRESENT - AKLNG 2014	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CO
743.12	Tributary of Ivan River	Minor	Summer	Isolation Cut	247-30-10010-2023	Kr	PLANNED – AKLNG 2015	salmonid-unspecified, stickleback-unspecified	Yes	Yes	Unknown		
744.28	Lewis River	Minor	Summer	Isolation Cut	247-30-10070	COr,Ksr,Pp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	K
747.44	Theodore River	Intermediate	Summer	Isolation Cut	247-30-10080	CHp,COr,Ksr,Pp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	K
749.04	Pretty Creek	Minor	Summer	Isolation Cut	247-30-10090-2010	COr,Kr,Ps,Sr	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	K, P
749.89	Unnamed Stream	Minor	Summer	Open Cut		CO p	PLANNED – AKLNG 2015	48 Coho and Dolly Varden collected in MT, school of juvenile salmonids observed	CO	CO	Unknown		
751.32	Tributary of Pretty Creek	Minor	Summer	Isolation Cut	247-30-10090-2010-3015	COp,Ksr,Ps,Sp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	K, P
751.56	Tributary of Pretty Creek	Minor	Summer	Isolation Cut	247-30-10090-2010-3015-4015	COp,Kp,Ps,Sp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	P
752.94	Olson Creek	Intermediate	Summer	Isolation Cut	247-30-10090-2020	COsr,Ksr,Pp	PRESENT – ADFG	Anadromous stream, fish present	Yes	Yes	Yes	Yes	CO, K
756.04	Beluga River	Major	Summer	Open Cut	247-30-10090	COpr,Kpr,Pp,Spr	PRESENT – ADFG, AFFI	Anadromous stream, fish present	Yes	Yes	Unknown		
762.68	Threemile Creek	Minor	Summer	Isolation Cut	247-20-10002	CHp,COsr,Kpr,Ps,Sp	PRESENT – ADFG, AFFI	stickleback-unspecified	Yes	Yes	Yes	Yes	CO, P, S
PTTL													
25.6	Shaviovik River East	Intermediate	Winter	Open Cut	330-00-10310	Ps,DVp	PRESENT – AKLNG 2015	Anadromous stream, fish present	Yes	Yes	Yes	Yes	P
44.13	Sagavanirktok River Main Channel	Major	Winter	Open Cut	330-00-10360	CHp,Ps,BCp,DVr,LCp,Wp		Ninespine stickleback	Yes	Yes	Yes	Yes	P, W
53.68	Sagavanirktok River (West Channel)	Major	Winter	Aerial	330-00-10361	CHp,Pp,BCp,DVr,LCp,Wp		Anadromous stream, fish present	Yes	Yes	Yes		W

Notes:

1 – Overwintering habitat was assumed at crossing locations within or near salmon spawning habitats identified in the AWC.

Anadromous species codes from State of Alaska Anadromous Waters Catalog

Code	Species	Code	Species
K	Chinook	LP	Lamprey
S	Sockeye	LC	Least Cisco
CO	Coho	NSSB	Ninespine stickleback
CH	Chum	PC	Pacific lamprey
P	Pink	OM	Rainbow Smelt

AW	Arctic cisco	RBTR	Rainbow trout
GRAY	Arctic grayling	SF	Sheefish
LC	Arctic lamprey	SLSC	Slimy sculpin
BW	Bering ciso	SH	Steelhead
BC	Broad whitefish	TSSB	Threespine stickleback
DV	Dolly Varden	W	Whitefish
OU	Eulachon	PIKE	Northern pike
FHSC	Fourhorn sculpin		

