4.24 FISH VALUES

The following section provides a description of the potential impacts to fish values (i.e., fish and aquatic invertebrates and their habitat) from the project in the Environmental Impact Statement (EIS) analysis area. Potential direct and indirect impacts to fish values described in this section include:

- Direct loss of aquatic (stream, lake, estuarine, and marine) habitat
- Direct impacts to fish and other aquatic organisms, including displacement, injury, and mortality
- Changes in surface water and groundwater flows that could indirectly affect stream productivity and spawning or rearing habitat
- Increased sedimentation of aquatic habitat caused by erosion from vegetation removal, access road stream crossing construction, or shoreline vessel wake
- Changes to freshwater and marine water quality, including water temperature, turbidity, pH, dissolved oxygen, and metal or chemical concentrations changes

Primary Impacts in or Near the Mine Site:

- Mine site development would permanently remove approximately 22 miles of fish habitat in the North Fork Koktuli and South Fork Koktuli drainages.
- The loss of habitat is not expected to have a measurable impact on fish populations based on physical habitat characteristics and fish density estimates in the affected reaches.

4.24.1 EIS Analysis Area

The EIS analysis area includes drainages and downgradient aquatic habitats that could be affected by project activities, from streams to marine waters.

The analysis area for the mine site under all alternatives and variants includes portions of the North Fork Koktuli (NFK), South Fork Koktuli (SFK), and Upper Talarik Creek (UTC) drainages. This area includes all aquatic habitats potentially directly or indirectly affected by permitted mine site activities (Figure 3.24-1). The geographic extent of the analysis area is driven by the modeled 2 percent reduction in suitable habitat in the NFK and SFK drainages, and extends to the confluence of the NFK and SFK rivers.

The analysis area for the port and transportation and natural gas pipeline corridors (where co-located) includes all aquatic habitat within 0.25 mile of the infrastructure; this analysis area is where potential effects may occur from construction and operations under all alternatives and variants.

The pipeline-only natural gas pipeline corridor analysis area includes the areas where the pipeline is not co-located with the transportation corridor. These sections of the natural gas pipeline have an impact width of 91 feet through Iliamna Lake, 102 to 183 feet through Cook Inlet, and 150 feet through overland areas.

The analysis area is not meant to encompass the aquatic habitat of all fish species known to occur in the analysis area. Rather, fish species that occur in and transit through the analysis area may be exposed to a variety of impacts from the project, and then move beyond/outside of the analysis area. It is understood that many fish species have a much larger range than the analysis area; however, this section focuses on fish species and habitat that have a potential to be affected during project construction, operations, and closure.

4.24.2 Methodology for the Analysis of Impacts to Fish Values

Impacts to fish values were evaluated based on regional data, baseline data, water management plans, surface water modeling, instream flow modeling, and water quality modeling. Impacts are assessed for different fish life-stages (incubation, spawning, rearing, and migration) and various aquatic habitats, where applicable. The construction, operations, closure, and post-closure phases of development are considered in the analysis.

The methodology applied to analyze and predict direct and indirect effects is based on the following factors:

- Magnitude—Effects on fish values depend on the specific species sensitivity to the type and scale of disturbance
- Potential—How likely the project impacts would affect species biology and habitat
- Duration—Four categories based on species recovery:
  - Temporary—Recovery days to weeks
  - Short-term—Recovery less than 3 years
  - Long-term—Recovery greater than 3 years to less than 20 years
  - Permanent—Recovery greater than 20 years, or no recovery
- Geographic extent—Depends on the season and location in which the disturbance occurs (e.g., during salmon migrations)

Concerns were expressed during the scoping meetings about the potential impacts to fish from the project. Commenters were concerned about the effects of ferry operations on resident and migrating fish; gravel pits (material sites) on stream hydrology and fisheries; disruption of habitat that could affect nutrients; water withdrawal on fish habitat; potential contamination from spills, the potential for fugitive dust to add heavy metals to fish streams; impacts to Amakdedori port on salmon and Dolly Varden; and erosion from construction and operations on fish and fish habitat. Commenters also requested that potentially impacted cataloged anadromous streams and anadromous streams that are not currently cataloged be discussed. Concerns about impacts from bridge and culvert placement were also expressed by commenters.

This section describes the evaluation and potential direct and indirect effects of Alternative 1a. Impacts of alternatives and variants and potential cumulative effects on fish values are also addressed. The quantification of impacts to aquatic resources is based on the field-verified stream mapping as described in Section 3.22, Wetlands and Other Waters/Special Aquatic Sites. It is important to note that the loss of habitat described in this section does not directly represent fish habitat. Impacts to known fish habitat based on baseline surveys and regionally available data are quantified and analyzed as appropriate.

Potential impacts to aquatic resources from various spill scenarios are described in Section 4.27, Spill Risk. Specific measures proposed by Pebble Limited Partnership (PLP) to mitigate impacts, including an Aquatic Resources Monitoring Plan, are discussed in Chapter 5, Mitigation. To the extent possible, these measures—including any associated potential impacts—were considered when assessing the impacts of the project on fish. Where there is insufficient detail to determine a measure's effectiveness (i.e., the Aquatic Resources Monitoring Plan), the measure could not be incorporated into the impact analysis but serves to inform the public of PLP's commitments.

4.24.3 Summary of Key Issues

Table 4.24-1: Summary of Key Issues for Fish Values

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Mine Site	**Habitat Loss:** **Stream habitats:** NFK: Permanent loss of 8.5 miles of anadromous fish stream habitat and 12.7 miles of resident fish and invertebrate stream habitat. SFK: ~~Permanent~~ loss of 1.4 miles of resident fish and invertebrate stream habitat. UTC: No habitat loss in mine site footprint. **Riverine Wetlands:** Permanent loss of 125 acres of riverine wetland habitat **Fish Displacement and Mortality:** Anadromous and resident fish mortality would occur in streams in the direct footprint of the mine site. Temporary fish displacement would occur during mine site construction. **Blasting:** Blasting impacts would be minimized during operations by following the guidelines established in the 2013 ADF&G Technical Report (No. 13-03) Alaska Blasting Standard for the Proper Protection of Fish. **Streamflow:** streamflow would be permanently removed from Tributary NK 1.190, and sections of NK 1.120, SK 1.0, and SK 1.190. Based on the project PHABISM fish habitat model, changes in the amount of suitable habitat during operations or closure are predicted to be low (e.g., less than a 2 percent change), in mainstem reaches of the NFK, SFK, and UTC for most species and life stages. Predicted decreases in suitable habitat are primarily based on changes to surface flows and are highest in tributaries draining the mine site (NK 1.190 and SK 1.190), whereas predicted changes are low or positive (increased habitat) in mainstem reaches downstream of the mine site for most Pacific salmon, and all resident salmonid species and life-stages. **Stream Productivity:** Fisheries, invertebrate, and riparian habitat and	Same as Alternative 1a.	Same as Alternative 1a.	Same as Alternative 1a. *Concentrate Pipeline Variant*: Mine site footprint would increase by 0.7 acre. Impacts would be similar to Alternative 1a.

Table 4.24-1: Summary of Key Issues for Fish Values

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	productivity would be permanently removed from Tributary NK 1.190, sections of NK 1.120 and SK 1.0, and SK 1.190. Downstream effects from loss of habitat includes less primary production, reduced nutrient cycling, reduction or loss in gravel recruitment, and less terrestrial inputs. Downstream water chemistry would be altered. **Stream Sedimentation and Turbidity:** Increased stream sedimentation could affect fish values during all project phases. Sedimentation could affect the quality and quantity of aquatic habitat, including salmonid spawning habitat, fish overwintering habitat, and invertebrate habitat. Erosion and sedimentation may increase turbidity, which can adversely affect fish feeding, growth, and survival (Lloyd 1987). Temporary impacts from sedimentation and turbidity could occur during construction. **Fish Migration:** Tributaries NK 1.190 and NK 1.200 and sub-tributary stream channels between the bulk TSF and the SCP would be blocked by the SCP embankment, and would not be accessible to anadromous fish migrating upstream. Fish migration would be permanently blocked from Tributaries NK 1.190, and sections of NK 1.120, SK 1.0, SK 1.34, and SK 1.190. **Water Temperature:** Slight increase in local surface water temperatures would be expected to occur immediately below discharge points, but would be required to be within ADEC water quality standards in NFK, SFK, and UTC. **Water Chemistry:** Permitted treated water discharges could affect fish and aquatic habitat; however, non-point discharges of treated water to surface water would not be planned. No noticeable changes in water chemistry greater than background levels would be expected.			

Table 4.24-1: Summary of Key Issues for Fish Values

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Transportation Corridor	**Road/Pipeline Waterbody Crossings:** *Total: 233 Fish stream crossings: 56 **Habitat loss:** Permanent loss of 1.7 acres of riverine wetlands[1] habitat in corridor footprint at fish stream crossings. Temporary disturbance of instream habitat at culvert and bridge crossings during construction. **Fish Displacement and Mortality:** Fish disturbance and mortality during culvert and bridge construction. **Blasting:** Fish streams within 1,000 feet: 40 **Streamflow:** Temporary impacts to streamflow during bridge and culvert installation. **Stream Productivity:** Temporary impacts to stream productivity during bridge and culvert installation. **Stream Sedimentation and Turbidity:** Temporary impacts from sedimentation and turbidity during bridge and culvert installation. **Fish Migration:** Temporary and localized impacts to fish migration during culvert and bridge construction. **Water Temperature:** No impacts to water temperature. **Water Chemistry:** No impacts to water chemistry.	**Road/Pipeline Waterbody Crossings:** Total: 224 Fish stream crossings: 52 *Kokhanok East Ferry Terminal Variant:* Total: 210 Fish stream crossings: 41 **Habitat loss:** Permanent loss of 4.4 acres of riverine wetlands habitat in the corridor footprint at fish stream crossings. *Kokhanok East Ferry Terminal Variant:* 4.4 acres of riverine wetlands. **Blasting:** Fish streams within 1,000 feet: 44 Impacts would be similar to those described for Alternative 1a, although lesser in geographic extent due to the fewer number of waterbodies crossed by the road corridor.	**Road/Pipeline Waterbody Crossings:** Total: 220 Fish Stream crossings: 55 **Habitat loss:** Permanent loss of 7.2 acres of riverine wetlands habitat in the corridor footprint at fish stream crossings. *Newhalen River North Crossing Variant*: The bridge design under this variant is similar to the base case Alternative 2: both require 5 spans. **Blasting:** Fish streams within 1,000 feet: 34	**Road/Pipeline Waterbody Crossings:** Total: 205 Fish Stream Crossings: 54 **Habitat loss:** Permanent loss of 7.7 acres of riverine wetlands habitat in the corridor footprint at fish stream crossings. *Concentrate Pipeline Variant*: There would be an increased area of disturbance, because the road corridor would be widened for pipeline inclusion. **Blasting:** Fish streams within 1,000 feet: 16
Ferry Terminals	**Habitat Loss:** Permanent loss of approximately 0.56 acre of benthic habitat at elevations less than the OHW level beneath the footprint of the ferry terminal at Eagle Bay, and 1.10 acres at the south ferry terminal. **Fish Displacement and Mortality:** Permanent loss of benthic organisms in the footprint of the ferry terminal. Temporary and localized impacts of	**Habitat Loss:** Permanent loss of approximately 0.8 acre of benthic habitat at the north and south ferry terminals. Other impacts would be similar to Alternative 1a.	Impacts are similar to Alternative 1a. Loss of benthic habitat at the Pile Bay ferry terminal would be 0.32 acre.	No impacts from the ferry terminals.

Table 4.24-1: Summary of Key Issues for Fish Values

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	propeller and wake disturbances during operation. **Streamflow:** No impacts to streamflow. **Benthic Productivity:** Permanent loss of approximately 1.66 acres of benthic productivity. **Stream Sedimentation and Turbidity:** Temporary sedimentation and turbidity impacts during construction. **Fish Migration:** No impacts to fish migration. **Water Temperature:** No impacts to water temperature. **Water Chemistry:** No impacts to water chemistry.	*Kokhanok East Ferry Terminal Variant:* Impacts would be the similar to those for the Eagle Bay terminal under Alternative 1a. *Summer-Only Ferry Operations Variant:* Larger vessel size may increase temporary and localized impacts to fish from propeller and wake disturbances during ferry operations. Other impacts are the same as Alternative 1a.		
Port	**Habitat Loss:** Permanent loss of 2.1 acres of benthic habitat beneath the caisson dock. **Fish Displacement and Mortality:** Mortality impacts to benthic organisms in the footprint of the port site. Noise displacement and potential mortality during caisson installation. Potential temporary and localized impacts of propeller and wake during ferry operations. **Streamflow:** No impacts to streamflow. **Marine Productivity:** Permanent loss of 2.1 acres of benthic productivity. **Sedimentation and Turbidity:** There would be no placement of fill; therefore, impacts due to suspended sediments and turbidity would not occur. **Fish Migration:** Temporary and localized impacts to fish migration during construction. No permanent impacts to fish migration.	**Habitat Loss:** Permanent loss of 10.6 acres of benthic habitat beneath footprint of causeway and jetty. Increase of about 1,900 feet of rock and aggregate riprap substrate along the port causeway. **Sedimentation and Turbidity:** Temporary impacts from sedimentation and turbidity during construction. Other impacts would be the same as Alternative 1a. *Pile-Supported Dock Variant:* ***Habitat Loss:*** 0.1 acre of benthic habitat. ***Fish Displacement and Mortality:***	**Habitat Loss:** Permanent loss of 14 acres of benthic habitat beneath dock footprint, similar to Alternative 1. Permanent impact to 58 acres of benthic habitat loss associated with construction and maintenance channel dredging for the life of the mine. Other impacts are similar to Alternative 1a and Alternative 1. *Pile-Supported Dock Variant:* ***Habitat Loss:*** Reduction from 14 acres of benthic habitat loss beneath the dock footprint to 3.68 acre.	Impacts would be the similar as Alternative 2. *Pile-Supported Dock Variant:* Impacts would be the same as Alternative 2.

Table 4.24-1: Summary of Key Issues for Fish Values

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
		Reduction of mortality to benthic organisms in the port footprint. Increased potential of noise-related disturbance and mortality during pile installation.		
Natural Gas Pipeline	**Habitat Loss:** Permanent loss of 1 acre of benthic habitat beneath pipeline footprint in Iliamna Lake. **Cook Inlet Natural Gas Pipeline:** 104 miles of pipeline placed in Cook Inlet. **Fish Displacement and Mortality:** Mortality impacts would occur to benthic organisms in the footprint of the pipeline and anchor activities during construction. **Streamflow:** No impacts to streamflow. **Stream Sedimentation and Turbidity:** Temporary sedimentation and turbidity impacts during construction. **Marine Productivity:** Long-term impacts to 11 acres of benthic productivity. **Fish Migration:** Temporary and localized impacts to fish migration during construction. No permanent impacts to fish migration.	**Habitat Loss:** Permanent loss of 4 acres of benthic habitat beneath the pipeline footprint in Iliamna Lake. Other impacts would be the same as Alternative 1a.	**Habitat Loss**: **Cook Inlet Natural Gas Pipeline:** 75 miles of pipeline in Cook Inlet. Other impacts would be the same as Alternative 1a.	Same as Alternative 2.

Notes:

[1] Riverine wetland acres are derived from the riverine and riverine hydrogeomorphic (HGM) classes described in Section 3.22, Wetlands and Other Waters/Special Aquatic Sites.

NFK = North Fork Koktuli
SFK = South Fork Koktuli
UTC = Upper Talarik Creek
ADF&G = Alaska Department of Fish and Game
TSF = tailings storage facility
SCP = seepage collection pond
ADEC = Alaska Department of Environmental Conservation
OHW = ordinary high water

Footprint based on project GIS data (PLP 2019-RFI 153).

Mitigation

Potential impacts were evaluated with consideration of mitigation measures described in Chapter 5, Mitigation. Additional mitigation measures would be developed through the Essential Fish Habitat (EFH) consultation with the National Marine Fisheries Service (NMFS). The draft EFH Assessment is provided as Appendix I.

4.24.4 No Action Alternative

Under the No Action Alternative, federal agencies with decision-making authorities on the project would not issue permits under their respective authorities. The Applicant's Preferred Alternative would not be undertaken, and no construction, operations, or closure activities specific to the Applicant's Preferred Alternative would occur. Although no resource development would occur under the Applicant's Preferred Alternative, PLP would retain the ability to apply for continued mineral exploration activities under the State's authorization process (ADNR 2018-RFI 073) or for any activity not requiring federal authorization. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration by other individuals or companies.

It would be expected that current State-authorized activities associated with mineral exploration and reclamation, as well as and scientific studies, would continue at levels similar to recent post-exploration activity. The State requires that sites be reclaimed at the conclusion of their State-authorized exploration program. If reclamation approval is not granted immediately after the cessation of activities, the State may require continued authorization for ongoing monitoring and reclamation work as it deems necessary.

4.24.5 Alternative 1a

This section describes the potential impacts of the project on aquatic species and habitat. The Draft EFH Assessment, referred to in these subsections, is provided in Appendix I.

4.24.5.1 Mine Site

Potential impacts to fish values at the mine site include direct loss of aquatic habitat in the NFK and SFK drainages; fish displacement, injury and mortality; changes in surface water and groundwater flows that could impact fish spawning, rearing, and off-channel habitat; increased sedimentation and turbidity in streams; impacts to fish migration; changes in surface water temperatures; and changes to surface water chemistry. Impacts to EFH from development of the mine site are quantified and described in Appendix I.

Direct Loss of Aquatic Habitat

The magnitude, duration, and extent of aquatic habitat loss from development of the mine site would be the removal of 99.7 miles of streambed habitat and 125 acres of riverine wetland habitat (See Section 3.22, Wetlands and Other Waters/Special Aquatic Sites, for a description of riverine wetlands). This loss of streambed habitat represents about 20 percent of available habitat in the Headwaters Koktuli River drainage, 12 percent of available habitat in the larger Koktuli River drainage, and 0.3 percent of available stream and river habitat in the Nushagak watershed. Note that the mine site area has been extensively surveyed while the remaining portions of the watersheds have not and there are many streams in these watersheds outside the mine site that have not been mapped. Thus, the loss of habitat is certainly overstated in context of the larger watersheds due to the lack of refined mapping.

The mine site would eliminate 21 miles of fish habitat in the Koktuli River watershed, 8.5 miles of which is anadromous habitat (see Section 3.24). No streambed habitat would be eliminated in the UTC drainage. As noted in Section 3.24, the quantification of fish stream habitat is based on project baseline surveys and regionally available data. It is recognized fish could occupy additional or fewer habitats, depending on a multitude of factors.

Direct stream habitat loss is described for each drainage (NFK, SFK, and UTC) in the following sections.

North Fork Koktuli

A total of 80 miles of stream habitat would be eliminated in the NFK drainage, including 8.5 miles of anadromous Pacific salmon habitat and 12.5 miles of resident fish habitat. Habitat removal would be limited to Tributary NK 1.190, Tributary NK 1.200, and their sub-tributaries in the NFK drainage (Figure 4.24-1). Chinook and coho salmon, along with Arctic grayling, Dolly Varden, rainbow trout, and sculpin species, have been documented in Tributary NK 1.190, Tributary NK 1.200, and sub-tributaries (see Section 3.24, Fish Values). These impacts would be certain to occur if the project is permitted and constructed.