Appendix Table A- 2: Marine Essential Fish Habitat Occurring in the Project Area

Facility/ Milepost	Waterbody Name	Fisheries Management Plan	Fishes	Potential Source/Season	Habitat Loss (acres)	EFH Species
Liquefaction Facility						
LNG Plant	Cook Inlet	Alaska EEZ Salmon FMP; Gulf of Alaska Groundfish FMP	Salmon[1] – marine stages Groundfish[2]; Forage fish[3]	Marine Discharge Potential for Spills/year-round	27 acres	Pacific salmon marine EFH
Marine Terminal	Cook Inlet	Alaska EEZ Salmon FMP; Gulf of Alaska Groundfish FMP	Salmon[1] – marine stages Groundfish[2]; Forage fish[3]	Habitat modification Potential for Spills Ballast Water/year-round	63.6 acres temporary 18.7 acres permanent	Pacific salmon marine EFH
Pipelines						
Mainline	Cook Inlet	Alaska EEZ Salmon FMP; Gulf of Alaska Groundfish FMP	Salmon[1] – marine stages Groundfish[2]; Forage fish[3]– egg larvae	Buried trenchless crossing, In-water construction/TBD	49 acres temporary	Pacific salmon marine EFH
Gas Treatment Plant						
Associated GTP Infrastructure	Beaufort Sea	Arctic FMP Alaska EEZ Salmon FMP	Arctic cod, saffron cod Salmon[1] – marine stages	West Dock Modifications/TBD	47.3 acres temporary 31 acres permanent[d]	Arctic Cod; Pacific salmon marine EFH
Dock Modifications – PTU	Beaufort Sea	Arctic FMP; Alaska EEZ Salmon FMP	Arctic cod, saffron cod, snow crab; Salmon[1] – marine stages	In-water Construction, Maintenance Dredging/TBD	5,000 cubic yards	Arctic Cod; Pacific salmon marine EFH

Notes:

[a] **Alaska EEZ Salmon FMP**

Chinook Salmon
Chum Salmon
Coho Salmon
Pink Salmon
Sockeye Salmon

[b] **GOA Groundfish FMP**

Walleye Pollock	Dusky Rockfish
Pacific Cod	Thornyhead Rockfish
Sablefish	Atka Mackerel
Yellowfin Sole	Squids
Arrowtooth Flounder	Sculpins
Northern Rock Sole	Skates
Alaska Plaice	Sharks
Rex Sole	Octopuses
Dover Sole	Southern Rock Sole
Flathead Sole	Yelloweye Rockfish
Pacific Ocean Perch	
Northern Rockfish	
Shortraker Rockfish	
Blackspotted/Rougheye Rockfish	

[c] **Forage Fish Complex**

Osmeridae (smelt)
Myctophidae (lanternfish)
Bathylagidae (deep-sea smelt)
Ammodytidae (sand lance)
Trichodontidae (sand fish)
Pholidae (gunnels)
Stichaeidae (pricklebacks)
Gonostomatidae (bristlemouths)
Euphausiacea (krill)

[d] Dockhead 4 (DH 4) at West Dock will not be operated or maintained by the Project.

Sources: Resource Report No. 1; NPFMC, 2009, 2014; NPFMC et al., 2012

Appendix Table A- 3: Potential Material Source Sites within 300 feet of EFH Waters.

Milepost	Material Site ID[a]	Stream Name	AWC Stream Code[b]	AWC Species[c]
75.97	65-9-072-2 FP2	Sagavanirktok River	330-00-10360	CHp,Ps,BCp,DVr,LCp,Wp
95.91	Proposed Site 1 Extra FP	Sagavanirktok River	330-00-10360	CHp,Ps,BCp,DVr,LCp,Wp
406.47	2015-LF1 FP	Tolovana River	334-40-11000-2490-3151	Kr
581.94	35-4-033-2 FP	Chulitna River	247-41-10200-2381	CHs
592.21	35-4-101-2 FP	East Fork Chulitna River	247-41-10200-2381-3260	Kr
617.92	35-3-027-1 FP	Horseshoe Creek	247-41-10200-2381-3220	COs

Notes:

Primary material sites located within 300 feet of an EFH waterbody.

Anadromous Waters Catalog (AWC) stream code (ADF&G, 2015).

[C] Anadromous species and life stage codes: BC = Broad Whitefish; CH = Chum Salmon; CO = Coho Salmon; DV = Dolly Varden; K= King Salmon; LC = Least Cisco; and W = Whitefishes, undifferentiated. Activity life stage modifiers: m =migration; p = present; r = rearing; and s = spawning.