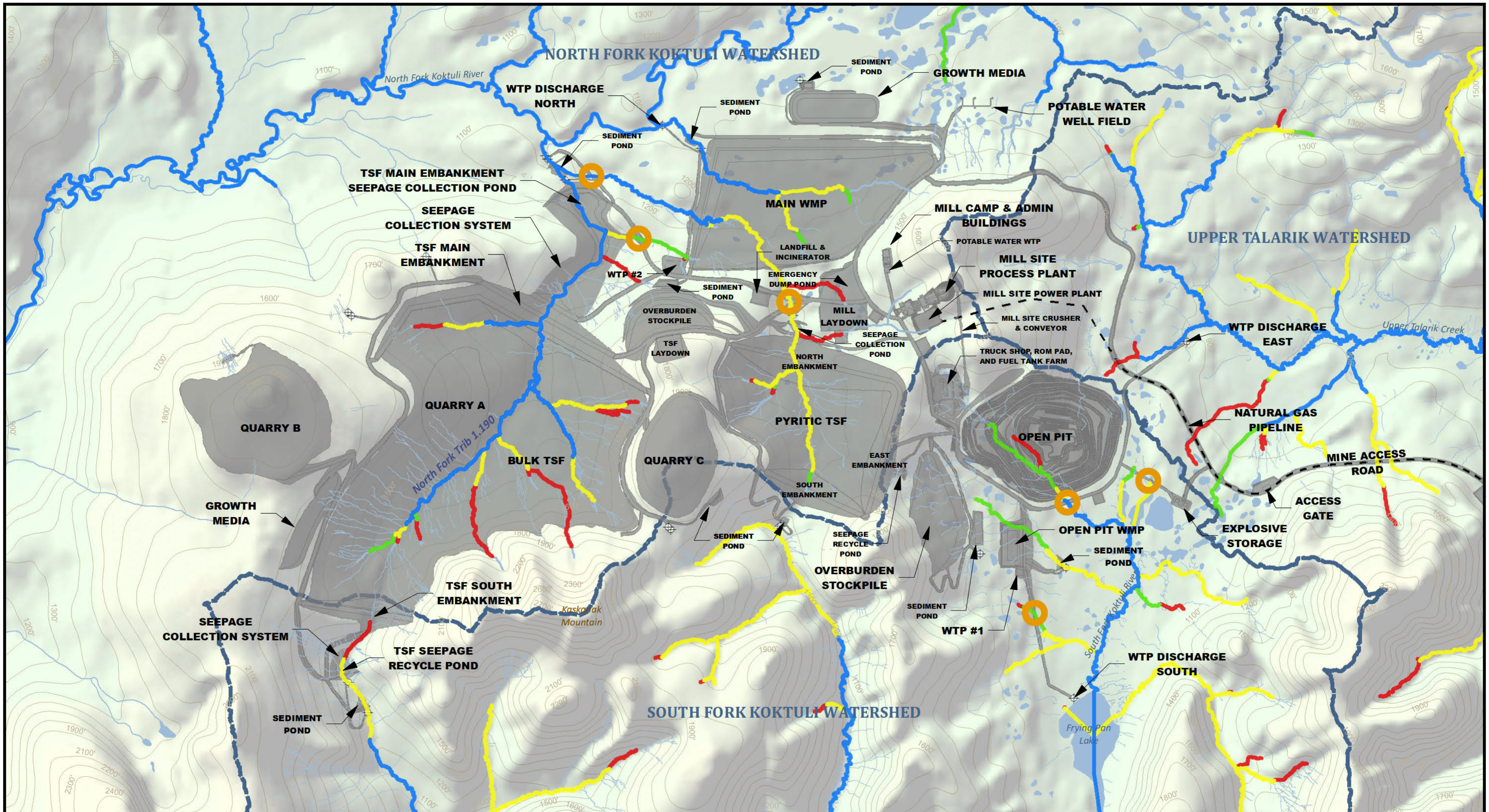
Except for coho salmon, Pacific salmon spawning has not been documented in Tributary NK 1.190 and sub-tributaries (see Table 3.24-4B), although resident fish species rear and presumably spawn in these tributaries. The substrate and physical characteristics of the tributary indicate it is not ideal spawning and rearing habitat for salmon (see Table 3.24-1 and Table 3.24-2). In contrast, heavy use of the mainstem NFK by spawning and rearing coho salmon is well documented downstream of the mine site (see Section 3.24, Fish Values). Most adult and spawning salmon were observed in the lower portion of the NFK in these downstream reaches (see Figure 3.24-6 and Appendix K4.24, Fish Values) (R2 et al. 2011a), indicating that adequate quantities of suitable spawning and rearing habitat are available to salmon downstream of the mine site.

Rearing juvenile salmon were observed in Tributaries NK 1.190 and NK 1.200, although at much lower densities compared to the mainstem NFK, Reaches A, B, and C (see Table 3.24-9 and Table 3.24-10). Tributary NK 1.190.10 exhibits intermittent flow upstream of the confluence with Tributary NK 1.190 for approximately 2 miles during the late summer. Low densities of juvenile Chinook salmon were documented in Tributary NK 1.200.

South Fork Koktuli

In terms of magnitude, duration, and extent, a total of 19 miles of stream habitat would be eliminated in the SFK drainage. No juvenile or adult Pacific salmon were observed in SFK habitat that would be directly lost with development of the mine site. Habitat removal would be limited to the uppermost headwater channels and sub-tributaries of SK 1.190, SK 1.340, and mainstem SFK (1.0) in the SFK drainage (Figure 4.24-1). The lost channels are known to contain sculpin and stickleback, and are likely to contain Dolly Varden and Arctic grayling. The loss of fish habitat would be certain to occur with development of the mine site.

Arctic grayling, Dolly Varden, rainbow trout, stickleback and sculpin species have been documented in lower reaches of Tributary SK 1.190 and sub-tributaries (see Section 3.24, Fish Values). Spawning coho salmon and chum salmon have also been documented in lower Tributary SK 1.190, 1 mile upstream of and at the mouth of the SFK confluence, respectively (see Figure 3.24-3A) (R2 et al. 2011). Coho salmon have been documented rearing in Tributary SK 1.190 approximately 4 miles upstream of the SFK confluence (R2 et al. 2011a). These habitats would not be eliminated with development of mine site facilities.



Sources:PLP 2019-RFI153; USGS; ADF&G AWC & AFFI; PLP (R2 et al. 2011)

US Army Corps of Engineers®

0.5 0 0.5 1
Miles

Fish Distribution
- Anadromous Salmonids
- Resident (non-anadromous) Salmonids
- Non-Salmonid Fish Only
- No Fish Observed
- Stream Crossing

Alternative 1a
- Monitoring Wells
- Natural Gas Pipeline
- Mine Site Footprint

Other Features
- Perennial/Intermittent Streams
- Lake/Pond
- Watershed
- 100' Contour (Existing)

MINE SITE AREA FISH DISTRIBUTION

PEBBLE PROJECT EIS

FIGURE 4.24-1

Upper Talarik Creek

The open pit and mine access road would extend to the western edge of the UTC drainage. Only a portion of the mine access road, the buried natural gas pipeline, and the WTP discharge location would be constructed in the UTC drainage (Figure 4.24-1). There would be a direct loss of less than 0.02 mile of streambed habitat in the UTC with development of the mine site.

Riverine Wetlands

The magnitude, duration, and extent of riverine wetlands loss from development of the mine site would be the removal of 125 acres of riverine wetland habitat. Riverine wetlands provide important rearing and refuge habitat for numerous fish species, along with a myriad of other functions (see Section 3.22, Wetlands and Other Waters/Special Aquatic Sites; and Section 3.24, Fish Values). The loss of riverine wetlands habitat would be certain if the project were developed and would result in the loss of functions these habitats provide to aquatic resources. The loss of these functions is considered in the downstream impact's discussion below.

Fish Displacement, Injury, and Mortality

Fish displacement, injury, and mortality would occur with the permanent removal of stream habitat in the NFK and SFK drainages. Temporary displacement of fish could occur with construction of the discharge chamber in UTC 1.46.

Surveys documented low densities and wide distributions of resident and anadromous fish throughout reaches in the NFK and SFK. Regardless of the protocol of the capture and relocation effort, the magnitude of impacts would be that some fish would be displaced, and experience injury or mortality. The extent or scope of these impacts would be limited to waters in the vicinity of the mine site footprint and may not be observed downstream from the affected stream channel.

Blasting for mine site construction and operations could also contribute to fish displacement, injury, and mortality, and would occur near fish-bearing waters in the headwaters of the SFK and tributaries to the NFK. Blasting can cause in-water overpressures and particle velocities lethal to fish (Kolden and Aimones-Martin 2013), resulting in changes to suspended sediment transport and turbidity, and direct impacts to fish spawning habitat (redds), adults, juveniles, and prey items. Impacts to fish and developing embryos could occur despite efforts to maintain sublethal thresholds, which would result in fish mortality in the immediate vicinity of blasting activities occurring adjacent to fish-bearing waters. Blasting during construction would be required to follow the guidelines established in the 2013 ADF&G Technical Report (No. 13-03) Alaska Blasting Standard for the Proper Protection of Fish. Additional fish surveys could be required in affected streams to determine fish presence and develop appropriate mitigation measures to reduce impacts.

Non-lethal blasting impacts may disturb or displace fish, but fish that are not killed would likely return to pre-activity conditions and distribution after the activity ceases. The duration and extent of non-lethal impacts would be temporary and limited to the immediate area. Measurable impacts to fish populations are not expected to occur from blasting activities, although individual mortalities are possible. Impacts would be expected to occur if the project is permitted and blasting were enacted as planned for the mine site.

Downstream impacts from Changes to Water Flows and Loss of Headwater Habitats

Mine site operations would be expected to result in an overall change in available water for release into downstream channels. Instream flows in the mainstem and certain tributary reaches of the NFK, SFK, and the UTC would be temporarily reduced during construction. These changes in surface water flow and groundwater result in indirect impacts to aquatic resources in approximately 66 miles of stream habitats The duration of flow changes would be permanent, beginning at project construction, and continuing through mine operations and post-closure.

The predicted changes in fish suitable habitat from changes in surface flows rely on the project streamflow modeling (Knight Piésold 2019r), which incorporates the groundwater modeling (BGC 2019a). Results of streamflow modeling indicate that most of the streamflow impacts would occur due to changes in surface water flows, and reduction in the groundwater contribution (because of pit dewatering) to streamflow would be minimal (see Section 4.17, Groundwater Hydrology). It is recognized that streamflow and groundwater interactions are complex, and dependent on a multitude of factors, and therefore, introduces a degree of uncertainty in terms of the magnitude and extent of impacts on aquatic resources. Uncertainties and limitations with the Baseline Watershed Model and Groundwater Model are described in Appendix K4.16, Surface Water Hydrology; and Appendix K4.17, Groundwater Hydrology, respectively. Appendix K4.17 describes the different predicted zones of influence that have been identified based on simulating a broad range of variability in hydrogeologic properties. The boundary conditions assigned to the model were used to evaluate the effects of variability of these parameters. Although the base case model is considered a suitable tool for evaluating the effects of pit dewatering, other viable simulations of the model using different input parameters are possible, and are discussed in Appendix K4.17, Groundwater Hydrology.

Appendix K4.24, Fish Values, describes the details regarding the selection, methods, and application of the instream flow model used to predict the effects of mine operations and closure on the quantity and quality of suitable habitat for the predominant anadromous and resident fish species. The habitat suitability criteria used in the instream flow model to define species- and life-stage–specific habitat preferences are presented in R2 et al. 2011a, Appendix 15.1C, Attachment 1, and further described in Appendix K4.24, Fish Values. The potential increases and decreases in suitable habitat described below are based on the criteria used in the instream flow model. It is recognized that the criteria applied in this analysis does not capture all habitat functions important to fish life-history stages, and therefore, the predicted changes could over- or underestimate the extent and magnitude of changes in suitable habitat.

The following subsections describe the potential impacts of streamflow changes and loss of headwater habitats on downstream aquatic habitats. The loss of headwater aquatic habitats, including 125 acres of riverine wetlands, would have downstream impacts to aquatic resources through post-closure. As described in Section 3.24, Fish Values; and Section 3.22, Wetlands and Other Waters/Special Aquatic Sites, these habitats provide numerous important inputs to downstream habitats. Potential impacts could include a reduction in downstream nutrients and organic material, changes in water quality and food availability, and reduction in gravel recruitment important to salmon spawning habitat. Downstream geomorphology could be altered over the long-term with the loss of physical contributions. These impacts are considered in the downstream impact analysis below.

Changes in Habitat Suitability

Downstream of the project footprint, habitat changes (as measured in acres of suitable habitat) vary by species, life-stage periodicity; drainage basin and reach; and for wet, average, and dry years (R2 Resource Consultants 2019a).

Although operations would be expected to change the availability of surface flows to area streams, releases of surplus treated water from the mine site into the NFK, SFK, and UTC would be optimized to benefit priority species and life-stages for each month and stream (Table 4.24-2). Reductions in streamflow would, in some cases, result in a predicted increase in habitat suitability (as measured in acres) for some species and life-stages, particularly those that show preferences for slower water velocities; for example, the juvenile life-stages of most species.

Table 4.24-2 Priority Species and Life Stages used to Determine the Seasonal and Spatial Distribution of Treated Water Discharges in the Mine Site Area

Month	Priority Species/Life Stages		
	SFK	NFK	UTC
January	Chinook Juvenile Rearing	Chinook Juvenile Rearing	Coho Juvenile Rearing
February			
March			
April	Arctic Grayling Spawning	Arctic Grayling Spawning	Arctic Grayling Spawning
May			
June	Rainbow Spawning	Rainbow Spawning	Rainbow Spawning
July	Chinook Spawning	Chinook Spawning	Sockeye Spawning
August			
September	Coho Spawning	Coho Spawning	Coho Spawning
October			
November			
December	Chinook Juvenile Rearing	Chinook Juvenile Rearing	Coho Juvenile Rearing

In general, changes in the amount of acres of suitable habitat during peak operations or closure are predicted to be small (i.e., less than a 2 percent change) in mainstem reaches of the NFK, SFK, and UTC for all species and life stages, with a majority of changes estimated to increase the amount of suitable habitat (Appendix K4.24, Fish Values). Decreases in suitable habitat would occur in NFK Tributary NK 1.190 (near 100 percent due to blockage) with some impacts to SFK Tributary SK 1.190; however, project-related flow changes at the mine site are not expected to negatively affect habitat in UTC Tributary UT 1.190 or in the UTC mainstem reaches. With few exceptions, predicted changes in habitat in the modeled portion of the upper mainstem Koktuli River (upstream of the Swan River) are near zero or positive, suggesting that project effects from flow changes would not negatively impact reaches downstream of the NFK and SFK confluence, or in UTC. These impacts associated with changes in streamflow would be certain to occur and would be permanent, lasting throughout the life of the project and closure.

Impacts to Spawning and Rearing Habitat

The loss of headwater habitats and changes in flow regimes could indirectly impact fish through effects on the quantity of suitable spawning and rearing habitat. Table K4.24-1 lists the predicted changes in the quantity (acres) of suitable spawning habitat by species per modeled reach and tributary for wet, average, and dry water years during pre-mine, operations, and closure phases. The percent change in habitat quantity from pre-mine to operations or closure are also shown, with predicted decreases of more than 2 percent shown.

Relatively few mainstem reaches show decreases in habitat of greater than 2 percent, with slightly more decreases in the dry year scenario than in the average year scenario, and fewer decreases in the wet year scenario. However, percent decreases equal or approach 100 percent for NFK Tributary NK 1.190, which would be removed by placement of mine site features just upstream of its confluence with the mainstem NFK, and would provide little or no spawning or rearing habitat for fish. Most of Tributary NK 1.200 would also be lost under the main WMP. Reductions in flow are also predicted to have impacts on spawning and rearing habitat in SFK Tributary SK 1.190.

In mainstem reaches, few changes in surface water flows are expected to result in decreased suitable habitat exceeding 2 percent. Most changes would be expected to increase suitable habitat (see Table K4.24-1), partially because of the WTP treated water discharge into the mainstem reaches (or tributaries immediately upstream of the mainstems) of the NFK, SFK, and UTC, according to the species and life-stage priorities listed in Table 4.24-2. Figure 4.24-2 shows that 81 to 90 percent of expected changes in suitable spawning habitat would be positive, or within 2 percent of pre-mine conditions, with more predicted increases in habitat than decreases, for both anadromous and resident fish species in an average water year scenario. All predicted decreases in suitable habitat exceeding 10 percent are from tributaries NK 1.190 and SK 1.190. Expected decreases in suitability of mainstem habitat for anadromous fish that would exceed 2 percent in an average water year scenario include Chinook salmon spawning in reaches NFK-B, NFK-C, SFK-B, and SFK-C (see Table K4.24-1 and Figure K4.16-3). The only decreases that would be expected to exceed 2 percent in the mainstem UTC are for Chinook salmon and chum salmon spawning in UTC-F in dry years, with all changes in other UTC reaches or water years either near-zero or positive.

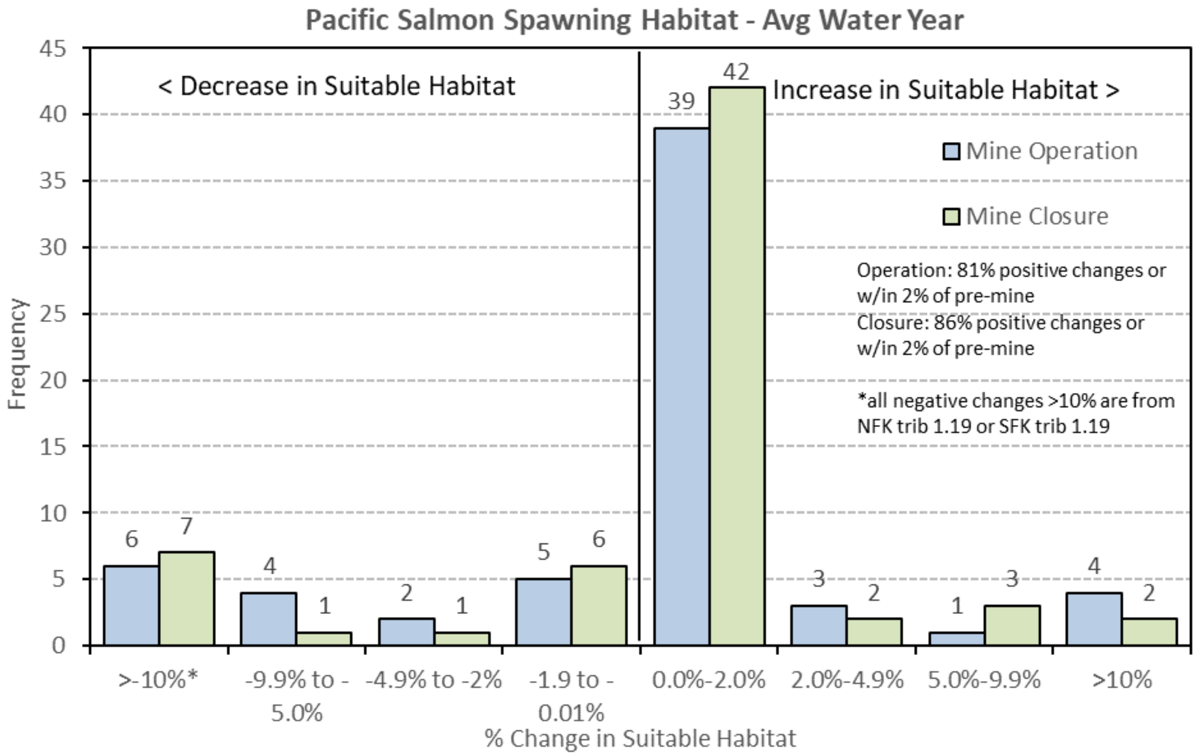
Figure 4.24-3 illustrates the relationship between predicted habitat for Chinook salmon spawning during pre-mine, operations, and closure with distance downstream of the mine site (see Table K4.24-1 for values representing other species and life-stages). More habitat occurs in reaches downstream of the mine site, with predicted changes due to operations in mainstem reaches generally minimal or indistinguishable from pre-mine conditions, except in Tributary NK 1.190 and Tributary SK 1.190.

Note that fish habitat modeling was conducted in three tributaries to mainstem reaches: NK 1.190, SK 1.190, and UT 1.190. Streamflow changes are also expected to occur and may result in decreases in suitable habitat in Tributary NK 1.200 and Tributary SK 1.340, which would be dammed; and UT 1.460, which would receive discharge of treated water. Reductions in groundwater may also result in minor (0.01 to 0.3 cubic foot per second [cfs]) changes in surface flows and fish habitat in Tributary SK 1.330, Tributary SK 1.370, Tributary SK 1.380 and Tributary UT 1.410.

The indirect impacts of flow changes on juvenile rearing habitat show similar patterns to those seen for spawning (Figure 4.24-4), with few predicted habitat decreases larger than 2 percent, except in NK Tributary 1.190 and SK Tributary 1.190 (see Table K4.24-2). Observed densities of juvenile anadromous salmonids were lower in these tributaries than in mainstem reaches farther downstream (see Table 3.24-9 and Table 3.24-10). The only mainstem decreases over 2 percent occurred for rearing juvenile sockeye, Dolly Varden, and Arctic grayling in NFK-D, and juvenile sockeye in SFK-C, all but one of which were for wet years, likely due to flows greater than optimal for those species. Note that estimates for NFK-D only represent the lower 1.2 miles of the reach downstream of Tributary NK 1.200, which is where the NFK treated water discharge would be located; the remaining 6.2 miles of mainstem habitat upstream of the discharge location would not be subject to flow modifications.

Instream flow modeling for adult rearing habitat for resident salmonids showed mostly positive changes in suitable habitat during operations (see Table K4.24-3 and Figure 4.24-5). Estimated decreases in adult habitat exceeding 2 percent are also evident for each species in NK Tributary 1.190, SK Tributary 1.190, and for Dolly Varden in NFK-D and Arctic Grayling in SFK reaches B and C.

Figure 4.24-2: Frequency of Percentage Change in Suitable Spawning Habitat from Pre-Mine to Operations or Closure during Average Water Year Scenario for Anadromous or Resident Salmonid Species



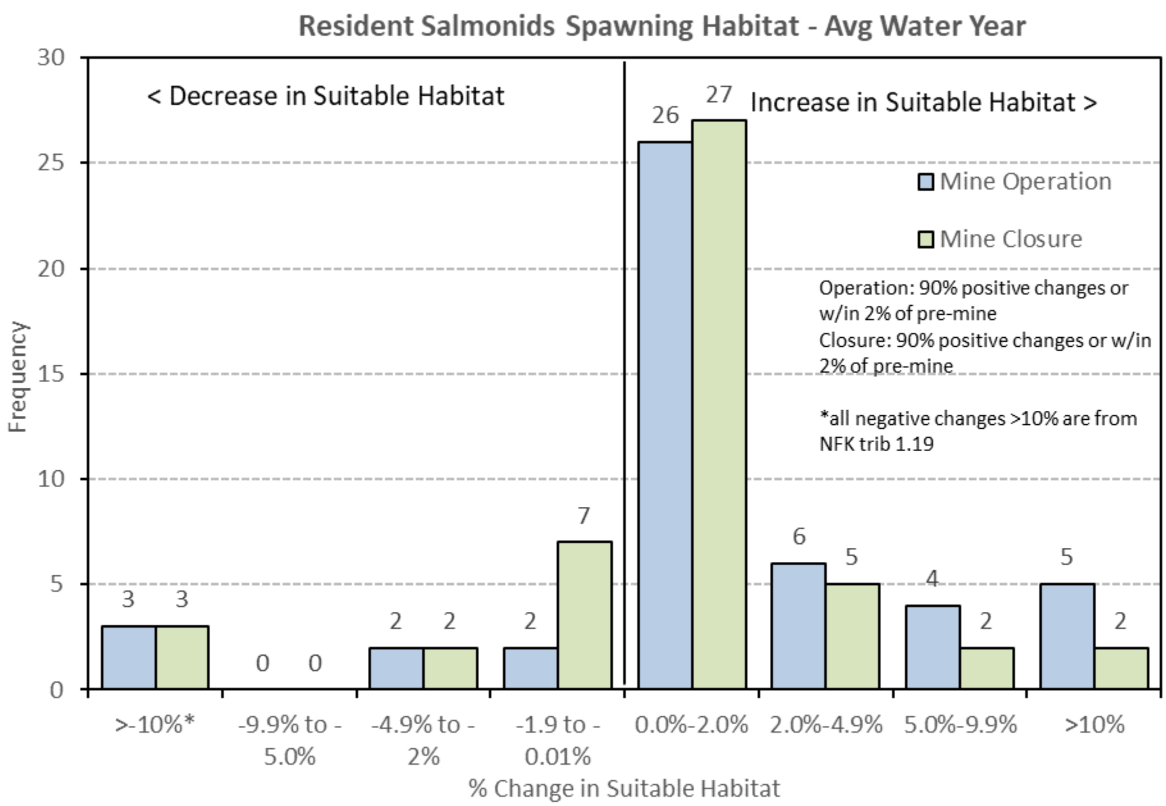


Figure 4.24-3: Predicted Changes in Suitable Habitat for Chinook Salmon Spawning during Average Water Year Scenario According to Reach and Project Phase

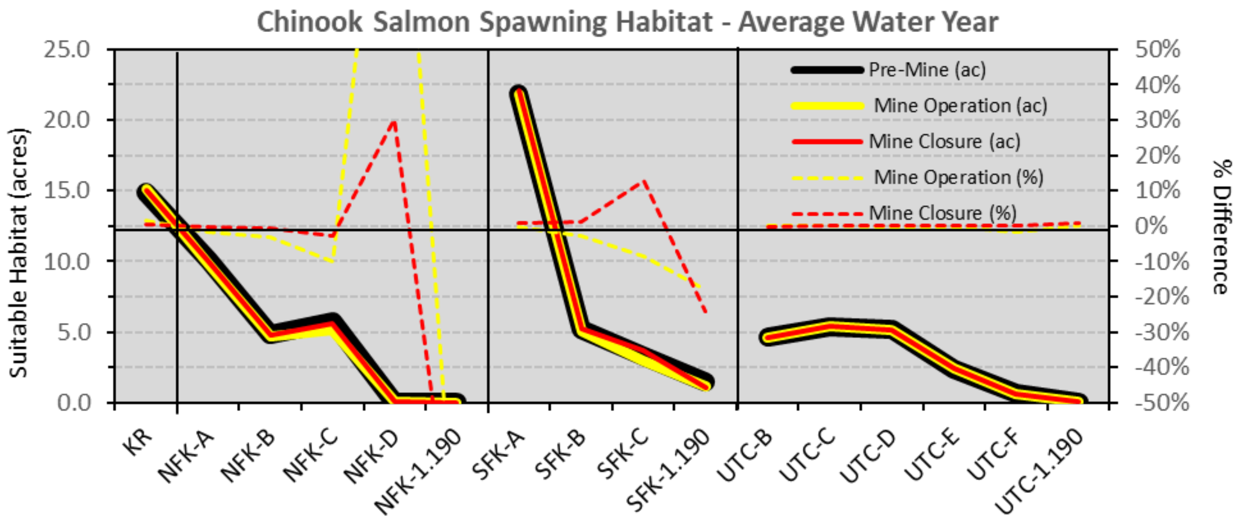


Figure 4.24-4: Frequency of Percentage Change in Suitable Habitat for Rearing Juvenile Salmonids from Pre-Mine to Operations or Closure during Average Water Year Scenario

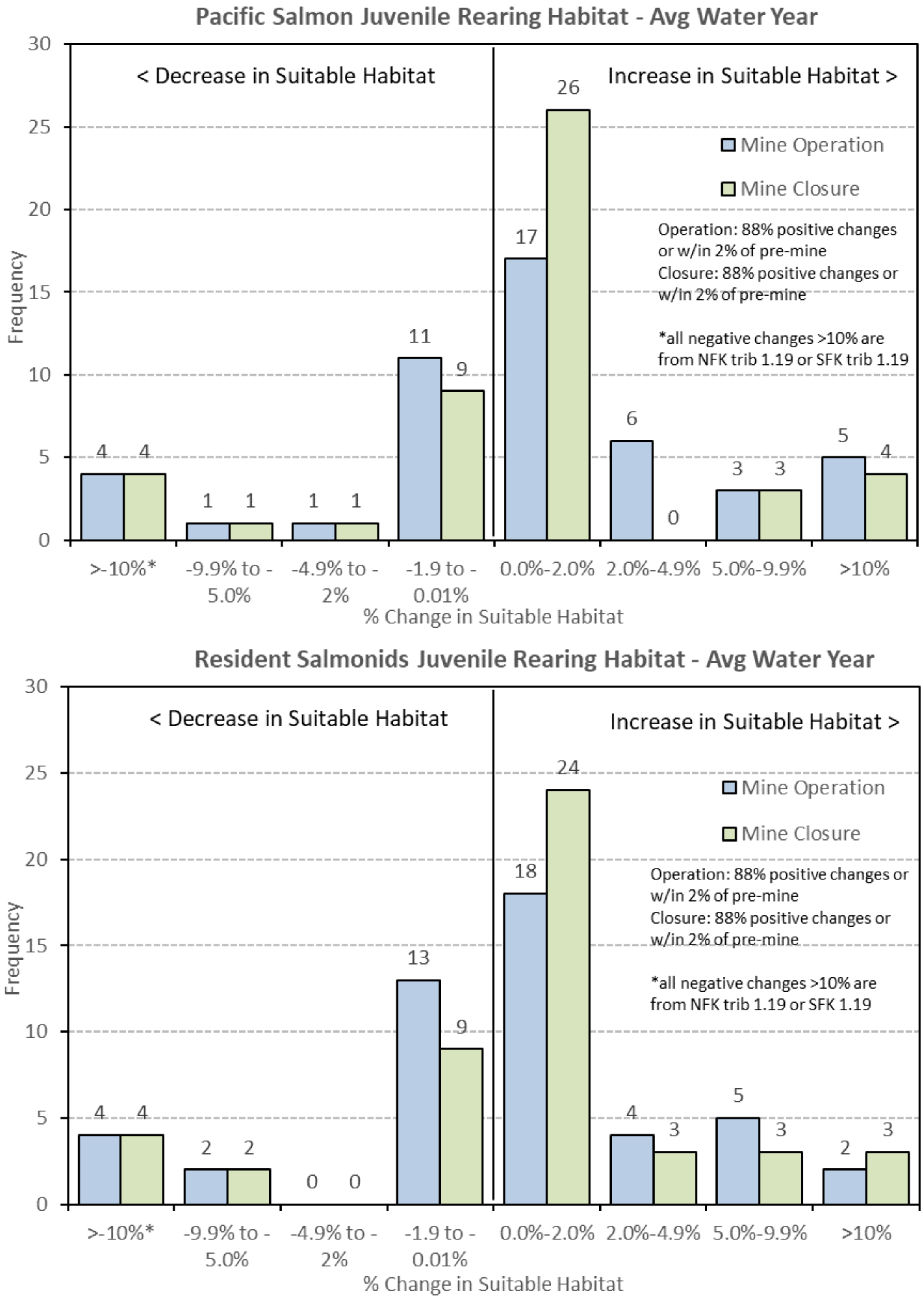
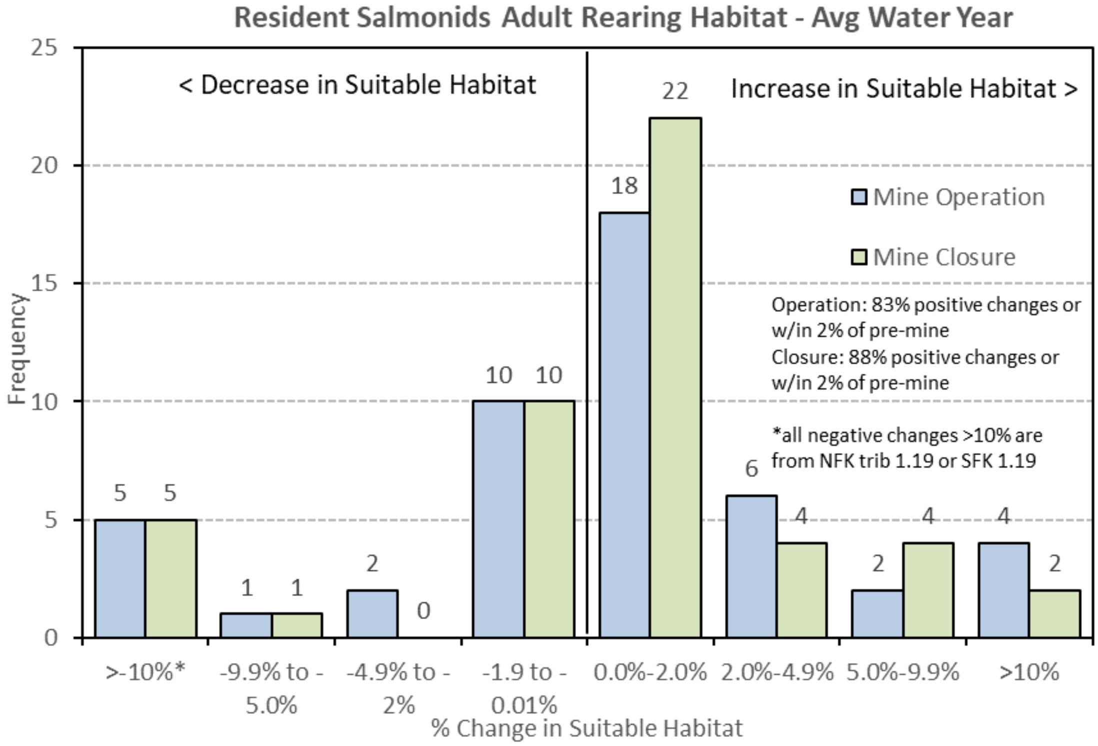


Figure 4.24-5: Frequency of Percentage Change in Suitable Habitat for Rearing Adult Resident Salmonids from Pre-Mine to Operations or Closure during Average Water Year Scenario



Indirectly, the loss of connection between NFK Tributaries NK 1.190 and NK 1.200 with the mainstem NFK and resulting decreased flows due to the construction of mine site features could result in permanent effects on the quality and quantity of spawning habitat by interrupting gravel transport into the mainstem NFK. Visual estimates of spawning gravel concentrations indicate that the substrate in Tributary NK 1.190 consists of cobbles with 20 percent or less gravel along most of its length; concentrations of gravel increase to 40 to 60 percent immediately upstream of the NFK confluence (R2 et al. 2011a, Appendix 15.1) (see Section 3.24, Fish Values). These data indicate gravel recruitment is primarily driven by tributaries other than NF 1.190. In addition, Chinook and sockeye salmon spawning areas were concentrated in the first 10 miles of the mainstem NFK, approximately 20 miles downstream of the mine site, where potential impacts of upstream gravel interruptions are unlikely. Two other sizeable tributaries (NFK Tributary NK 1.170 and Tributary NK 1.120) meet the mainstem NFK within 5 miles downstream of the confluence of the NFK and Tributary NK 1.190, so the extent of effects of reduced gravel recruitment would likely be local to the area directly downstream of the confluence of Tributary NK 1.190 and the NFK mainstem.

Most baseline survey pebble count sites in SK Tributary 1.190 showed low (less than 20) percentages of gravel (R2 et al. 2011a, Appendix 15.1F), and aerial counts revealed relatively low numbers of adult spawners in the tributary (see Figure 3.24-10). Note that SK Tributary 1.190 would be dammed in the uppermost headwaters (see Figure 3.24-3); therefore, the majority of that tributary and its subtributaries would retain unimpeded sediment transport into lower reaches of the tributary and into the mainstem SFK, where heavy spawning activity has been observed. Median pebble sizes in the upper SFK above Frying Pan Lake are generally smaller than in tributaries and mainstem reaches in the lower SFK; and although some pebble count locations showed high percentages of gravel, transported coarse sediments are ultimately trapped in Frying Pan Lake (R2 et al. 2011a).

Impacts to Fish Habitat from Alterations to Groundwater Hydrology

As described in Section 3.24, groundwater is an important feature of Pacific salmon habitats. Groundwater exchange directly affects the ecology of surface water by:

- Sustaining stream base flows
- Providing stable temperature habitats
- Supplying nutrients

The interaction between surface and groundwater has been shown to strongly influence the structure, function, and biodiversity of aquatic communities (Woody and Higman 2011). Groundwater has also been shown to play an important role in redd site selection of Pacific salmon due to some of the factors listed above. Spawning surveys conducted in 2008 indicated the heaviest spawning by coho and chum salmon in the NFK were concentrated 4 miles downstream of the confluence of NFK and Tributary NK 1.190, and were associated with groundwater expressions (see Figure 3.24-6). Coho, chum, and sockeye salmon adults were also aggregated in regions of groundwater influence in the SFK (see Figure 3.24-10).

Habitat suitability in mainstem reaches exhibiting groundwater influence were well represented in the instream flow modeling. Overall, 35 percent of PHABSIM transects were in groundwater areas, and 30 to 45 percent of HSC observations were made at redds or juvenile habitats in groundwater areas. Based on the instream flow modeling, open water habitats supported by groundwater are expected to be largely unaffected by changes in flow. As previously noted, streamflow and groundwater interactions are complex, and dependent on a multitude of factors, and therefore introduce a degree of uncertainty in terms of the magnitude and extent of impacts on aquatic resources. Larger predicted changes in groundwater flows could result in impacts to Pacific salmon natal homing, incubation, and overwintering habitats in the mine site analysis area. These changes in habitat functions could result in less fish productivity in the Koktuli River watershed due to the key functions these habitats provide to fish. These potential impacts are expected to be most apparent in headwater tributaries to the NFK (NK 1.200), the SFK (SK 1.190, SK 1.330, SK 1.370, SK 1.380) and UTC (UT 1.190 and UTC 1.410) and are not expected to result in significant changes to groundwater functions important to fish within the Koktuli River basin.

Impacts to Off-Channel Habitat

Based on the results of the streamflow modeling (see Table 4.16-3 and Appendix K4.24, Fish Values), flow alterations are expected to result in small changes to the availability of off-channel fish habitat in the mine site analysis area.

OCH in the NFK exhibits mainstem connectivity over a wide range of flows from 14 to 490 cfs, with similar ranges of connection flows in the SFK and UTC (see Section 3.24, Fish Values). Results of streamflow modeling described in Section 4.16, Surface Water Hydrology (Knight Piésold 2019q), indicates that mean monthly flows during operations (end of mine) would maintain stream and OCH connectivity within this range of flows for the NFK, SFK, and UTC. In general, a majority of OCH appears to become hydrologically connected to the main channel when flows exceed approximately 20 percent of bankfull in all three analysis area rivers. From a flow frequency/duration perspective, the 20 percent of bankfull level equates to roughly the mean July flow at the US Geological Survey gages on each of the three rivers (PLP 2018b).

Streamflow modeling suggests that the largest reductions in surface flows, (i.e., 30 to 50 cfs in the NFK during operation) (see Section 3.16, Surface Water Hydrology), are expected to occur during spring snowmelt, when flows are typically at their highest (i.e., 200 to 400 cfs in the NFK). Although OCH area is expected to decrease due to flow reductions, substantial OCH would remain during the spring high flow period. Also note that 85 to 93 percent of OCH are composed of beaver ponds, which stabilize water surface elevations and are less susceptible to changes in streamflow than are alcoves, side channels, or other flowing habitat types. In contrast to spring and summer months, mine operations are expected to increase surface flows during winter months, mostly by 5 to 20 cfs in the NFK, which would increase OCH area during a critical time, when many juvenile salmonids seek OCH as refuge from severe environmental conditions.

Modeled flows post-closure indicates that during dry years, mainstem connectivity may decrease in late winter during the month of April, but return to connectivity with the mainstem in May. This potential loss of connectivity could temporarily strand juvenile fish delaying their smolt out-migration or transition to preferred rearing habitats, and could result in increased competition for food sources. Habitat suitability in off-channel habitats outside of the mine site analysis area are not expected to be impacted.

Impacts to Nutrients and Productivity

Changes to surface water flow and loss of stream habitats and riverine wetlands could impact the availability of nutrients and invertebrate drift, thereby affecting overall stream productivity. Downstream functions could be altered with the removal of physical and chemical inputs from the loss of some headwater habitats. Functional connections between streams and riparian wetlands and their downstream waters vary geographically and over time, based on several factors, including proximity, relative size, and environmental conditions. Commonly exchanged inputs that could be affected from interruption of connectivity include water, heat, energy, nutrients, sediment, and organic matter (Leibowitz et al. 2019). Some downstream habitats could become less productive with the loss of physical, chemical, and biological inputs. Increased competition for food sources could occur for some individuals, and growth rates could be affected.

Nutrient concentrations in the analysis area are discussed in Section 3.24. Nutrient concentrations remain consistent throughout the mainstem NFK drainage, indicative of either local cycling of nutrient inputs and uptakes in stream reaches, or dilution from combining with mainstem flows. From gage NK 119A to 23 miles downstream at gage NK 100A1, the difference in measured nutrient concentrations is 0.018 milligram per liter (mg/L). Although this information is the only proxy available relating to direct impacts to riparian productivity in NFK Tributary 1.190, local attenuation of tributary nutrient contributions to mainstem reaches follow the same trends in the SFK and UTC drainages. The relative effects of losses of upstream subsidies would be highly context-dependent (Wipfli 2007) (see Section 3.24, Fish Values). The extent or scope of the impact of loss of riparian productivity would likely be limited to waters in the vicinity of the mine site footprint, and may not extend downstream past gage NK100B.

Indirectly, the loss of connection between Tributary NK 1.190 and the mainstem NFK because of mine site features could also result in permanent effects on the quantity of invertebrate drift transported downstream into the mainstem NFK. In terms of magnitude and extent, the loss of connection could also impact available habitat for benthic macroinvertebrate production, which is critical for fish growth and survival. Macroinvertebrate studies conducted as part of the environmental baseline effort concluded that a variety of macroinvertebrates and periphyton exists in NFK Tributary NK 1.190 that would contribute via drift to the food web into downstream reaches. Two other sizeable tributaries (NFK Tributaries NK 1.170 and NK 1.120) meet the mainstem NFK within 2 to 5 miles downstream of the mine site (see Figure 3.24-1), so the extent of effects of reduced macroinvertebrate productivity to downstream resources would likely be limited to the area directly downstream of the mine site (within 5 miles). Effects in the SFK subbasin are expected to be less, because direct loss of habitat or fragmentation of habitat due to sediment dams only occurs at the very upstream end of the mainstem SFK or tributaries to the SFK (e.g., SK 1.190 and SK 1.340).

The importance of marine-derived nutrients (MDN) in Bristol Bay watershed lakes from returning salmon is well documented (see Section 3.24, Fish Values). The amount of adult salmon biomass actually available for ingestion by fish (directly via salmon eggs or fragmenting tissue, or indirectly through ingesting invertebrates that assimilate carcass tissue) would be expected to be a small fraction (estimated between 0.1 to 1 percent) of what enters headwater systems, after accounting for removal by vertebrates (Cederholm et al. 1989; Gende et al. 2004) and other "losses" from flushing, fragmentation, physical adsorption, or burial (Cederholm et al. 1989; Gende et al. 2002; Moore et al. 2004).