Appendix Table A- 4: Potential Sources of Water to Support Construction with Identified Freshwater EFH

Pipeline (Spread)	MP	Water Type[a]	Stream/Lake ID	Distance (miles)	Average Monthly Discharge (cfs)		Lake Depth (ft)	Fish Presence			Water Rights		
					max	min		AWC	AWC Code	Species[l]	MTRS	Water Rights	TWUA
PTTL	44.2	R[d]	Sagavanirktok River	0.00	7310[i, k, n]	2.2[i, k, n]	N/A	Yes	330-00-10360	CHp, Ps, BCp, DVr, LCp, Wp			
PTTL	44.9	L	Unnamed Lake 12	0.10				Yes	330-00-10360	CHp, Ps, BCp, DVr, LCp, Wp			TWUP A2012-82
PTTL	45.8	L	Lake #10-01	3.35				Yes	330-00-10360	CHp, Ps, BCp, DVr, LCp, Wp			TWUP A2012-75
PTTL	53.0	R[b]		0.00	7310[i, k, n]	2.2[i, k, n]	N/A	Yes	330-00-10361	CHp, Ps, BCp, DVr, LCp, Wp			
Mainline (1)	36	R[d]	Sag River[h]	0-2	7310[i]	2.2[i]	N/A	Yes	330-00-10360	CHp,Ps,BCp,DVr,LCp,Wp	Various	Yes[m]	No
Mainline (1)	84	R[d]	Sag River[h]	0-2	7310	2.2	N/A	Yes	330-00-10361	CHp,Ps,BCp,DVr,LCp,Wp	Various	Yes[m]	No
Mainline (1)	95	R[d]	Sag River[h]	0-1	5920[k]	37	N/A	Yes	330-00-10360	CHp,Ps,BCp,DVr,LCp,Wp	Various	Yes[m]	No
Mainline (1)	101	R[d]	Sag River[h]	0	383[j]			Yes	330-00-10360	CHp,Ps,BCp,DVr,LCp,Wp	U006S014E05	Yes[m]	Yes[m]
Mainline (1)	211	R[f]	Middle Fork Koyukuk River[h]	0	364		N/A	Yes	334-40-11000-2125-3912	CHp,Kp,SFp,Wp	F031N011W19	No	Yes[m]
Mainline (2)	221	R[f]	Stream[h]	0	364[j]		N/A	Yes	334-40-11000-2125-3912	CHp,Kp,SFp,Wp	F031N011W19	No	Yes[m]
Mainline (2)	229	R[d]	Middle Fork Koyukuk River & Minnie Creek[h]	0-1	3560[k]	2.2	N/A	Yes	334-40-11000-2125-3912 & 334-40-11000-2125-3912-4128	CHp,Kp,SFp,Wp & KR	F030N011W18	No	Yes[m]
Mainline (2)	230	R[d]	Middle Fork Koyukuk River & Wiseman Creek[h]	0	111[k]	0	N/A	Yes	334-40-11000-2125-3912 & 334-40-11000-2125-3912-4123	CHp,Kp,SFp,Wp & KR	F030N011W19	No	Yes[m]
Mainline (2)	237	R[b]	Marion Creek[h]	0			N/A	Yes		CHs, KR	334-40-11000-2125-3912-4112	No	Yes[m]
Mainline (2)	242	R[f]	Slate Creek[h]	0-2	220[k]	0.57	N/A	Yes	334-40-11000-2125-3912-4100	CHp,Kp	F028N012W15	Yes[m]	Yes[m]
Mainline (2)	273	R[b]	Jim River	0			N/A	Yes	334-40-11000-2125-3740-4080	COr	F024N014W26	Yes[m]	No[m]
Mainline (2)	282	R[f]	Prospect Creek	0	5430[j]		N/A	Yes	334-40-11000-2125-3740-4080-5030	Ksr	F023N014W31		
Mainline (2)	357	R[d]	Yukon River	0	329000[k]	22400	N/A	Yes	334-40-11000	CHp,COp,Kp,Pp,Sp, SFp,Wp	F012N011W12	Yes[m]	No
Mainline (3)	403	R[f]	Tolovana River & West Fork Tolovana	0	481[k]	0.23	N/A	Yes	334-40-11000-2490-3151 & 334-40-11000-2490-3151-4501	CHp,COp,Kp & CHp	F007N005W05	No	Yes[m]
Mainline (3)	439	R	Chatanika Creek				N/A	Yes	334-40-11000-2490-3151-4020	CHp, COp,Kp	F002N006W25 F002N006W24	No	No
Mainline (3)	473	R[e]	Nenana River & Tanana River[h]	0-3	60400[k]	6570	N/A	Yes	334-40-11000-2490-3200 & 334-40-11000-2490	CHp,COp,Kp & CHp,COp,Kp	F004S008W14 & Various	Yes[m]	No