Based on project baseline surveys, the streams directly impacted in the mine site are not considered major contributors of MDN from spawning salmon relative to downstream portions of the river network, making terrestrial nutrient sources relatively more important. This can be attributed to the comparatively small numbers of spawning fish, high flushing flows in the fall after spawning has occurred, and the lack of large woody debris or pool habitats for carcass retention. The extent or scope of impacts would likely be limited to waters in the vicinity of the mine site footprint and may not extend downstream from the affected stream channel.

Overall, downstream productivity in the NFK and SFK drainages would be affected with the loss of chemical, physical, and biological inputs from streams and wetlands eliminated with development of the mine site. Given the amount of MDN lost, limited nutrients and lack of woody debris in these affected streams, the magnitude of this impact is not expected to affect overall productivity in the greater Koktuli River basin. There are abundant small headwater streams in the Koktuli River drainage that would be unaffected by mine site development, and would continue to provide downstream inputs important for stream productivity. The extent of this impact would be confined to habitats immediately downstream of the impacted areas. Productivity in the NFK and SFK drainages would be impacted through post-closure and is certain to occur if the project is developed. Measurable changes to fish populations in the Nushagak watershed are not expected to occur from changes in stream productivity based on the extent and magnitude of changes in stream productivity.

Impacts to Fish Values from Increased Stream Sedimentation and Turbidity

Mine site activities that have the potential to release sediment into drainages and tributaries are discussed in Section 4.16, Surface Water Hydrology; and Section 4.18, Water and Sediment Quality. Increased stream sedimentation could affect fish values during all project phases. There would be potential for increased upland and stream channel erosion due to removal of natural vegetation, construction in streams, or the construction of earthen structures. Although the magnitude of the erosion would be larger than natural historic variation, the water management practices would keep the magnitude of the impact of the eroded sediment small (see Chapter 5, Mitigation).

Sedimentation is known to affect the quality and quantity of aquatic habitat. Fine sediments in streams are associated with degradation of salmonid spawning habitat quality and can affect the survival of incubating eggs, inhibit fry emergence, reduce instream cover and overwintering refuges for juvenile fish, reduce overall fish-carrying capacity, and decrease fish food availability (Limpinsel et al. 2017). Although sediment transport and deposition are natural stream processes, disruptions of the stream system and its functions could occur when sediment delivery is substantially changed, or when the ability or capacity of the stream to transport sediment is altered due to natural events or human activities. Erosion and sedimentation also may elevate turbidity, which can adversely affect fish feeding, growth, and survival (Lloyd 1987).

The potential for increased channel erosion downstream from road culverts in the mine site would be expected during construction. Based on the typical culvert drawings (see Figure 2-22 and

Figure 2-23), if a suitable flood-peak discharge is used for design, the magnitude of the impact is estimated to be small. The duration of the impact would be long-term, from construction through operations and into closure. The geographic extent of the impact would be within a few hundred feet of the downstream side of the culverts.Measurable changes in the quality and character of aquatic habitat from sedimentation would be limited to the mine site and road corridor footprint and immediate downstream areas in the NFK, SFK, and UTC drainages. The potential for increased erosion downstream from road culverts due to a culvert washout is considered unlikely, based on the typical culvert drawings provided (see Figure 2-22 and Figure 2-23), and if a suitable flood-peak discharge is used for design.

Permit-required monitoring of fine sediments deposited in spawning gravel would identify any degradation in spawning habitat quality and sources of potential impact. These impacts would be expected to occur if the project is permitted and constructed.

Development and operations of the mine site and its associated facilities (e.g., roads, embankments, and buildings) would be expected to result in increased surface runoff, which—if not captured and re-routed to treatment facilities—could lead to elevated turbidity in adjacent stream channels. Increased turbidity of discharge effluent may result if treatment of captured water in sediment and seepage ponds is not successful in removing all suspended sediments. Turbidity may also occur due to dissolved solids, which can alter color in treated discharge water. Best management practices (BMPs) would be implemented and maintained during construction and maintenance of all mine facilities to minimize surface runoff. All effluent discharged from WTPs would be subject to water quality criteria dictated by discharge permits, if issued. Treated water would be discharged through buried infiltration chambers designed to provide energy dissipation, erosion control, and freeze protection. Sampling at water discharge locations at all three principal tributaries would monitor any changes in turbidity over background levels and would identify Alaska Pollutant Discharge Elimination System (APDES) permit exceedance conditions and initiate remediation procedures. The magnitude and extent of impacts to turbidity would be in the mine site footprint; particularly when extreme weather events coincide with ground-disturbance activities. The duration of impacts would be permanent, lasting through the life of the mine; but greater over the short-term, when construction activities are occurring, and more turbid runoff would be expected.

Impacts to Fish Migration

NFK Tributary NK 1.190 mainstem and sub-tributary stream channels would be blocked by the bulk TSF SCP dam and would not be accessible to anadromous fish migrating upstream. Resident species may continue to use stream channels that provide suitable habitat that are blocked to fish passage, but not dewatered as spawning and rearing habitat. In addition, approximately 1.2 miles of stream channel in Tributary NK 1.190.10 would remain free flowing and provide resident fish habitat downstream of the main WMP to the bulk TSF sediment pond. As described previously, Tributary NK 1.190.10 exhibits intermittent flow upstream of its confluence with NK 1.190. NFK Tributary NK 1.200 would also be blocked to upstream migrant fish about 0.35 mile upstream of its confluence with the mainstem. Fish surveys showed the presence of juvenile Chinook and coho salmon in the lower end of this tributary (see Table 3.24-4E); however, it is unknown if these fish were the product of local spawning or were immigrants from the mainstem NFK.

Changes to Surface Water Temperatures at Treated Water Discharge Locations

Construction and operations may lead to changes in water temperature in downstream locations that have the potential to impact fish. Aldelfio (2018) describes how warmer winter water temperatures during warm/rain-transitional winters yielded a 58-day reduction in the median duration of coho salmon egg incubation in the Copper River Delta, Alaska. However, the magnitude of change at individual sites varied widely, and was largely controlled by water source. At groundwater-fed sites, temperature variations were strongly attenuated, leading to small interannual differences in incubation duration that were relatively insensitive to short-term changes in air temperature. In contrast, modeled incubation duration was shortened by up to 3 months during warm/rain-transitional winters at precipitation-fed sites. Studies reviewed by Weber-Scannell (1991) were conducted at water temperature ranges substantially higher than post-mining temperatures predicted in NFK, SFK, or UTC. Coho and sockeye salmon length at emergence decreased between 2 degrees Celsius (°C), and 2.0°C and 5.0°C, while chum and Chinook salmon length at emergence increased between and 5.0°C and 8.0°C, then decreased with higher temperatures (Weber Scannell 1991).

The Alaska Department of Environmental Conservation (ADEC) (2018b) standards for water temperature criteria associated with growth and propagation of fish, shellfish, and other aquatic life and wildlife in freshwater, state that at no time should maximum water temperatures exceed 20 degrees Celsius (°C), with the following life stage specific maxima: 15°C for migration and rearing, and 13°C for spawning and egg and fry incubation (ADEC 2018b). Although the baseline summer water temperature regimes in the analysis area frequently exceeded the ADEC criteria during the 2004-2009 sampling period, adult and juvenile salmon and resident fish species remain relatively abundant (see Section 3.24, Fish Values). Winter water temperature changes from mine operations could impact eggs and alevins in spawning gravels, primarily through increased metabolism, growth, and changes in time of emergence. Increases in water temperatures during alevin development can increase development rates and associated yolk conversion rates, potentially leading to faster yolk depletion and early emergence from the gravel at overall smaller sizes (Weber-Scannell 1991). Fry could emerge too early at suboptimal periods of the year and experience poor feeding, growth, and survival. The timing of hatch, and emergence in spring, are critical for survival; individuals that emerge early are more likely to establish feeding territory and competitive dominance than those that emerge later; however, if hatchlings emerge too early, they may experience high predation and reduced prey availability (Rooke et al. 2019). Spawn timing and incubation temperature are considered key factors affecting phenology of hatch, with warmer incubation temperatures resulting in faster physiological development and shorter incubation periods. Numerous other factors affect the timing of hatch/emergence beyond water temperatures, including dissolved oxygen, temporal thermal variability, sedimentation, and the spatial variability of intra-gravel incubation conditions (Rooke et al. 2019).

Modeling of temperature impacts applied baseline temperatures, flow data, and predicted WTP discharge temperatures to determine the expected temperature effects(R2 Resource Consultants 2019b). In terms of extent of impacts to surface waters, the modeled temperature effects are based on a limited set of measured water temperatures and flow scenarios collected at specific locations; the calculated discharge impacts reflect those conditions and locations. The duration and likelihood of impacts would be long-term, and certain to occur if the mine is permitted and constructed as designed. The calculated temperature effects provide a reasonable estimate of typical temperature effects from operational WTP discharges, and are summarized in Table 4.24-3 for the NFK, SFK, and UTC. It is recognized that temperatures are reported on a monthly average versus a daily timestep, and therefore provide a broader view of modeled temperature changes. The potential for daily temperature variations beyond the modeled ranges presented below exist; however, the range reported is considered representative of potential temperature changes.

Table 4.24-3: Range of Average Stream Water Temperatures Pre-Mine and After Release of Treated Water

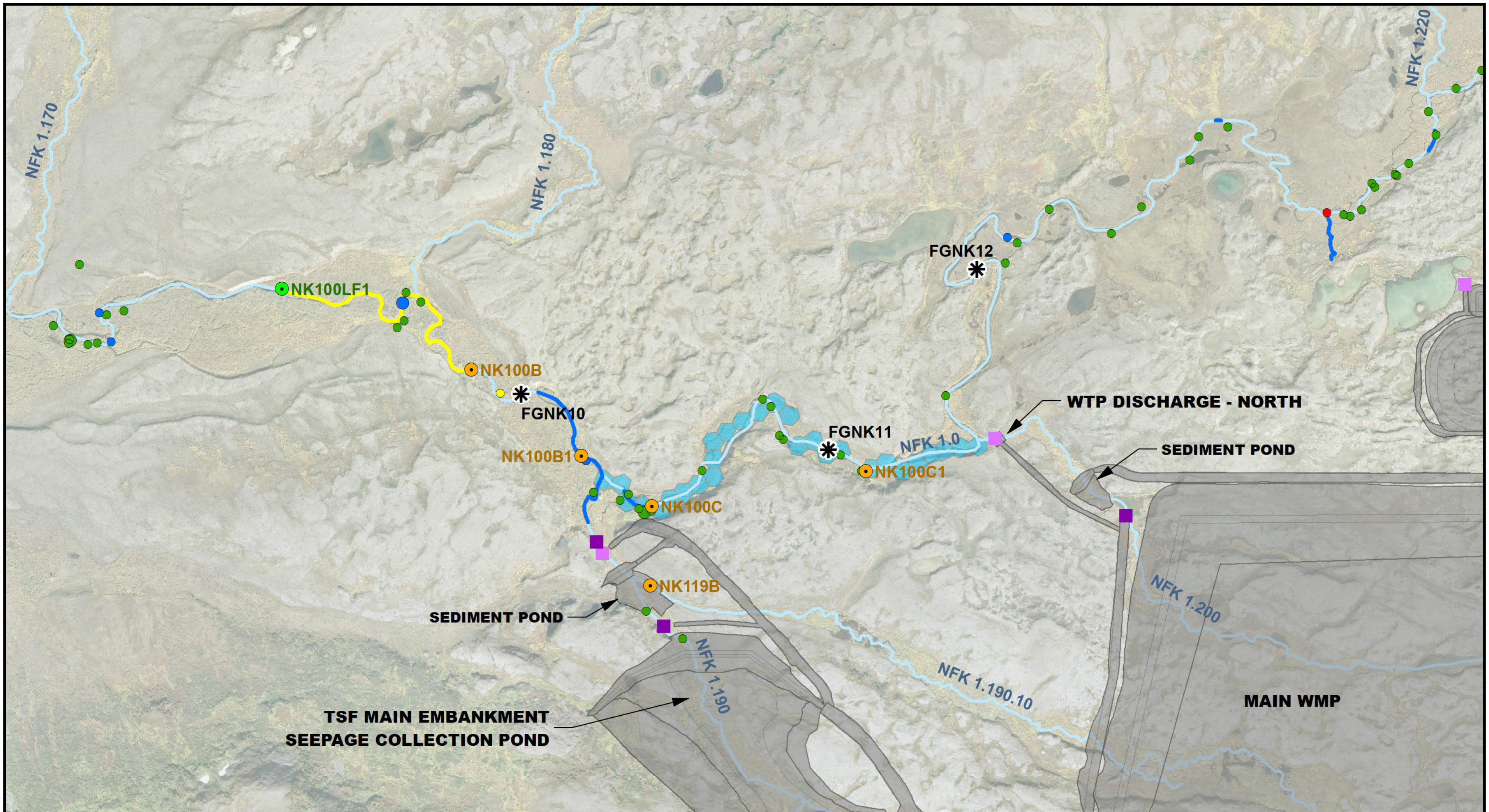
Stream	Winter		Summer	
	Pre-Mine °C	With Treated Water °C	Pre-Mine °C	With Treated Water °C
NFK River	0.2	1.4 to 3.0	6.3 to 14.5	7.2 to 12.9
SFK River[1]	0	0.85	3.3 to 14.1	3.7 to 14.6
UT Creek	0.2	0.4 to 0.7	3.2 to 12.5	3.4 to 12.7

Notes:
[1]During winter months, only the month of April shows a slight increase in water temperatures of 0.2 to 0.85°C, because Frying Pan Lake attenuates the thermal input – SFK River winter data are for April only.
°C = degrees Celsius
NFK = North Fork Koktuli
SFK = South Fork Koktuli
UT = Upper Talarik
Source: PLP 2019-RFI 145 (Potential mine effects on water temperatures)

North Fork Koktuli River

NFK surface water temperatures are summarized in Section 3.24, Fish Values; and Appendix K3.18, Water and Sediment Quality. In terms of magnitude, duration, and extent, temperature changes in the NFK drainage approximately 0.5 mile downstream of the WTP discharge point would be expected to be in the range of about -1.60 to +1.60°C; (average of about +0.02°C) in summer months, and from about +1.2 to +2.8°C (average of about +1.94°C) in winter months. As shown in Figure 3.24-6, low numbers of coho, Chinook and sockeye salmon have been observed spawning in this reach of the NFK (R2 Resource Consultants 2019b).

As described in Section 4.18, Water and Sediment Quality, treated effluent from WTP would be discharged into buried discharge chambers in the stream substrate. Discharged water is expected to be expressed as a surface water discharge immediately downstream of the discharge chamber. Groundwater modeling (BGC 2019a) indicates that the NFK WTP outfall is adjacent to a losing reach of groundwater expression in Tributary NK 1.200, which transitions to a primarily gaining reach at the confluence of the NFK that extends approximately 1 mile downstream to just downstream of the confluence of Tributary NK1.190 (Figure 4.24-6). The existing winter groundwater temperatures in this area from November to May range from 2.8°C to 3.6°C (Schlumberger et al. 2011a), while winter surface water temperatures are around 0 to 0.2ºC (R2 et al. 2011a; R2 Resource Consultants 2019b). Predicted winter month surface water temperatures 0.5 mile downstream of the discharge point are anticipated to be greater than baseline conditions; however, the change is anticipated to be attenuated by the influence of groundwater to some degree throughout the reach. Except for the area immediately adjacent to the WTP discharge chamber, surface water impacts to groundwater temperatures would not be expected to exceed natural temperature variations. Egg incubation and hatching periods could be slightly accelerated, with increases in water temperatures during winter months and could impact coho and sockeye emergence times in the limited Pacific salmon spawning habitats within this reach, This impact is expected to be limited to the habitats within this reach and would not be expected to have a measurable effect on Bristol Bay salmon populations due to the magnitude and extent of the effect. Impacts could be more pronounced if groundwater does not attenuate the surface water to the degree assumed in the groundwater model (BGC 2019a). Modeled treated surface water temperatures would meet the ADEC (2018b) standards for water temperature criteria associated with growth and propagation of fish, shellfish, and other aquatic life and wildlife in freshwater.



Sources: PLP 2019-RFI153; HDR

US Army Corps of Engineers

1,000 0 1,000 2,000
Feet

Observed Species, Count
- CH; 1 - 5
- CS; 1 - 5
- CS; 6 - 20
- KS; 1 - 5
- KS; 6 - 20
- SS; 1 - 5

- Continuous Monitoring Gage Stations
- Early Spring Low-Flow Measurement Sites
- Geomorphology Site
- Open Water (2006 Survey)
- Losing Stream Segment
- Simulated Flow Model (Gaining)
- North Fork Koktuli Streams

Alternative 1a
- GW Quality Monitoring and Pump Back
- Water Quality Monitoring Point
- Mine Site

WATER TREATMENT PLANT NORTH DISCHARGE GROUND WATER HYDROLOGY/SPAWNING HABITAT

PEBBLE PROJECT EIS

FIGURE 4.24-6

South Fork Koktuli River

SFK water temperatures are discussed in Section 3.24, Fish Values; and Appendix K3.18, Water and Sediment Quality. In terms of magnitude, duration, and extent, temperature changes in the SFK drainage at the outlet of Frying Pan Lake approximately 1.4 miles downstream of the WTP discharge point would be expected to be in the range of about -0.20 to +0.40˚C (average of about -0.038˚C) in summer months. Thermodynamic temperature modeling indicates that during winter months, there is no anticipated downstream change in temperature for most winter months. Modeling only predicted a change in downstream temperature of +0.85˚C for the month of April (R2 Resource Consultants 2019b). Modeling for SFK River at Frying Pan Lake indicates that treated water would cool as it flows through the lake, and effectively reduce downstream water temperatures to pre-mine conditions during most winter months. A slight increase in water temperature is likely too small for manifestation of adverse effects to rearing fish. Based on the available data and the low occurrence of spawning in the vicinity of Frying Pan Lake (Figure 3.24-10), it is unlikely that the potential increases in April water temperatures would be sufficient to either enhance or adversely affect developing alevins in the SFK. The duration of these changes would be long-term, lasting though the life of the project; and would be expected to occur if the project is developed.

Upper Talarik Creek

Existing UTC water temperatures are discussed in Section 3.24, Fish Values; and Appendix K3.18, Water and Sediment Quality. In terms of magnitude, duration, and extent, temperature changes in the UTC drainage approximately 2.75 miles downstream of the WTP discharge point would be expected to be in the range of about +0.10 to +0.60˚C (average of about 0.26˚C) in summer months, and from about +0.20 to +0.50˚C (average of about +0.36˚C) in winter months.

Modeled discharges indicate that water temperatures would not exceed ADEC's temperature threshold for spawning fish of 13°C for the summer months during mine operations and closure (R2 Resource Consultants 2019b). Baseline winter water temperatures in this reach are just greater than 0°C (R2 Resource Consultants 2019b). An increase in surface water temperature of 0.6°C would be less than the ADEC threshold and could impact incubating eggs, juveniles, or other overwintering resident fish. The duration of these impacts to water temperatures would be long-term, lasting though the life of the project; and would be expected to occur if the project is developed.

Changes to Surface Water Chemistry

Permitted discharges from the mine could affect fish and aquatic habitat. Baseline natural water quality conditions have been documented throughout the analysis area, and are described in Section 3.18, Water and Sediment Quality. Some baseline stream water samples collected proximal to the Pebble deposit contained concentrations of copper, molybdenum, nickel, zinc, and sulfate, exceeding the most stringent water quality standards.

Non-point discharges of process water to surface water are not planned. Permitted point discharges of process water to surface water would occur at three locations: 1) NFK Tributary NK 1.19 immediately upstream of the NFK confluence; 2) the SFK at its confluence with Frying Pan Lake; and 3) a tributary to the UTC approximately 2 miles downstream of its headwaters (Figure 4.24-1; see also Section 3.18 and Section 4.18, Water and Sediment Quality). As discussed in Section 4.18, Water and Sediment Quality, discharge of treated water from WTPs during operations may affect water quality parameters other than water temperature in receiving waters (e.g., dissolved oxygen levels, turbidity, nutrient levels). As with temperature in terms of extent, these effects would be expected to be spatially limited to the area of and immediately downstream of discharge points. Additionally, discharge infiltration chambers at discharge points would reduce effects on certain water quality parameters such as turbidity and dissolved oxygen by baffling the discharge and equilibrating water quality at the discharge point (Knight Piésold 2018f).

Permitted discharges would be in compliance with APDES permit stipulations; that is, discharge process water would have been treated to achieve the water quality criteria that are protective of aquatic life. Based on an independent review of the WTP source terms and processes (Appendix K4.18, Water and Sediment Quality; AECOM 2018i), discharge water from the WTPs is expected to meet ADEC criteria. Therefore, release of metals to surface water via point discharges of process water are not expected to induce metal toxicity (lethal and sublethal) to fish and aquatic invertebrates. Refer to Section 4.27, Spill Risk, for an analysis of impacts associated with spill scenarios. As described in Section 4.18, Water and Sediment Quality, calculations indicate an expected change in the concentration of metals in surface water as a result of dust deposition would not result in exceedances of the most stringent water quality criteria in baseline conditions or WTP outflow conditions (see Table K3.18-1).

For constituents that exceed criteria in background surface water and groundwater (see Section 3.18 and Appendix K3.18, Water and Sediment Quality), there are currently no plans to incorporate site-specific background levels of constituents into discharge limits (ADEC 2018-064a).

Toxicity and Bioaccumulation

Appendix K4.24, Fish Values, describes an analysis of impacts from the dust deposition and runoff of several heavy metals, including selenium, mercury, copper, and cadmium. The analysis is based on the projected concentrations as described in Section 4.20, Air Quality; and Section 4.18, Water and Sediment Quality. The results of analysis indicate that bioaccumulation of heavy metals in the food chain would not be expected to occur from development of the mine site (see Appendix K4.24, Fish Values).

Summary of Mine Site Impacts—Alternative 1a

Direct Effects

In summary, development of the mine site would permanently remove approximately 99 miles of streambed habitat in the NFK and SFK drainages. Direct effects on fish, including displacement, injury, and mortality, would occur with the permanent removal of stream habitat in the NFK and SFK drainages due to mine site construction. Stream productivity in the NFK and SFK drainages would be reduced to some degree with the loss of physical and biological inputs. These impacts would be permanent, and certain to occur.

The NFK impacted tributary habitat consists of incised coarse gravel, cobble, and boulder stream beds with slopes of 1 to 3 percent. Channel habitat features in this reach are dominated by short rapids/riffle reaches and irregularly spaced scour pools. Due to the substrate, slope, and lack of cover, this is not considered to be preferred spawning or rearing habitat for anadromous and resident fish compared to downstream habitats where anadromous fish are considerably more abundant (Section 3.24, Fish Values). Consequently, except for coho salmon, spawning has not been documented in NFK Tributary NK 1.190. Most spawning and rearing salmon are found in the lower portion of the NFK, downstream of the mine site. The 1.4 miles of habitat removed from SK 1.0, SK 1.340, and SK 1.190 provide habitat for populations of resident fish, including sculpin species, Dolly Varden, Arctic grayling, and stickleback species. No anadromous fish were documented in these habitats during baseline surveys.

Indirect Effects

Mine site operations would be expected to result in an overall change in surface and groundwater flows. Approximately 66 miles of stream habitat is expected to be affected by drawdown and changes in habitat suitability. Instream flows in the mainstem and select tributary reaches of the NFK, SFK, and the UTC would be reduced due to filling and excavating in stream channels, capture of groundwater at the open pit, or the retention of surface runoff from mine facilities. Indirect effects of headwater stream and off-channel habitat losses and changes in streamflows would include reduced input of spawning gravels, organic material, nutrients, water, and macroinvertebrates to downstream reaches. The magnitude and extent of impacts from the change in streamflows would be to directly change the quantity and quality of instream spawning and rearing habitat for resident and anadromous fish. Changes in flows could also directly alter available habitat for benthic macroinvertebrate production, which is important for fish growth and survival. These impacts would be mitigated to some extent by measures described in Chapter 5, Mitigation.

Increased sediment in streams could affect fish values during all three phases of the project. Sedimentation is known to affect the quality and quantity of aquatic habitat. Erosion and sedimentation also may elevate turbidity, which can adversely affect fish feeding, growth, and survival (Lloyd 1987). Mitigation measures would be developed to reduce the potential for increased turbidity and sedimentation.

Mine construction and operations would lead to changes in water temperature in downstream locations, which could potentially impact fish. Permitted discharges from the mine could affect fish and aquatic habitat; however, non-point discharges of process water to surface water are not proposed. As with water temperature in terms of extent, these effects would be expected to be spatially limited to the area of and immediately downstream of discharge points.

The magnitude and extent of impacts as described previously would vary among the three principal tributaries, according to the degree of surface water and groundwater capture, the location of impacts in the basin, the proximity and size of downstream tributaries, and the magnitude of flow augmentation at the water release facilities. The cumulative effects of indirect impacts described above are expected to change overall productivity in the NFK and SFK drainages, although to a lesser degree in the SFK basin based on the quality and quantity of habitats impacted. Noticeable impacts to productivity in the UTC basin are not expected based on the magnitude and extent of impacts described above.

4.24.5.2 Transportation Corridor and Natural Gas Pipeline Corridor

Under Alternative 1a, potential impacts along the transportation and natural gas pipeline corridors include direct loss of aquatic habitat at stream crossings, at the Eagle Bay ferry terminal site and at the south ferry terminal west of Kokhanok (see Figure 2-1). Direct loss of benthic aquatic habitat would also occur along the natural gas pipeline crossings of Iliamna Lake and Cook Inlet. Other potential impacts along the transportation and natural gas pipeline corridors include fish displacement, injury, and mortality at these locations; changes in stream surface water flows; increased sedimentation and turbidity at crossings and terminal sites; and potential impacts to fish migration. Impacts to EFH from development of the transportation and natural gas pipeline corridors are quantified, and described in Appendix I, EFH Assessment.

Direct Loss of Aquatic Habitat

Mine and Port Access Roads and Onshore Natural Gas Pipeline

Project roads would cross stream habitat that supports five species of Pacific salmon (Chinook, chum, coho, pink, and sockeye) and numerous resident fish species, including rainbow trout and Arctic grayling. Anadromous and resident fish species known to occur in the affected area are listed in Table 3.24-11. Based on field-verified stream mapping as described in Section 3.22, Wetlands and Other Waters/Special Aquatic Sites, the magnitude and extent of aquatic habitat loss from development of the transportation corridor and onshore portions of the natural gas pipeline would be the removal of 5.7 miles of streambed habitat and 1.7 acres of riverine wetland habitat. The corridor would cross 233 waterbodies, 56 of which have been documented to support resident and anadromous fish. Eighteen of these waterbodies have been documented to support Pacific salmon. As noted in Section 3.24, Fish Values, the potential exist for fish to occupy additional stream habitats based on numerous factors. The Anadromous Fish Act (Alaska Statute [AS] 16.05.871.901) requires that an individual or government agency provide prior notification and obtain permit approval from the Alaska Department of Fish and Game (ADF&G) before altering or affecting "the natural flow or bed" of a specified waterbody, or fish stream. Bridge and culvert design, streamflows, and habitat loss would be reviewed by ADF&G during the permitting process. ADF&G permit stipulations could include seasonal restrictions on instream activities to avoid impacts to habitat during critical life stages (e.g., spawning and egg development). Single-span bridge crossings would be designed to maintain a riparian buffer between the bridge abutments and the active channel. PLP has also committed to designing culverts to meet the US Fish and Wildlife Service's culvert design guidelines for ecological function (USFWS 2002), which would minimize impacts to aquatic habitat.

Under Alternative 1a, there would be multi-span bridges across the Newhalen and Gibraltar rivers. There would be a permanent loss of some habitat within the direct footprint of bridge piers on these rivers. Free passage of resident and anadromous fish may be temporarily interrupted but would continue unimpeded after construction is completed. Construction of all stream crossings would avoid spawning migration windows as much as possible; and where potential in-stream work could obstruct passage of fish for longer than 48 hours, diversion methods could be employed under the guidance of the ADF&G. Juvenile and adult fish passage facilities may be incorporated on all water diversion projects (e.g., fish bypass systems). Habitat at the immediate location of culverts would be altered, but fish would continue to use the streams. The duration of habitat disturbance from construction effects would be short-term and temporary but would be expected to occur if the project is permitted and built.

Iliamna Lake—Ferry Terminals and Natural Gas Pipeline

Aquatic Lake Habitat Loss from Ferry Terminal Construction—Facilities at the Eagle Bay and south ferry terminals in Iliamna Lake would extend into lake waters. The magnitude and extent of impacts to aquatic lake habitat are such that the ramps would cover approximately 0.56 acre of Eagle Bay benthic habitat and 1.1 acres of benthic habitat at the south ferry terminal. Discharge of fill material to construct the ferry terminals and ramps would permanently remove this aquatic habitat.

Iliamna Lake provides abundant spawning and rearing habitat for the Bristol Bay sockeye salmon fishery. Adult sockeye were documented along the northern and southern shorelines at the Eagle Bay ferry terminal (see Section 3.24, Fish Values). Spawning surveys indicate heavy use of the northeastern arm of Iliamna Lake, with highest densities associated with the main island archipelagos, Knutson Bay, Pedro Bay, and Pile Bay. Lower densities of spawning have been observed near Eagle Bay or in the eastern extremity of Pile Bay. Surveys indicate the habitat that would be lost at the south ferry terminal receives limited use as rearing habitat by juvenile Pacific salmon. Potential indicators of spawning were observed at the proposed Eagle Bay terminal, suggesting the affected area may provide spawning habitat for sockeye salmon (Paradox 2018b). The combined loss for the two terminals of less than 2 acres is minimal relative to the abundance of littoral habitat that would remain undisturbed in Iliamna Lake, particularly given the limited use for salmonid spawning and rearing in these locations (Owl Ridge 2019).

No freshwater mussels have been documented in the Eagle Bay and south ferry terminal footprints. Riprap placed around the landing ramp would be similar in size and character to the boulder habitat currently present in both locations, and would not represent a novel habitat feature. Riprap would be colonized in the short-term, and subsequently used by fish and their prey organisms. Habitat abutting fill locations may be disturbed or degraded during construction, but the duration of the impact would be short-term, because habitat is expected to recover after construction activities are completed.

Aquatic Lake Habitat Lost due to Natural Gas Pipeline Construction—Construction of the natural gas pipeline across Iliamna Lake would have permanent and temporary effects on lake habitat. Trenching methods would be used to install the pipeline segments from the lakeshore into waters deep enough to avoid navigational hazards.

Trenching methods for pipe installation at the shoreline transitions on the lake would include an extended-reach backhoe working from a small barge with spuds to maintain position (effective in water depths up to 30 feet [9.1 meters]) or a jet sled operated from the lay barge. A 30-foot (9.1-meter-)-wide corridor would be disturbed during trenching to install the submerged portions of the natural gas pipeline plus any areas where spoils would be temporarily side cast.

Sections of pipe up to several miles in length would be welded on shore and pulled out into Iliamna Lake along the bottom, and/or using floats. Long segments of pipe would be joined using divers and underwater welding. The pulling of pipe along the lake bottom has the potential to harm habitat in areas where the pipe encounters the lake substrate; other areas (e.g., lake substrate depressions and areas where the pipe does not make complete contact with the substrate) would be left relatively intact. Areas affected by the pipe pulling would be expected to recolonize in the short-term.

There would be permanent, direct mortality of any benthic organisms beneath the pipeline footprint on the bottom of Iliamna Lake. However, given the water depths, lack of light, and oligotrophic status of Iliamna Lake, impacts to deepwater benthic areas and invertebrates are not expected to be substantial, and this habitat would be expected to recolonize in 1 to 2 years. For example, pelagic, open-water areas are the dominant habitat used by sockeye salmon juveniles in the lake (Paradox 2018c). To the extent this benthic habitat has value to salmon and resident fish species, the benthic habitat under the pipeline would be permanently lost, but the pipeline itself would provide additional areas that can be colonized by invertebrates. Pipe-laying operations may result in temporary habitat disturbance in and near the construction area, but fish habitat adjacent to the pipeline would be expected return to pre-activity conditions after the activity ceases. These impacts would be certain to occur if the project is permitted and the natural gas pipeline is installed.

Pipeline installation would involve the construction of a 0.6-mile underwater berm in Iliamna Lake. Approximately 10 sections, each less than 100 feet in length, would require a 13-foot-wide berm to be placed on the lake bottom; however, a permanent footprint of 1 acre conservatively assumes the berm would be placed along the entire 0.6-mile stretch (PLP 2019c). The berms would be constructed using clean graded engineered fill and rock. Gradation and sizing of the fill and rock would be selected to ensure the material stays in place and is not susceptible to berm sidewall failure or long-term scour/erosion. The fill would be drawn from one of the existing onshore material sites and transported from shore using a barge and placed using a barge mounted clamshell dredge or extended reach backhoe depending on water depth. Fish and benthic invertebrates would be temporarily displaced during construction and increases in turbidity are expected. The affected area would be recolonized in the short-term. Habitat alterations are considered permanent, and benthic community structures would likely be permanently affected. Effects would be limited to the disturbed area.

Cook Inlet Portion of the Natural Gas Pipeline

The natural gas pipeline would be installed on the sea floor of Cook Inlet between Anchor Point on the Kenai Peninsula and Amakdedori port. The heavy wall pipe would be trenched into the sea floor for approximately 61 miles, laid on the surface for the next approximately 11 miles, and then trenched into the sea floor for the final approximately 32 miles of the Cook Inlet crossing (PLP 2019h). Trenching and burial would occur with use of traditional cut and fill excavation using extended-reach backhoes for non-horizontal directional drilling (HDD) shore crossings. Clamshell dredging/conventional excavation would be used for shallow water areas, and mechanical dredging and/or jet trenching for deepwater areas. Ploughing technology could also be used for trenching and lowering the pipeline into the trench if ploughs are available and suitable for use in the lower Cook Inlet at the time of construction; however, the use of ploughs has not been identified as a primary option.

The pipeline route crosses through several types of substrate as it transects Cook Inlet. Key conditions include ripples, waves, dunes, compound and complex bedforms, scour, boulder fields and isolated rocks, and outcropping or shallow buried rocks (IntecSea 2019). Sediments are predominantly sand and coarser materials over most of the route (IntecSea 2019). At Anchor Point on the Kenai Peninsula, HDD would be used to install the pipeline segments from the shoreline into waters deep enough to avoid navigational hazards, and potential impacts are similar to those described previously. Substrate would be expected to recover quickly as biomass is likely lower and organisms are also likely adapted the constant rearrangement of the substrate. Submerged boulder areas or isolated rocks and rock outcrop areas could include greater biomass than sandy dynamic areas, making for a longer recovery time ranging from months to years.

The magnitude and extent of impacts from construction would include temporary impacts to 628 acres of benthic habitat during installation of the pipeline. Installation of the pipeline would avoid managed weathervane scallop (*Patinopecten caurinus)* beds. Trenching could result in the mortality of benthic fauna. Habitat disturbances resulting from pipeline installation would range from temporary to short-term and would be minimal in the context of existing available habitat in lower Cook Inlet unaffected by this activity. Changes to fish distribution and abundance from installation of the pipeline would not be expected to occur based on the magnitude and duration of disturbance. Fish species, including commercially managed fish (see Section 4.6, Commercial and Recreational Fisheries) would be expected to avoid the area during construction but return upon once construction activities cease.

The mooring system, as described in Chapter 2, could impact the benthic fauna or disrupt the seafloor habitat structure. There are two components of impact: the loss of habitat from the permanent anchor; and the scraping or sweeping of the sea bottom from the movement (cable sweep) of anchor chains across the bottom. The weight of the permanent anchors on the seafloor would result in removal of benthic habitat within the anchors' footprint, with impacts and recovery being short-term as marine species colonize the anchor structures. Once colonized, the anchors would provide approximately 0.4 acre of reef-type habitat. In contrast, the area affected by cable sweep is expected to be larger, but the effect on live bottom considerably less than the permanent anchors. It is expected that areas of live bottom (e.g., areas of live bottom organisms in depressions and areas where the cable does not make complete contact with the sediments or rock) would survive relatively intact from cable sweep during and after installation. The areas could provide stock material for a more rapid re-colonization and recovery of adjacent live bottom habitat. Once installed, the mooring system design would minimize cable sweep.

The magnitude and extent of potential impacts from the placement of anchors for the pipe-laying barge would include disruption to the seafloor habitat structure. The permanent loss of benthic habitat from construction of the spread anchor mooring system is minimal relative to the available habitat in Kamishak Bay and Cook Inlet. Recolonization of permanent anchors by aquatic species is expected to be short-term, potentially creating new habitat. Furthermore, the anchor design would minimize cable sweep impacts. Benthic habitat characteristics would return to normal after the activity ceases. Benthic habitat removed would be minimal and permanent, but this would be further minimized in the short-term once recolonized by aquatic organisms creating new habitat.

Displacement, Injury, and Mortality of Fish and Benthic Organisms

Mine and Port Access Roads and Overland Gas Pipeline

Direct displacement, injury, or mortality of fish could occur during construction of bridges, culverts, and the overland portions of the natural gas pipeline.

Culverts and Bridges—Temporary water diversions or dewatering of stream reaches during construction could result in direct mortality of fish due to stranding and desiccation. Entrainment or impingement at intake screens during water withdrawals could also result in direct mortality or injury. Increased sedimentation may cause displacement or injury. Section 4.16, Surface Water Hydrology; and Section 4.18, Water and Sediment Quality, address the potential for increased erosion and sedimentation and resulting water quality, respectively.

ADF&G is responsible for review of permit applications and verification of bridge and culvert designs. Permit stipulations could include seasonal restrictions to protect critical life stages (e.g., spawning and incubation) to avoid or minimize injury or mortality. Construction of stream crossings may avoid spawning migration windows as much as possible, and where potential in-stream work could obstruct passage of fish for longer than 48 hours, diversion methods may be employed under the guidance of the ADF&G. Juvenile and adult fish passage facilities would be incorporated for all water diversion projects (e.g., fish bypass systems) as per ADF&G permit stipulations.

Fish could also be directly impacted by noise and vibration during backhoe use to install culverts and bridges, and by vibration and noise from traffic using those bridges. Noise and vibration studies and impact evaluations in the Port Mackenzie Rail Extension Final EIS used the Federal Transit Administration general assessment method (FTA 2018). As summarized in the Port MacKenzie Rail Extension EIS (Surface Transportation Board 2011), peak particle velocities for bulldozer operations during construction were estimated to range from 0.000056 to 0.006372 inch per second (in/s) 145 to 3,400 feet away from the construction activity. These velocities are less than the ADF&G peak particle velocity limit of no more than 2.0 in/s in spawning gravels during the early stages of embryo incubation (Timothy 2013). Based on the foregoing data, particle velocities during bulldozer use transferred to spawning substrates through bridge piers or culverts or from truck traffic during mine operations are unlikely to result in a detectable effect on incubating salmonid eggs, survival to emergence, or juvenile and adult abundance.

The installation of bridges would generate noise and vibrations from pile-driving activities. Several caged fish studies of the effects of pile-driving have been conducted, and most have involved salmonids. Ruggerone et al. (2008) exposed caged juvenile coho salmon (93 to 135 millimeters) at two distance ranges (near 1.8 to 6.7 meters, and distance 15 meters) to 0.5-meter steel piles driven with a vibratory hammer. Sound pressure levels reached 208 dB (decibels) re

1 microPascal (μPa) peak, 194 dB re 1 μPa rms, and 179 dB re 1 μPa^{2}s SEL, leading to a cumulative sound exposure level (SEL) of approximately 207 dB re 1 μPa^{2}s during the 4.3-hour period (underwater acoustics are defined in Appendix K4.25, Threatened and Endangered Species). All observed behavioral responses of salmon to pile strikes were subtle; avoidance response was not apparent among fish. No gross external or internal injuries associated with pile-driving sounds were observed. The fish readily consumed hatchery food on the first day of feeding (day 5) after exposure. The study suggests that coho salmon were not significantly affected by cumulative exposure to the pile-driving sounds.

Blasting—Fish and fish eggs could be injured or killed due to blasting near anadromous and resident fish streams. Effects of blasting on fish are described below. Blasting would be needed for road and pipeline construction. Blasting would occur along approximately 25 miles of the south access road between Amakdedori port and the south ferry terminal, and along 1.8 miles on the mine access road between the mine site and the Eagle Bay ferry terminal. Estimated pressure and vibration forces generated by blasting at gravel mine sites and along the transportation corridor have not been calculated, pending future blasting plans. Impacts to resident and anadromous fish and developing embryos could occur despite efforts to maintain sublethal thresholds, which would result in fish mortality in the immediate vicinity of blasting activities occurring adjacent to fish-bearing waters. Impacts would be limited to the affected area, and are not expected to result in a measurable loss of fish. Blasting during construction would be required to follow the guidelines established in the 2013 ADF&G Technical Report (No. 13-03) Alaska Blasting Standard for the Proper Protection of Fish. Additional fish surveys could be required in affected streams to determine fish presence and develop appropriate mitigation measures to reduce impacts.