Pipeline (Spread)	MP	Water Type[a]	Stream/Lake ID	Distance (miles)	Average Monthly Discharge (cfs)		Lake Depth (ft)	Fish Presence			Water Rights		
					max	min		AWC	AWC Code	Species[l]	MTRS	Water Rights	TWUA
Mainline (3)	499	R[e]	Nenana River[h]	0-3	14500[k]	645	N/A	Yes	334-40-11000-2490-3200	CHp,COp,Kp	F008S009W14	Yes[m]	No
Mainline (3)	586	R[e]	Middle Fork Chulitna River[h]	0	21900	1010	N/A	Yes	247-41-10200-2381	CHs,COp,Kp,Pp,Sp	Various	Yes[m]	No
Mainline (3)	593	R[b]	Hardage Creek[h]	0			N/A	Yes	247-41-10200-2381-3260-4020	Kr	F021S010W02	No[m]	No[m]
Mainline (4)	647	R[e]	Chulitna River[h]	0-3	21900[k]	1010	N/A	Yes	247-41-10200-2381	CHs,COp,Kp,Pp,Sp	Various	Yes[m]	No
Mainline (4)	675	R[a,e]	Susitna River[h]	1-5	62900[k]	3460	N/A	Yes	247-41-10200	CHp,COs,Kp,Pp,Sp,ALp,DVp,HWp,OUs	Various	Likely[m]	No
Mainline (4)	690	L[b]	Trapper Lake[h]	0.37				Yes	247-41-10200-2081-3050-0050	COpr,Kr	S022N006W	No[m]	No[m]
Mainline (4)	704	R	Deshka River/Kroto Creek[h]					Yes	247-41-10200-2081	CHs,COsr,Kpr,Pp,Spr,ALp,HWp	S020N006W27	Yes[m]	No
Mainline (4)	721	R[e]	Yentna River[h]	0-5	53900[k]	2600	N/A	Yes	247-41-10200-2053	CHs,COsr,Kpr,Pp,Spr,OUs	Various	Yes[m]	No
Mainline (4)	725	R[e]	Susitna[h]	0-5	129000[k]	7160	N/A	Yes	247-41-10200	CHp,COs,Kp,Pp,Sp,ALp,DVp,HWp,OUs	Various	Likely[m]	No
Mainline (4)	744	R[b]	Lewis River	0			N/A	Yes	247-30-10070	COr,Ksr,Pp	Various	Likely[m]	No
Mainline (4)	756	R[b]	Beluga River				N/A	Yes	247-30-10090	COpr,Kpr,Pp,Spr	S013N010W07	Likely[m]	No
Mainline (4)	762	L[b]	Tukallah Lakes and Three Mile Creek	0.04				Yes	247-20-10002-0010, 247-20-10002-0020, 247-20-10002	CHp,COsr,Kpr,Ps,Sp	S012N010W07	Likely	No

Notes:

[a] L= Lake; R = River

[b] No gauge

[c] Anadromous

[d] Peak month = June

[e] Peak month = July

[f] Peak month = May

[g] Peak month = August

[h] Paralleling river or stream

[i] Low estimate of flow, draw off much farther downstream than gage

[j] Peak flow data only, not an average monthly cfs

k Summer demand met and peak met for entire year

[l] AC – Arctic Char, AW – Arctic Cisco, Al – Arctic Lamprey, BW – Bering Cisco, BC – Broad Whitefish, K = Chinook Salmon, CH – Chum Salmon, CO – Coho Salmon, CT – Cutthroat Trout, DV – Dolly Varden, OU – Eulachon, GS – Green Sturgeon, HW – Humpback Whitefish, SF – Inconnu/Sheefish, LP – Lamprey (undifferentiated), LC – Least Cisco, OL – Longfin Smelt, PC – Pacific Lamprey, P – Pink Salmon, OM – Rainbow Smelt, LV – River Lamprey, SM – Smelts (undifferentiated), S – Sockeye Salmon, SH – Steelhead Trout, ST – Sturgeon (undifferentiated), W – Whitefishes (undifferentiated), WS – White Sturgeon; m –Migration, p – Present, r – Rearing, s – Spawning; C – Copper River Meridian, F – Fairbanks Meridian, K – Kateel River Meridian, S – Seward Meridian, U – Umiat Meridian

[m] Peak flow to request split per source (assuming yearly demand met within a month period)

[n] Distributed sources (cfs) – 2.3

A full list of potential water sources is provided in the Water Use Plan in Resource Report No. 2.