Trenching and HDD—Direct displacement, injury, or mortality of fish could occur during HDD and trenching activities associated with construction of the natural gas pipeline at stream crossings. Eggs and fish could be directly impacted (smothered or buried) by the loss of HDD drilling fluid through subsurface fractures (frac-out). Drilling fluid is typically composed of only water and bentonite and poses a low risk to aquatic life. However, fluid loss may result in a temporary increase in turbidity or siltation that can negatively impact aquatic life by covering spawning and feeding areas, and clogging fish and invertebrate gills. Monitoring would be conducted throughout the HDD process to determine whether a subsurface fluid loss had occurred. To ensure that the pressure on the drilling fluid is set to match the geological formations encountered, the pressure levels would be set as low as possible to be effective and would be closely monitored. The pressure should not exceed what is needed to penetrate the formation. A significant drop in pressure or drop in mud return could indicate a potential fluid loss, and drilling would be halted immediately. Details regarding prevention, detection, and response to a potential frac-out or drilling fluid release would be addressed in the HDD plan and SWPPP. Discharges to freshwater or the land surface from activities associated with construction and operation of the natural gas pipeline (including HDD, hydrostatic testing, or other potential discharge sources) would be regulated under ADEC Wastewater Discharge Authorization Program, General Permit AKG320000, Statewide Oil and Gas Pipelines. Impacts to surface water quality in excess of allowable standards from erosion of HDD sites during and after construction would not be anticipated if proper procedures and BMPs are applied (PLP 2018-RFI 011). Design parameters, such as the geometry of the drillhole, would be selected to minimize fluid loss (PLP 2019-RFI 011a).

Trenching impacts could include mortality of fish related to diversion and dewatering activities and displacement due to temporary increases in turbidity. Juvenile and adult fish passage facilities (e.g., fish bypass systems) may be incorporated on all water diversion project as per permit stipulations.

Water Withdrawals—The Alaska Department of Natural Resources (ADNR) and ADF&G are responsible for permitting water withdrawals from fish-bearing waters. Permit conditions would be protective of fish migration and critical life stages. Permit conditions would also restrict rates, volumes, and total withdrawals to protect fish and fish habitat. Water pump intake screens used for dewatering and water withdrawal would be designed, constructed, and certified according to ADF&G standards to prevent fish impingement to reduce impacts. Fish would not be expected to be exposed to injury, displacement, or mortality due to water withdrawals.

Iliamna Lake—Ferry Terminals and Natural Gas Pipeline

Iliamna Lake Ferry Terminals—The Eagle Bay and south ferry terminal locations are used for rearing by juvenile salmonids in the spring, although low densities of spawning salmon have been observed near Eagle Bay, indicating this area does provide rearing habitat for sockeye salmon (Hart Crowser 2018a; Hart Crowser 2018b; Paradox 2018a). Potential indicators of spawning were also observed at the proposed Eagle Bay terminal, suggesting the affected area may provide spawning habitat for sockeye salmon. Threespine stickleback are the most common species at the terminal locations. Construction of the ferry terminal dock is not likely to cause widespread injury or mortality to fish, but may temporarily displace them from the immediate area. These impacts are certain to occur if the project is permitted and the ferry terminals are constructed.

Natural Gas Pipeline Crossing Iliamna Lake—The natural gas pipeline segment under Alternative 1a would cross the lake from the south ferry terminal to Newhalen. Construction of the natural gas pipeline across Iliamna Lake using trenching, and pipe pulling methods previously described could lead to displacement of fish, but is not likely to cause widespread direct injury or mortality of fish. Sockeye salmon are known to use shoreline habitat for spawning, and therefore could be potentially affected by disturbance and increased turbidity during construction. Construction of the pipeline by trenching (PLP 2020d) at the north and south ferry terminal would cause short-term increase of suspended sediment concentration in the water column. Extent of the impact would be limited to the immediate vicinity of the construction, and could persist for a few days before being cleared away by wind-driven currents and mixing. Nearshore trenching could temporarily disturb and displace sockeye salmon fry and adults during construction, but fish use is expected to return to previously existing conditions after the activity ceases.

Iliamna Lake Ferry Operations

The ferry crossing from the Eagle Bay terminal to the south ferry terminal under Alternative 1a would not intersect known sockeye spawning habitat. However, the ferry route under Alternative 1a would pass within 0.35 to 0.5 mile of the Eagle Bay Island and Rabbit Island groups, each of which have supported beach spawning ranging from 20,000 to 40,000 sockeye in some years (Morstad 2003).

Juvenile sockeye exhibit the highest potential to interact with the ferry operations due to their relative abundance and wide distribution throughout Iliamna Lake.

Propeller Entrainment or Injury—Assessment of the potential for direct injury or mortality of anadromous or resident fish from vessel propellers is limited to a few studies (Holland 1986; Killgore et al. 2011; Whitfield and Becker 2014). A review of these publications indicated that the potential exists for chronic, direct adverse interaction of ferry propeller blades and various life stages of migratory and non-migratory fish species throughout the 20-year operations phase. The ferry has the potential to entrain fish into the turbulent zone created by propeller blades, although benthic species or midwater species larger than 10 millimeters are less susceptible to entrainment (Killgore et al. 2011). Sockeye fry hatch-out much larger than 10 millimeters in length (Beacham and Murray 1991), and typically remain nearshore until early summer (Hoag 1972). Rich (2006) found that fry densities were highest in the eastern basin east of Eagle Bay. In contrast, yearling sockeye exhibit pelagic, open-water behavior; however, they are larger (i.e., bigger than 70 millimeters) (Rich 2006) and stronger swimmers, and would be expected to detect and avoid propeller-related impacts. Also, juvenile sockeye typically occupy deeper water during daylight hours, then ascend into shallower water (although often deeper than propeller depths) at night or at dusk (Clark and Levy 1988; Schuerell and Schindler 2003). Consequently, direct interaction between juvenile sockeye and the ferry, which would operate during the day, is expected to be limited due to the fish's diel vertical migration patterns. Although sockeye are known to exhibit diel movement patterns in winter (Steinhart and Wurtsbaugh 1999), it is unknown if juveniles would be more likely to encounter the ferry during the winter season, when light intensity remains low during daylight hours. Although light penetration would be greater in the ice-free path of the ferry, it is likely that surface waters would also be colder in the ferry's path, which could discourage occupation of near-surface depths by juvenile sockeye. Although possible, propeller strikes or shear forces could result in fish injury or mortality. Impacts are expected to be localized at the individual level, and would be expected to occur if the project is permitted and constructed.

Wake Impacts—Vessel wake can cause fish to be stranded and suffer mortality (Pearson et al. 2006). Pearson et al. (2006) noted that fish stranding occurred primarily during nighttime vessel passages, and no stranding occurred at the same locations during daytime passages. A radio telemetry study by Otter Tail (2010) on the Kuskokwim River reported no evidence of stranding of seaward-emigrating salmon when the prevailing wake height was less than 1.5 inches along the gravel bars surveyed; however, these fish did not occupy confined segments of the river.

Habitat descriptions for the Eagle Bay and south ferry terminal locations are provided in Section 3.24, Fish Values. In contrast to studies conducted on rivers, stranding of fry from ferry wake is not expected to be a source of mortality in Iliamna Lake due to the perpendicular route of ferry travel in relation to the shoreline. The magnitude of the wake produced by the Iliamna Lake ferry is expected to be 4 inches at the ferry's 6-knot approach speed; however, the wake would dissipate within 30 feet of the hull (PLP 2018-RFI 013). Consequently, any impacts on juvenile and adult fish from vessel wake would be limited both spatially and temporally.

Noise and Vibration Impacts—Fish have been shown to react when engine and propeller sounds exceeds a certain level (Olsen et al. 1983; Ona 1988; Ona and Godo 1990). Avoidance reactions have been observed in fish such as cod and herring when vessel sound levels were 110 to 130 decibels (dB) re 1 μPa rms (Olsen 1979; Ona and Godo 1990; Ona and Toresen 1988). Vessel sound source levels in the audible range for fish are typically 150 to 170 dB re 1 μPa/Hz (Richardson et al. 1995) (see Appendix K4.25, Threatened and Endangered Species). The vessels used during the activities would be expected to produce levels of 170 to 175 dB re 1 μPa rms when in transit. Based on the reports in the literature and the predicted sound levels from these vessels, there may be some avoidance by fish in the immediate area. Where fish or invertebrates responded to noise, the affects were temporary and of short duration (Popper et al. 2005). Consequently, disturbance to fish species would be short-term, and fish would return to their pre-disturbance behavior once the activity ceases. Additional information from noise and vibration impacts on fish are provided in Appendix K4.25, Threatened and Endangered Species.

Pipeline-Only Overland Portion of the Natural Gas Pipeline

Based on field-verified stream mapping as described in Section 3.22, Wetlands and Other Waters/ Special Aquatic Sites, the overland pipeline-only portion of the natural gas pipeline would cross 18 streams, one of which has been documented to support anadromous fish. Impacts on fish and fish habitat would be similar to those described for the mine access roads, and include loss and alteration of habitat, fish displacement and injury, and changes in stream productivity. Impacts are expected to occur, and would be short-term in duration and limited to the disturbed area.

Cook Inlet Portion of the Natural Gas Pipeline

Most marine fish would not be expected to suffer direct mortality or injury during pipe-lay operations (regardless of the dredge technology used); however, benthic fish species such as flatfishes (e.g., halibut, soles, flounders), lingcod (*Ophiodon elongatus*), sculpins (*Cottidae*), skates (*Rajidae*), and sand lances (*Ammodytes)* would be more vulnerable than pelagic or semi-pelagic fish species, and all fish species could be temporarily displaced from the immediate vicinity of construction activity. As described under direct loss of aquatic habitat, there would be permanent, direct mortality of benthic invertebrates beneath the natural gas pipeline footprint on the seabed of Cook Inlet. Organisms in soft substrates (bivalves and polychaetes) could be more impacted during pipeline construction; however, the pipeline would add a hard substrate to the marine environment, providing additional habitat for marine plants and animals (for example, kelp and mussels) that require a hard substrate. Therefore, the overall effect of pipeline installation would be to alter species diversity in a small area. The pipeline landfall on the Kenai Peninsula would alter a few acres of intertidal habitat. This development would temporarily displace some coastal organisms. The impacts on benthic habitat would be short-term and certain to occur if the natural gas pipeline is constructed.

Construction activities would introduce in-water noise with potential to impact marine fish. Noise-generating activities and sources include installation of the pipeline, including trenching, placement of vessel anchors, and marine vessels. In-water noise has the potential to be perceived by fish at an intensity that would result in fish avoiding the immediate area. Construction-related noise impacts are anticipated to be temporary, and fish would return to the area once the in-water noise has ceased. Appendix K4.25, Threatened and Endangered Species, provides a more detailed analysis of the potential impacts from underwater noise on fish.

Benthic infauna individuals would likely suffer mortality from the placement of anchors for the pipe-lay barge. Impact sources include anchor scarring each time an anchor is set, and the scraping or sweeping of the seafloor from the movement of the anchor cables across the seafloor (cable sweep). The weight of the anchor and potential depth of the scar could potentially result in mortality of benthic fauna, including weathervane scallops. The benthic fauna would be expected to recover; therefore, the duration of the impacts would be short-term.

Changes in Surface Water Flows and Iliamna Lake Circulation

Mine and Port Access Roads and Overland Gas Pipeline

Access Road Construction—Except for temporary construction impacts, potential impacts on streamflows are not expected to occur at bridge and culvert crossings. Bridge and culvert design, streamflows, fish passage requirements, and habitat loss would be reviewed by ADF&G per the State's Anadromous Fish Act (AS 16.05.871-.901) during the permitting process. Permit stipulations may include seasonal restrictions on instream activities to avoid impacts to habitat during critical life stages (e.g., spawning and egg development). Routine inspection and maintenance of culverts, bridges, and roads would be regularly conducted in compliance with right-of-way (ROW) and ADF&G permit conditions, if issued, to ensure that culvert-related erosion, wash-out, or debris blockage do not result in permanent impacts to streamflow or downstream habitat. More stringent monitoring and maintenance standards may be required by ROW lease stipulations from state and local governments.

Water Extraction Sites—Water extraction would be expected to temporarily affect streamflows during construction. Water withdrawals would occur at lakes, ponds, and streams along the road corridor for dust control and hydrostatic testing of the pipeline during the summer construction seasons (Chapter 2, Alternatives, describes the proposed water extraction sites and estimated volumes and rate of withdrawal). The ADNR and ADF&G are responsible for permitting water withdrawals from fish-bearing waters. ADF&G reviews permit applications to ensure that water withdrawals are protective of fish by verifying that adequate flows for fish passage are available, particularly during critical life stages, and water levels are sufficient to avoid stranding juveniles and dewatering redds. Permit conditions would set limits on water withdrawal (typically maximum pumping rate, maximum gallons per day, and total volume withdrawn per stream) necessary to protect fish and their habitat, and would require the installation of screens at water intake points to prevent fish entrapment. Disposal methods for hydrostatic test water would be developed in accordance with ADEC APDES General Permit AKG320000 for implementing the federal Clean Water Act with respect to energy dissipation and sediment control. No chemicals would be added to the hydrostatic test waters. Impacts would be temporary.

Overland Natural Gas Pipeline Construction—The final configuration of the natural gas pipeline would generally be in the prism of the access road. Pipeline stream crossings would be open cut or accomplished by HDD, or the pipeline would be attached to bridge structures. This configuration would reduce the risk of ponding, interception of surface water flows, and sedimentation.

The magnitude and extent of potential impacts to groundwater and surface water during pipeline construction would involve interception of shallow groundwater and surface water during trenching activities, which would be captured and locally flow along the trench backfill. Ditch plugs are typically installed to intercept shallow groundwater flows. Backfilling would occur immediately following end of construction. Permits would stipulate that surface water flows would be returned to their normal condition. Typical BMPs for surface water management could include maintaining natural surface water patterns; crowning of ditch backfill to allow for settlement to original ground level; contouring of surrounding terrain; construction of settlement infiltration basins; and prompt revegetation of riparian and wetlands and a robust monitoring and maintenance program (see Chapter 5, Mitigation).

Trench dewatering and hydrostatic test water would be required to be discharged to approved sites as per ADEC requirements (Wastewater Discharge Authorization Program, General Permit AKG320000, Statewide Oil and Gas Pipelines). ADF&G is responsible for permitting work in fish-bearing streams. Pipeline construction would be subject to design considerations, restoration requirements, and timing windows, as specified by ADF&G. The duration of impacts could extend beyond the life of the project (i.e., permanent), because the pipeline would be abandoned in place. The likelihood of the impact would be certain if the project is permitted and the pipeline is constructed.

Iliamna Lake

Placement of rock and aggregate in the nearshore area during construction of the Eagle Bay and south ferry terminals could locally modify water circulation patterns by changing the direction or velocity of water flow; alter the location, structure, and dynamics of aquatic communities, including prey; and alter shoreline and substrate erosion and deposition rates. Section 4.16, Surface Water Hydrology, describes water quality impacts that could result from construction at the ferry terminals on the lake.

Changes to Stream and Lake Productivity

Access Roads and Overland Gas Pipeline

The access roads and pipeline would cross anadromous and resident fish streams. In some locations, such as culvert crossings, the road/pipeline footprint would impact riparian and floodplain connectivity in the 100-year floodplain. Downstream functions could be altered with the reduction of physical and chemical inputs from the interruption of floodplain connectivity. Functional connections between streams and riparian wetlands and their downstream waters vary geographically and over time based on several factors, including proximity, relative size, and environmental conditions. Commonly exchanged inputs that could be affected from interruption of connectivity include water, heat, energy, nutrients, sediment, and organic matter (Leibowitz et al 2019). Some downstream habitats could become less productive with the disruptions in connectivity. Increased competition for food sources and growth rates could be affected for some individuals. Loss of riparian vegetation can also result in increased erosion and stream sedimentation and reduction in stormwater retention capacity, and could increase flows and alter instream functions, including productivity.

In terms of magnitude and extent, the road/pipeline footprint and associated crossing structures would directly impact riparian vegetation, and interrupt floodplain connectivity in some waterbody crossings. Impacts would be most pronounced during high flow events. The duration of the impact to riparian vegetation would be for the life of the project and would be expected to occur if the project is permitted and built.

Iliamna Lake—Ferry Terminals and Natural Gas Pipeline

In terms of magnitude, duration, and extent, there would be short-term, indirect disturbance effects from the construction of the ferry terminals, including the combined loss of less than 2 acres of benthic habitat under the Eagle Bay and south ferry terminal footprints. Rock and aggregate that would be placed around the landing ramps of the terminals would be similar in size and character to existing boulders in Iliamna Lake, and would be colonized in the short-term, and subsequently used by prey organisms. The aquatic food web in Iliamna Lake would not be expected to be impacted by terminal construction and ferry operations.

Trenching would be used to install the natural gas pipeline segments at the shore transitions. In terms of magnitude, duration, and extent of impacts, there would be local, temporary impacts during construction, and permanent benthic habitat loss. Zooplankton communities would be disturbed with ferry operations, but long-term impacts to community structure and productivity are not expected to occur.

Changes to Marine Productivity

Cook Inlet Portion of the Natural Gas Pipeline

Long-term changes to benthic habitat would affect rearing and adult Pacific salmon and marine species in depths of less than 262 feet. Fish assemblages both on and off pipelines were found to be similar; however, two to three times higher biomass of large-body commercial species were found to be associated with proximity to pipelines (Bond et al. 2018). Pelagic, semi-pelagic, and benthic fishes may re-inhabit the pipeline corridor within hours to days after construction operations cease and the trenched areas have refilled.

Pipeline construction would be expected to impact individual fish and shellfish, but would not be expected to have population-level impacts. Consequently, the overall effects of pipeline construction activities on fish and shellfish productivity would likely be undetectable.

Increased Stream and Lake Sedimentation and Turbidity

Mine and Port Access Roads

Operations are expected to require 35 round-trips by truck per day, which would result in dust impacts to aquatic resources in proximity to roads, including at stream crossings. In terms of magnitude, duration, extent, and likelihood, road construction, maintenance, and use could result in short- and long-term impacts to streams from increased surface erosion and deposition of fine sediments. Surface erosion could result from clearing and grading activities; and from poorly surfaced or maintained roads with steep grades, high traffic volume, and insufficient stormwater management facilities. Accumulations of fine sediments in streams have been associated with decreased fry emergence, reductions in winter carrying capacity and benthic production, and changes in species composition in benthic invertebrate communities (NMFS 2011a).

Increased water turbidity from erosion and sedimentation would primarily occur during construction at bridge or culvert crossings. ADF&G is responsible for permitting any activities in fish-bearing waters. Bridge and culvert construction activities in anadromous waters would be authorized by ADF&G and documented in ADF&G permit requirements to avoid impact to critical fish life stages (e.g., spawning and egg incubation). Routine inspection and maintenance of culverts, bridges, and roads as required by ADF&G permit conditions would be conducted to ensure that drainage-structure–related erosion, wash-out, or debris blockage do not result in impacts to water quality or downstream habitat. The duration of construction-related sedimentation would be temporary and short-term, due to mitigation and control measures, State of Alaska permit stipulations, and timing windows. Stream crossings associated with the roads and pipelines would be designed to minimize potential impacts on surface water hydrology, water quality, and fish passage. Road and pad maintenance BMPs, including application of dust suppressants during dry periods, routine grading, and routine maintenance of drainage ditches and stream crossings, would be implemented and maintained during mine operations (see Chapter 5, Mitigation). Additional monitoring, BMPs, and maintenance standards may be required by ROW lease stipulations from state and local governments. Specific BMPs designed to reduce sedimentation and turbidity from road construction and operations are described in Section 4.16, Surface Water Hydrology.

The deposition of fine-sized particles in streams and resulting increases in turbidity are expected to occur during project operations and through post-closure. Implementation of dust suppression, BMPs, and enforcement of slow speed limits at all stream crossings would minimize dust-related impacts to aquatic ecosystems during project operations and post-closure (see Table 5-2).

Overland Gas Pipeline

The three construction techniques that would be used to cross waterbodies during the onshore installation of the natural gas pipeline are discussed below (see Figure 2-44 for typical drawings of pipeline waterbody crossings).

Suspend Pipeline Beneath Bridges—This crossing method would place the pipeline and fiber-optic cable over the stream, suspended or secured to bridges; no sedimentation or turbidity impacts to fish or aquatic habitat would be expected other than temporary construction impacts associated with the bridge construction itself.

Horizontal Directional Drilling—This technique would install the pipeline beneath the stream bed. HDD typically results in minimal disruption to riparian vegetation adjacent to the stream, and no disturbance to the stream bed. Temporary turbidity or sedimentation impacts could occur due to frac-out. Potential impacts and mitigation measures were previously discussed.

Trenching—Streamflow would be diverted, and a trench would be excavated using chain excavators, wheel trenchers, and/or backhoes. Side-cast material from the excavation of the trench would be temporarily stored at an elevation greater than the ordinary high-water mark of the creek, in the abutting 30-foot road construction buffer. The trench would be deep enough to provide the design soil/sediment cover depth over the top of the pipeline and fiber-optic cable. Construction and water diversion methods would vary, depending on soil type and stream channel characteristics. Excavators would generally be used in areas of steep slopes, high water tables, soils with cobbles and boulders, or deep trench areas such as river and stream crossings.

Temporary turbidity and sedimentation impacts could occur from diverting rivers or streams, removing riparian vegetation, and excavating streambed materials (typical trench width is 8 feet). Juvenile and adult fish passage facilities would be incorporated on all water diversion projects (e.g., fish bypass systems) as required by permit. Turbidity and sedimentation impacts would be temporary during construction, and short-term until riparian vegetation becomes re-established.

Iliamna Lake—Ferry Terminals and Natural Gas Pipeline

In terms of magnitude, duration, extent, likelihood, there would be local, short-term turbidity increases to the water column that could indirectly affect fish and benthic organisms during construction of the ramps at the Eagle Bay and south ferry terminals. Transport of suspended sediment by wind-driven currents along the shore would not be expected to persist or to cover a large geographic area (see Section 4.16, Surface Water Hydrology). The increased water turbidity and indirect impacts on fish and aquatic life would be expected to occur if the project is permitted and constructed.

Cook Inlet Portion of Natural Gas Pipeline

Installation of the natural gas pipeline on the seafloor, including temporary placement of boat anchors, and trenching, including side-casting of trench material and backfilling of trench (if required) of the pipeline, may result in temporary increases in sediment and turbidity in localized areas immediately adjacent to the pipeline construction areas. Sediments mobilized by trenching operations from pipelay operations during construction of the pipeline in Cook Inlet would be rapidly redistributed by strong currents and tides before settling. Expected turbidity levels would be similar to maximum concentrations that would prevail in the bay under severe storm conditions (USACE 2019). Conditions would return to normal within hours to days after construction. The NMFS (2017) reviewed estimates of impacts due to turbidity from mechanical dredging, cutterhead dredging, and jet plow technology. According to this review, total suspended solids (TSS) as a measure of turbidity for mechanical dredging, independent of bucket type or size, can expect elevated suspended sediment concentrations at several hundreds of milligrams per liter (mg/L) above the background in the immediate vicinity of the bucket, but would settle rapidly within a 2,000-foot radius of the dredge location (NMFS 2017).

The trenching/dredging technology may crush benthic and epibenthic invertebrates from the physical components of the dredge; benthic organisms may be dislodged; and the suspended sediment may settle out and clog the gills or feeding structures of sessile invertebrates (82 FR 22099). Sedentary managed species, such as weathervane scallops, may be affected by the temporary increase in sediment loads in the water columns during construction. Material that is removed during trenching/dredging would temporarily increase turbidity (which would be rapidly dissipated by strong tidal currents) and cause avoidance by mobile fauna. Planktonic species would not be able to avoid increased turbidity in the water column and may experience increased abrasion and potential mortality. The effects would be limited in extent (but range farther away from the source depending on the method of pipeline installation); the duration would be short-term and temporary; and turbidity would rapidly return to background levels following active dredging.

Most adult fish are mobile and would actively avoid direct impacts from the pipe-laying and trenching activities. Some impairment of the ability of managed species to find prey items could occur, but this effect should be temporary and spatially limited to the immediate vicinity of pipeline construction activities. Increased sediment loads in the water column are expected to be temporary due to the high flushing in lower Cook Inlet.

Impacts to Fish Migration

Access Roads and Overland Gas Pipeline

Potential impacts on fish passage are not expected to occur at stream crossings, except temporarily during construction and when culverts become blocked due to extreme high-flow events.

Culverts and water diversion projects would be designed to facilitate juvenile and adult fish passage (e.g., fish bypass systems) as per permit stipulations. Figure 2-23 indicates that fish passage culverts would be installed with a buried invert; a constructed channel inside the culvert that matched the dimensions of the natural channel adjacent to the culvert; a streambed slope through the culvert that matches the channel slope to the maximum extent practical, but no more than 1 percent greater; a substrate in the culvert designed per Memorandum of Agreement Stream Simulation Design Requirements; inlet and outlet protection constructed per the Alaska Department of Transportation and Public Facilities Highway Drainage Manual; and inlet and outlet erosion protection that extends 16 feet upstream and downstream from the culvert. Implementation of BMPs would minimize the magnitude of impact on fish migration resulting from such disturbances.

The duration of impact on fish migration during construction would be temporary, because fish passage is expected to resume unimpaired after construction is complete. Installation of culverts and open cuts for pipeline installation may increase water turbidity and suspended sediments; fish may avoid the turbid areas, thereby impacting migration. The magnitude and extent of impacts would be such that fish may be temporarily disturbed or displaced from migrating but would return to their prior patterns after the activity ceases. Habitat functions would be altered, but would be expected to continue to perform key functions important to aquatic life. Short-term disturbance to fish and fish habitat would be expected to occur if the project is permitted and the access roads and pipeline are constructed.

The magnitude, duration, and extent of impacts on fish migration associated with culverts being temporarily blocked during high-flow events is expected to be similar to those described above for construction. The likelihood of culverts failing or being blocked for extended periods of time is low. Routine inspection and maintenance of culverts, bridges, and mine and port access roads would be regularly conducted and reported, in compliance with regulatory requirements, to ensure that culvert-related erosion, wash-out, or debris blockage do not result in impediments to fish passage or degradation of downstream habitat. Regular inspection and maintenance of culverts would continue through post-closure of the project as required by permit conditions.

Iliamna Lake—Ferry Terminals

The ramps required for the ferry at the Eagle Bay and south ferry terminals would not be expected to block fish passage or migration patterns in Iliamna Lake. ABR (2007) assessed the effects associated with two causeways extending approximately 2 miles from shore into the Beaufort Sea near Prudhoe Bay Alaska. The study found that the Arctic cisco population was more sensitive to environmental variability than to development activities; breaching of causeways had little effect on Arctic cisco migration; and overall, the effects of causeways were not detectable in the Arctic cisco population.

The spatial and temporal extent of the causeways in Prudhoe Bay project is of a much larger scale as compared to the ferry terminal ramps (2 miles versus 155 feet); therefore, impacts of the physical presence of the ramps to fish migration would be expected to be undetectable.

Changes to Surface Water Temperatures and Chemistry

Changes to surface water temperature and water chemistry in streams, Iliamna Lake, or Cook Inlet are not expected during construction and operations of the transportation and natural gas pipeline corridor. Potential water quality impacts are discussed in Section 4.18, Water and Sediment Quality. Potential impacts from spills are discussed in Section 4.27, Spill Risk.

Summary of Transportation and Natural Gas Pipeline Corridors Impacts—Alternative 1a

Direct Effects

In terms of magnitude and extent, the transportation and onshore pipeline corridors would eliminate 5.7 miles of streambed habitat and 1.7 acres of riverine wetlands. There would be a permanent loss of aquatic habitat within the footprint of bridge piers on the Newhalen and Gibraltar rivers. Unimpaired passage of resident and anadromous fish may be temporarily interrupted, but would continue unimpeded after construction is complete. Construction of stream crossings would avoid spawning migration windows; and where necessary, diversion methods—including juvenile and adult fish passage facilities—may be implemented under the direction and guidance of the ADF&G. Habitat at the immediate location of culverts would be altered, but fish would continue to use the streams. The duration of habitat disturbance from construction effects would be short-term and temporary, but would be expected to occur if the project is permitted and built.

The magnitude, duration, and extent of direct impacts to Iliamna Lake aquatic habitat would include permanent loss of small amounts of littoral (shallow shoreline habitat) at the Eagle Bay and south ferry terminals. Surveys indicate that the habitat lost receives limited use for rearing by juvenile Pacific salmon. Spawning fish were not observed in the immediate area of the terminals (Paradox 2018b). The combined loss of littoral zone habitat at the two terminals is minimal relative to the available littoral habitat that would remain undisturbed in Iliamna Lake. Riprap (rock and aggregate) placed around the terminal landing ramps would be colonized in the short-term, and subsequently used by fish and their prey organisms.

Construction of the natural gas pipeline across Iliamna Lake would have both permanent and temporary direct effects on lake habitat. There would be permanent, direct mortality of any benthic organisms beneath the pipeline footprint on the bottom of Iliamna Lake. However, given the water depths, lack of light, and oligotrophic status of Iliamna Lake, impacts to deepwater benthic areas and invertebrates are not expected to be substantial, with recolonization expected in 1 to 2 years. The pipeline itself would provide a hard surface that would be colonized by benthic macroinvertebrates and algae.

The Cook Inlet portion of the natural gas pipeline would temporarily impact 628 acres of marine benthic habitat. Long-term impacts would be expected for 11 acres of benthic marine habitat. An additional 21 acres of Cook Inlet marine benthic habitat would be temporarily impacted during construction from anchor and cable sweeps. It is expected that the pipeline itself would be quickly colonized by marine life, and soft substrate areas disturbed by construction would also recolonize.

Direct displacement, injury, or mortality of fish could occur during construction of bridges, culverts, and the overland portions of the natural gas pipeline. Potential impacts on fish passage are not expected to occur at stream crossings, except temporarily during construction activities; the duration of impact would be that unimpaired passage of fish may be temporarily interrupted during construction activities at stream crossings, but would resume unimpeded after construction is complete. Mitigation measures described in Chapter 5, Mitigation, including the use of HDD, construction timing windows, culvert design and maintenance, and ADF&G permit stipulations would be expected to reduce the extent and severity of impacts to fish migration.

The ferry terminals would be situated on beaches with no documented sockeye beach spawning habitat in the immediate vicinity; therefore, ferry operations would not be expected to directly impact adult sockeye salmon through propeller entrainment or injury, wake impacts, or due to noise and vibration from vessels. The short ramps required for the ice-breaking ferry at the Eagle Bay and south ferry terminals would not be expected to block fish passage or migration patterns in Iliamna Lake. Juvenile sockeye have the highest potential to interact with the ferry operations due to their relative abundance and wide distribution throughout the Iliamna Lake system.

Marine fish would not be expected to suffer direct mortality or injury during pipe-laying operations in Cook Inlet, but could be temporarily displaced from the immediate vicinity of construction activity. The presence of the natural gas pipeline would not be expected to impact fish passage or migration patterns in Cook Inlet, or to hinder marine macroinvertebrates (e.g., crabs). The diameter of the pipe resting on top of the seafloor would be within in the natural range of seafloor topography.

Direct effects on surface water flows at stream crossings are not expected except temporarily during culvert installation, HDD, or trenching. Water withdrawals at lakes, ponds, and streams along the road corridor would be expected to temporarily affect streamflows. Water withdrawals from fish-bearing streams require authorization from ADNR and ADF&G so that water levels and resident fish in the targeted waterbodies would not be permanently affected. The magnitude and extent of potential impacts to groundwater and surface water during pipeline construction would involve interception of shallow groundwater and surface water during trenching activities, which would be captured and locally flow along the trench backfill. Fill placed in the nearshore zone to construct ramps at the Eagle Bay and south ferry terminal locations could modify water circulation patterns by changing the direction or velocity of water flow; alter the location, structure, and dynamics of aquatic communities, including prey; and alter shoreline and substrate erosion and deposition rates. Chapter 5, Mitigation, describes methods that would reduce impacts to streamflow and lake circulation.

Indirect Effects

In terms of magnitude and extent, the road/pipeline footprint and associated crossing structures would impact riparian vegetation and interrupt floodplain connectivity in certain locations. This could reduce the input of terrestrial nutrients, thereby affecting downstream productivity. The duration of the impact to riparian vegetation would be permanent, and would be expected to occur if the project is permitted and built. However, additional non-impacted riparian habitat is available throughout the drainages, and BMPs and mitigation measures described in Chapter 5, Mitigation, would reduce impacts. Littoral habitat at the ferry terminals in Iliamna Lake would be lost due to construction of the ramps, but installed riprap and disturbed areas would be expected to recolonize. The aquatic food bed and overall productivity in the lake would not be expected to be impacted.

In terms of magnitude, duration, extent, and likelihood, road construction, maintenance, and use can result in short- and long-term impacts to streams and drainages from increased surface erosion and deposition of fine sediments. Operations are expected to require 35 truck round trips per day, which would result in dust impacts in proximity to roads, including at stream crossings. The increased water turbidity due to erosion and sedimentation and effects of dust generation are expected to be limited to bridge or culvert crossings, and mitigated by measures described in Chapter 5, Mitigation.

Temporary turbidity and sedimentation impacts could occur from diverting rivers or streams, removing riparian vegetation, and excavating streambed materials during overland pipeline installation. Turbidity and sedimentation impacts would be temporary during construction, and short-term until riparian vegetation becomes re-established. In terms of magnitude, duration, extent, and likelihood, there would be local, short-term turbidity increases to the water column in Iliamna Lake that could indirectly affect fish and benthic organisms during construction of the ramps at the Eagle Bay and south ferry terminal; this turbidity and increased water column suspended sediments would not be expected to persist, or to cover a large geographic area.

Pipeline construction activities in Iliamna Lake and Cook Inlet would be expected to have short-term impacts on individual fish and shellfish, but would not be expected to have population-level impacts, or to impact overall marine or lake productivity. In addition, changes to surface water temperature and water chemistry in streams, Iliamna Lake, or Cook Inlet are not expected during construction and operations of the transportation and natural gas pipeline corridor.

4.24.5.3 Amakdedori Port

Potential impacts to fish values at Amakdedori port would include direct loss of marine habitat; fish displacement, injury, and mortality; changes to marine productivity; increased sedimentation and turbidity; and impacts to fish migration. Impacts to EFH from development of Amakdedori port are quantified, and are described in Appendix I, EFH Assessment.

Direct Loss of Marine Habitat

In terms of magnitude and extent, placement of the caisson dock at the port would permanently impact 2.1 acres of marine benthic habitat. Fish surveys indicate the beach complex and subtidal mixed-gravel habitat at the port site are less productive than other areas sampled in Kamishak Bay (GeoEngineers 2018a, b). These impacts would be certain to occur if the project is permitted and Amakdedori port is built. Riprap placed on the causeway slopes would be similar in size and character to the boulder habitat currently present in both locations; would not represent a novel habitat feature; and would be recolonized in the short-term.

Displacement, Injury, and Mortality of Fish and Benthic Organisms

Short-term effects on both migratory and non-migratory marine fish species may occur during construction of the caisson dock port. The use of the caisson design effectively eliminates in-water impact noise that might adversely affect sensitive marine species. The duration of impacts would be temporary: fish may be disturbed or displaced, but direct mortalities would not be expected, and fish behavior would be expected to return to prior conditions after the activity ceases. Benthic organisms beneath the facility footprint would experience direct mortality. Razor clams have been reported from the Amakdedori area, as well as Augustine Island in Kamishak Bay; however, important harvest locations are outside of the project area (e.g., Chinitna Bay, Polley Creek, and locations farther north) (Nickerson 1975). The impacts would be expected to occur if the project is permitted and Amakdedori port is constructed.

Propeller Entrainment or Injury

Various propeller-driven tugs and other vessels would access Amakdedori port to transport equipment and personnel during project construction, operations, and closure. The magnitude, duration, extent, and likelihood of direct impacts to fish from vessel propellers are similar to those described for the Iliamna Lake ferry operations. This disturbance is expected to be limited in duration and geographic extent to the immediate vicinity of the port. The likelihood of impacts would be certain if the project is permitted and the Amakdedori port is built.

Wake Impacts

The magnitude of impacts during operations would be that marine barges or lightering vessels would make up to 33 trips per year between the port and the offshore anchored bulk carriers (see Chapter 2, Alternatives) The barge's low transit speeds (5 to 7 knots), minimal draft (3 to 8 feet), distance from shoreline to jetty mooring locations (approximately 1,500 feet), and the presence of naturally occurring waves in Kamishak Bay are all expected to limit wake-induced impacts on fish.

Changes to Marine Productivity

Discharge of fill material to construct the Amakdedori port would permanently remove benthic habitat; however, fish surveys indicate the beach complex and subtidal mixed-gravel habitat that would be removed are less productive than other areas sampled in Kamishak Bay (GeoEngineers 2018d). Herring spawn survey data suggest that the Amakdedori port location is isolated from known spawning areas. Herring spawn primarily on eelgrass and rockweed, found predominantly south of the port facility around reefs associated with Nordyke Island and Chenik Head, and near Contact Point, well north of the port (Owl Ridge 2019). Impacts to beach complex and subtidal mixed gravel would represent a reduction of 0.05 percent and 0.06 percent, respectively, of the total nearshore habitat mapped and available for colonization (GeoEngineers 2018a). Because of the existing available nearshore benthic habitat, there would be no anticipated impacts to the overall benthic productivity in Kamishak Bay.

Increased Sedimentation and Turbidity

The caisson-supported causeway and dock structure under Alternative 1a would excavate and cover approximately 2.1 acres of seafloor where caissons would be placed to support the dock structure. There would be a temporary disturbance to the seafloor and increased turbidity during dredging of materials to fill the caissons and prepare the seafloor for placement. The potential impacts from sedimentation and turbidity would be similar to those described for the natural gas pipeline, and are expected to be short-term in duration and localized in extent.

Impacts to Fish Migration

In terms of magnitude and extent, the Amakdedori dock would consist of a concrete caisson-supported access causeway and marine jetty in 15 feet of natural water depth. Both sides of the jetty would be fitted with floating barge ramps. This configuration is not expected to alter local currents and water circulation. Prevention or delay of fish migration is not anticipated from the port structure.

Summary of Amakdedori Port Impacts—Alternative 1a

Direct Effects

The magnitude and duration of direct impacts in marine habitat at the port site would be the loss of 2.1 acres of nearshore habitat at Amakdedori port (GeoEngineers 2018d). The benthic habitat that supports infaunal species would be removed, but surveys indicate the beach complex and subtidal mixed-gravel habitat at the port site are less productive than other areas sampled in Kamishak Bay (GeoEngineers 2018a, b). In terms of magnitude and extent, the beach complex and subtidal mixed gravel would represent a reduction of less than 0.05 percent of mapped beach complexes and gravel habitat (GeoEngineers 2018a, d). Riprap placed at the port would provide new habitat substrate that would be recolonized in the short-term.

Short-term displacement of both migratory and non-migratory marine fish species may occur during construction of the port due to noise exposure. Fish may be disturbed or displaced, but direct mortalities would not be expected, and fish behavior would be expected to return to prior conditions after the activity ceases.

The magnitude, duration, extent, and likelihood of direct impacts to fish from vessel propellers and vessel wakes are similar to those described for the Iliamna Lake ferry operations. This disturbance is expected to be chronic, but limited in duration and in geographic extent to the immediate vicinity of the port. Low barge transit speeds and the presence of naturally occurring waves would limit the effects of vessel wakes.

The causeway and jetty at the port would extend into Cook Inlet. The port structure is not anticipated to affect long-term fish migration patterns.

Indirect Effects

Herring spawn survey data suggest that Amakdedori port is not a known spawning area. Riprap placed around the landing ramp at the port would be recolonized in the short-term, and subsequently used by prey organisms. Because of the existing available nearshore benthic habitat, there would be no anticipated impacts to the overall marine productivity in Kamishak Bay.

4.24.5.4 Summary—Alternative 1a Impacts

The entire Bristol Bay drainage contains 9,816 miles of documented anadromous waters. (Johnson and Blossom 2018). Therefore, the loss of NFK tributaries NK 1.190 and NK 1.200 represent a 0.08 percent reduction of documented anadromous stream habitat. However, the total estimated mileage of anadromous waters in Bristol Bay drainage is likely much higher than what is currently documented. The mine site is one of the few locations in the Bristol Bay drainage where numerous small channels and tributaries have been extensively surveyed for fish distribution. Documented anadromous waters only represent waters where salmon have been observed and are not considered representative of all anadromous waters in the Bristol Bay drainage. The duration of direct impacts of the removal of anadromous habitat would be permanent. However, considering the physical characteristics and current fish use of habitat to be removed, the consequently low densities of juvenile Chinook and coho observed in the affected tributaries, and the few numbers of spawning coho observed (see Section 3.24, Fish Values), impacts to anadromous and resident fish populations from these direct habitat losses would not be measurable, and would be expected to fall within the range of natural variability.

Impacts to Bristol Bay salmon are not expected to be measurable and given the vast breadth and diversity of habitat (and salmon populations) in the Bristol Bay watershed, impacts on the Portfolio Effect[1] are certain but not likely to be noticeable in context of the Bristol Bay watershed.

4.24.6 Alternative 1

Impacts attributable to Alternative 1 and variants are described below by project component.

4.24.6.1 Mine Site

The magnitude, duration, extent, and likelihood of direct and indirect impacts to fish, aquatic habitat, streamflow, productivity, sedimentation and turbidity, and fish migration due to construction and operations at the mine site would be same as those described for Alternative 1a.

4.24.6.2 Transportation Corridor and Natural Gas Pipeline Corridor

Based on field-verified stream mapping as described in Section 3.22, Wetlands and Other Waters/ Special Aquatic Sites, the Alternative 1 transportation and natural gas pipeline corridor would cross 224 waterbodies. In terms of magnitude and extent, the Alternative 1 transportation and natural gas pipeline corridor would cross fewer rivers and streams (224) compared to Alternative 1a (233).

Project roads would cross stream habitat that supports five species of Pacific salmon (Chinook, chum, coho, pink, and sockeye) and numerous resident fish species, including rainbow trout and Arctic grayling. Anadromous and resident fish species known to occur in the affected area are listed in Table 3.24-11

Potential impacts to fish values along the transportation and natural gas pipeline corridors are similar to those described for Alternative 1a: direct loss of aquatic habitat at stream crossings, at ferry terminal sites on Iliamna Lake, and along the natural gas pipeline crossings of Iliamna Lake and Cook Inlet. Other impacts include fish displacement, injury, and mortality at these locations; changes in stream surface water flows; increased sedimentation and turbidity at crossings and terminal sites; and potential impacts to fish migration. Impacts to EFH from development of the transportation and natural gas pipeline corridors are quantified and described in Appendix I, EFH Assessment.

<u>Direct Loss of Aquatic Habitat</u>

Mine and Port Access Roads and Overland Gas Pipeline

The magnitude and extent of habitat loss from development of the transportation corridor and onshore portions of the natural gas pipeline would be the removal of 6.1 miles of streambed habitat and 6.2 acres of riverine wetland habitat. The corridor would cross 52 waterbodies

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[1] The **Portfolio Effect** is an observation that the Bristol Bay salmon run is produced from an abundance of diverse aquatic habitat; this diversity allows for a harvestable surplus even when some systems experience low abundance (Schindler et al. 2010). The term "Portfolio Effect" is taken from the concept of investment portfolios, where adding to the diversity of investments is thought to reduce risk (or the likelihood of occurrence of losses to the overall investment portfolio, even if some individual investments do not do well). Any loss of salmon production would have an effect on the Bristol Bay "portfolio," similar to the way that financial losses by individual investments would have an effect on an investor's portfolio. In this EIS, the effect to the Bristol Bay portfolio is considered by evaluating the amount of habitat and salmon production that would be lost. No long-term measurable changes in the number of returning salmon are expected, nor is genetic diversity expected to change; therefore, the impact to the Portfolio Effect would not be discernable.

documented to support resident and anadromous fish Sixteen of these waterbodies have been documented to support Pacific salmon (Table 4.24 1). There would be a permanent loss of some habitat within the direct footprint of bridge piers on the Newhalen and Gibraltar rivers.

The impacts on fish values due to the loss of this aquatic habitat would be greater in extent and magnitude based on the increased loss of streambed habitat and riverine wetlands compared to Alternative 1a.

Iliamna Lake—Ferry Terminals and Natural Gas Pipeline

Docking facilities for the ice-breaking ferry at the north and south ferry terminals under Alternative 1 would include rock-and-gravel ramps extending approximately 105 feet and 155 feet, respectively, into Iliamna Lake (Chapter 2, Alternatives[2]). The magnitude and extent of impacts to aquatic lake habitat would be the removal of approximately 0.1 acre of shallow lake aquatic habitat and 185 feet of shoreline habitat at the north terminal, and 0.7 acre and 738 feet at the south terminal, compared to 1.66 acres for Alternative 1a. Discharge of fill material to construct the ferry terminals and ramps would permanently remove this aquatic habitat; however, surveys indicate that the habitat that would be lost receives limited use as rearing habitat by juvenile Pacific salmon, and is not used for spawning by Pacific salmon (Paradox 2018b). The combined loss for the two terminals of 0.8 acre and 923 feet of littoral zone is minimal relative to the abundance of littoral habitat that would remain undisturbed in Iliamna Lake, particularly given the limited use for salmonid rearing and absence of adult spawning at these locations (Owl Ridge 2019).

No freshwater mussels have been documented within the north and south ferry terminal footprints. Riprap placed around the landing ramp would be similar in size and character to the boulder habitat currently present in both locations and would not represent a novel habitat feature. Riprap would be colonized in the short-term, and subsequently used by fish and their prey organisms. Habitat abutting fill locations may be disturbed or degraded during construction, but the duration of the impact would be short-term, because habitat is expected to recover after construction activities are completed.

The pipeline crossing the lake differs from Alternative 1a, and the impacts from loss of aquatic habitat by construction would be 4 acres; compared to 1 acre for Alternative 1a.

Pipeline-Only Overland Portion of the Natural Gas Pipeline

Based on field-verified stream mapping as described in Section 3.22, the overland pipeline-only portion of the natural gas pipeline would cross three streams under Alternative 1. Impacts on fish and fish habitat would be similar to those described for the mine access roads under Alternative 1a, and include loss and alteration of habitat, fish displacement and injury, and changes in stream productivity. Impacts are expected to occur, and would be short-term in duration and limited to the disturbed area.

Cook Inlet Potion of the Natural Gas Pipeline

The magnitude and extent of loss of aquatic habitat under Alternative 1 would be the same as described for Alternative 1a (Table 4.24-1).

[2] Footprint based on project GIS data (PLP 2019-RFI 153).

Displacement, Injury, and Mortality of Fish and Benthic Organisms

Mine and Port Access Roads, Iliamna Spur Road, and Overland Gas Pipeline

Direct displacement, injury, or mortality of fish could occur during construction of bridges, culverts, and the overland portions of the natural gas pipeline. With the exception of the extent of required blasting, these impacts would be the same as those described for Alternative 1a (Table 4.24-1).

Under Alternative 1, blasting would be needed for road and pipeline construction. Blasting would occur along approximately 25 miles of the port access road between Amakdedori port and the south ferry terminal (same as Alternative 1a), 1.4 miles on the mine access road between the north ferry terminal and the mine site, and 3 miles on the Iliamna spur road. There are 44 documented fish streams within 1,000 feet of blasting locations on the Alternative 1 corridor. Estimated pressure and vibration forces generated by blasting at gravel mine sites and along the transportation corridor have not been calculated, pending future blasting plans; however, blasting during construction would be required to follow the guidelines established in the 2013 ADF&G Technical Report (No. 13-03) Alaska Blasting Standard for the Proper Protection of Fish.

Iliamna Lake—Ferry Terminals, Ferry Operations, and Natural Gas Pipeline

The north and south ferry terminal locations are used for rearing by juvenile salmonids in the spring, but are not important locations for sockeye salmon rearing, adult sockeye salmon spawning, or the rearing of other salmonid species at other times of the year (Hart Crowser 2018a; 2018b; Paradox 2018a). Threespine stickleback are the most common fish species at the terminal locations. As described for Alternative 1a, construction of the ferry terminal docking facilities is not likely to cause widespread injury or mortality to fish, but may temporarily displace them from the immediate area.

The north and south ferry terminals are situated on exposed, high-energy beaches with no documented sockeye beach spawning habitat in the immediate vicinity; therefore, ferry operations are not expected to directly impact adult sockeye salmon though displacement, injury, or mortality. The ferry route would avoid the region of Iliamna Lake having the highest densities of sockeye fry, but juvenile sockeye are more abundant in the central lake basin and have the potential to interact with the ferry operations.

The pipeline route crossing the lake under Alternative 1 is slightly shorter than that of Alternative 1a. Therefore, direct impacts of displacement, injury, or mortality of fish and benthic organisms would be the same or slightly less than those described for Alternative 1a. Likewise, the ferry crossing route is shorter and more direct, so impacts of ferry operations under this alternative would be similar to or less than Alternative 1a (Table 4.24-1).

Changes in Surface Water Flows and Iliamna Lake Circulation

Impacts to surface water flows under Alternative 1 would be the same as described for Alternative 1a. Fill placed in the nearshore zone to construct ramps at the north and south ferry terminals could modify water circulation patterns by changing the direction or velocity of water flow; alter the location, structure, and dynamics of aquatic communities, including prey; and alter shoreline and substrate erosion and deposition rates.

Changes to Stream and Lake Productivity, Sedimentation, Turbidity, Temperatures, and Chemistry

Impacts to stream productivity, sedimentation, turbidity, water temperatures, and chemistry would be similar to those described for Alternative 1a, but could be less in magnitude because of the fewer number of streams crossed under Alternative 1 (52 streams for Alternative 1; 55 streams for Alternative 1a) (Table 4.24 1).

In terms of magnitude, duration, and extent, there would be short-term, indirect disturbance effects from the construction of ramps at the north and south ferry terminals, including the loss of approximately 0.8 acre of benthic habitat under the north and south ferry terminal footprints combined. Riprap placed around the landing ramps would be similar in size and character to existing boulders in Iliamna Lake, and would be colonized in the short-term, and subsequently used by prey organisms. The aquatic food web in Iliamna Lake is not expected to be impacted by terminal and ferry operations.

Local, short-term turbidity increases to the water column could indirectly affect fish and benthic organisms during construction and placement of fill for the ramps at the north and south ferry terminals. As described in Section 4.16, Surface Water Hydrology, transport of suspended sediment by wind-driven currents along the shore would not be expected to persist or to cover a large geographic area. The increased water turbidity and indirect impacts would be expected to occur if the project is permitted and constructed.

Changes to Marine Productivity

Impacts to marine productivity along the Cook Inlet portion of the natural gas pipeline would be the same as Alternative 1a.

Impacts to Fish Migration

Fish migration impacts from the access roads, spur road, and the natural gas pipeline under Alternative 1 would be the same or slightly less than those described for Alternative 1a (Table 4.24-1).

The rock-and-gravel ramps (up to 155 feet long) required for the ice-breaking ferry at the north and south ferry terminals would not be expected to block fish passage or migration patterns in Iliamna Lake. ABR (2007) assessed the effects associated with two causeways extending approximately 2 miles from shore into the Beaufort Sea near Prudhoe Bay. The study found that the Arctic cisco population was more sensitive to environmental variability than to development activities; breaching of causeways had little effect on Arctic cisco migration, and overall the effects of causeways were not detectable in the Arctic cisco population. The spatial and temporal extent of the causeways in the Prudhoe Bay project is of a much larger scale as compared to the ferry terminal ramps (2 miles versus 155 feet); therefore, impacts of the physical presence of the ramps to fish migration would be expected to be undetectable.

4.24.6.3 Amakdedori Port

Potential impacts to fish values at the Amakdedori port site under Alternative 1 include direct loss of marine habitat; fish displacement, injury, and mortality; changes to marine productivity; increased sedimentation and turbidity; and impacts to fish migration.

Direct Loss of Marine Habitat

The magnitude and duration of project impacts under Alternative 1 at the port site would be the removal and/or fill of 11 acres of nearshore habitat, including approximately 1.89 acres of beach complex and 8.7 acres of subtidal mixed-gravel habitat at the Amakdedori port location (Table 4.24-1) (GeoEngineers 2018d). If the Pile-Supported Dock Variant of Alternative 1 is constructed, the impact to marine benthic habitat would be reduced to 0.1 acre (Table 4.24-1). Because the footprint for this dock is larger than that for the caisson dock under Alternative 1a, impacts to benthic habitat would be greater. However, as described for Alternative 1a, fish surveys indicate the beach complex and subtidal mixed-gravel habitat at the port site are less productive than other areas sampled in Kamishak Bay (GeoEngineers 2018a, b). In terms of magnitude and extent, the beach complex and subtidal mixed gravel would represent a reduction of 0.05 percent and 0.06 percent, respectively, of locally mapped habitat (GeoEngineers 2018a, d). These impacts would be certain to occur if Alternative 1 is permitted and the Amakdedori port is built. Riprap placed on the causeway slopes would be similar in size and character to the boulder habitat currently present; would not represent a novel habitat feature; and would be recolonized in the short-term.

Displacement, Injury, and Mortality of Fish and Invertebrates

Short-term effects on both migratory and non-migratory marine fish species may occur during construction of the port. Marine facilities would include an earthen access causeway and sheet pile jetty instead of a caisson dock under Alternative 1a. Fish would be susceptible to injury and mortality from sound waves generated by pile-driving during construction of the dock (Caltrans 2015). The installation of sheet pile would require a permit from ADF&G; permit conditions (if issued) would limit exposure to noise to be consistent with established criteria. If ADF&G determines that pile-driving would occur in a location and during a timeframe that could cause impacts to a managed species, a noise monitoring and mitigation plan would be required to mitigate the potential impacts.

The duration of construction impacts would be temporary: fish may be disturbed or displaced, but direct mortalities would not be expected, and fish behavior would be expected to return to prior conditions after the activity ceases. Benthic invertebrates would be impacted in the port footprint. Razor clams have been reported from the Amakdedori area, as well as Augustine Island in Kamishak Bay; however, important harvest locations are well outside of the project area (e.g., Chinitna Bay, Polley Creek, and locations farther north) (Nickerson 1975). The impacts would be expected to occur if the project is permitted and the Amakdedori port is constructed.

Appendix K4.25, Threatened and Endangered Species, provides additional information on potential noise impacts to fish from development of the port.

Increased Sedimentation

Turbidity and deposition of suspended sediments in the nearshore environment at the port site could secondarily impact marine benthos and invertebrates. Temporary effects on both migratory and non-migratory marine fish species may also occur, particularly for benthic fish species expected to inhabit the immediate area.

The existing marine substrate at the port site consists of subtidal gravels (GeoEngineers 2018a). Although project-related activity would contribute to suspended sediment levels in marine water around the port site, sediment in the area is coarse grained, and the incremental increase in suspended sediment and redeposition due to project-related disturbance of this coarse-grained material would be limited in magnitude and extent (see Section 3.18, Water and Sediment Quality).

As described in Section 4.16, Surface Water Hydrology, construction of the earthen-fill causeway would cause elevated concentrations of suspended sediments that would be expected to persist for a few weeks after completion, but would not be substantially greater than the maximum levels routinely observed in lower Cook Inlet. The duration of impacts from port construction are expected to be short-term, lasting only during construction, and would be certain to occur if Alternative 1 is permitted and constructed.

Impacts to Fish Migration

In terms of magnitude and extent, the Amakdedori port causeway and jetty under Alternative 1 would extend approximately 1,900 feet into Cook Inlet and could alter local currents and water circulation. The causeway and jetty would be an obstacle that fish migrating along the beach would encounter. Obstacles are common along the Alaska coast, primarily in the form of reefs, rocky points, and peninsulas, many of which have similar structure as the rock-armored causeway. As discussed previously regarding ramps associated with ferry terminals, prevention or delay of fish migration would not be anticipated from the port structure.

4.24.6.4 Alternative 1 Variants

Summer-Only Ferry Operations Variant

The Summer-Only Ferry Operations Variant would preclude the need for ice-breaking operations. Impacts to Iliamna Lake under the Summer-Only Ferry Operations Variant would be similar to those described for Alternative 1 during the summer (open water) season. The ferry vessel would be larger than in Alternative 1a and Alternative 1, or there could be two vessels. Increased vessel size and horsepower could result in increased impacts from wake and propeller strike to juvenile fish, as described under Alternative 1a.; however, the Summer-Only Ferry Operations Variant would eliminate the potential impacts from ferry operations on juvenile sockeye during winter months.

Kokhanok East Ferry Terminal Variant

The access road route for the Kokhanok East Ferry Terminal Variant avoids the need for a bridge across the Gibraltar River. Specific fish sampling data are not currently available on fish resources for the Kokhanok East Ferry Terminal Variant or the 7 channels crossed via culverts along the Kokhanok East section of the transportation and natural gas pipeline corridor; however, a single bridge crossing would be required over Anadromous Water Catalog (AWC) stream 324-10-10150-2206 (near the Kokhanok East ferry terminal location), which is listed as supporting sockeye spawning and the presence of Arctic char.

Direct Loss of Aquatic Habitat

The variant portion of the road (Kokhanok east spur road) and pipeline corridor would cross non-anadromous channels requiring culverts, and would require 1 bridge crossing of an anadromous stream supporting sockeye salmon spawning and the presence of Arctic char. In terms of magnitude and extent, the port access road with the Kokhanok east spur road, and pipeline route would have 11 fewer stream crossings compared to Alternative 1a. Six of the crossing locations provide resident fish habitat, and five provide anadromous fish habitat, including the Gibraltar River bridge crossing. The magnitude and extent of impacts would be a reduction in impacts to anadromous and resident fish stream habitat because of the reduction in stream crossings under this variant, as compared to Alternative 1. The duration and likelihood of impacts would be the same as Alternative 1.

Fish Displacement, Injury, and Mortality

Fewer stream crossings would result in less associated impacts during construction, including culvert installation, stream diversion, water withdrawals, and pipeline trenching. The magnitude and extent of impacts from the displacement, injury, or mortality would be reduced compared to Alternative 1. The duration and likelihood of impacts would be the same as Alternative 1.

Changes in Streamflow, Productivity, Sedimentation, and Turbidity

Fewer stream crossings under the Kokhanok East Ferry Terminal Variant would reduce the magnitude and extent of streamflow, productivity, sedimentation, and turbidity impacts in the transportation corridor compared to Alternative 1. The duration and likelihood of impacts would be the same as Alternative 1.

Impacts to Fish Migration

Fewer stream crossings would reduce the magnitude and extent of impacts to fish migration compared to those described for Alternative 1.

Pile-Supported Dock Variant

The magnitude, duration, extent, and likelihood of impacts on fish migration and water temperature associated with this variant would be the same as described for Alternative 1. Impacts would be different under this variant as compared to Alternative 1 for the parameters discussed below.

Direct Loss of Aquatic Habitat

This variant would install 253 dock pilings instead of the gravel-filled causeway described in Alternative 1. The magnitude and extent of loss of benthic habitat under this variant would be less, at approximately 0.1 acre (Table 4.24-1) (PLP 2018-RFI 072), compared to approximately 11 acres under Alternative 1. The Pile-Supported Dock Variant would not require the approximately 2,000 lineal feet of large, rocky substrate provided by riprap armoring as required under Alternative 1. The duration and likelihood of impacts would be the same as Alternative 1.

Fish Displacement, Injury, and Mortality

Approximately 253 dock piles would be installed in the intertidal area under this variant (PLP 2018-RFI 072). Potential for displacement, injury, and mortality would be greater than Alternative 1 because of the duration and intensity of noise impacts during construction from pile-driving and other sources. Impacts would be similar to those described under Alternative 1a in relation to noise disturbance and displacement of fish. These impacts would be expected to occur if this variant is selected, and the project is permitted and built.

Changes to Marine Productivity

Under this variant, impacts related to the dock footprint would be less than Alternative 1 (0.1 acre of impacts to marine benthic productivity). However, productivity from re-colonized habitat provided by riprap armoring in Alternative 1 would be eliminated. These impacts would be expected to occur if this variant is selected, and the project is permitted and built.

Marine Sedimentation and Turbidity

The magnitude and extent of sedimentation and turbidity impacts would be less than Alternative 1, and in the immediate footprint of the piles during construction. These impacts would be likely to occur if this variant is selected, and the project is permitted and built.

Impacts to Fish Migration

Impacts to fish migration would be similar to those described for Alternative 1.

4.24.6.5 Summary—Alternative 1 Impacts

Impacts at the mine site and for the marine portion of the natural gas pipeline would be the same as those for Alternative 1a (Table 4.24-1). The total area of impact for the Iliamna Lake ferry terminals under this alternative is about 50 percent less than that for Alternative 1a. Although the pipeline and ferry routes across Iliamna Lake under Alternative 1 are slightly shorter than those for Alternative 1a, Alternative 1 would impact 4 acres of Iliamna Lake benthic habitat compared to 1 acre of impact under Alternative 1a. The short rock-and-gravel ramps required for the ice-breaking ferry at the north and south ferry terminals would not be expected to block fish passage or migration patterns in Iliamna Lake.

The port design under Alternative 1 consists of a solid fill causeway and jetty that would permanently impact about 11 acres of benthic marine habitat. Turbidity and deposition of suspended sediments in the nearshore environment during placement of fill for the causeway could secondarily impact marine fish, benthos, and invertebrates. The Amakdedori port causeway and jetty under Alternative 1 would extend 1,900 feet into Cook Inlet and could alter local currents and water circulation. However, prevention or delay of fish migration is not anticipated from the port structure.

4.24.7 Alternative 2—North Road and Ferry with Downstream Dams

This alternative would require less overall length of access roads and use a different design and method of construction (downstream construction) of the main bulk TSF embankment. This section describes the potential impacts related to Alternative 2 and variants.

4.24.7.1 Mine Site

The impacts to fisheries resources under Alternative 2 would be the same as Alternative 1a, except that some of the impacts would be about 40 feet upstream due to the upstream shift (compared to the centerline construction in Alternative 1a) of the main TSF embankment (Tributary NK 1.19, gaging station NK 119A). The magnitude, duration, extent, and likelihood of impacts to habitat, streamflow, productivity, sedimentation and turbidity, and fish migration would be the same as those described for Alternative 1a.

4.24.7.2 Transportation Corridor and Natural Gas Pipeline Corridor

Based on field-verified stream mapping, as described in Section 3.22, Wetlands and Other Waters/Special Aquatic Sites, the Alternative 2 transportation and natural gas pipeline corridor would cross 220 waterbodies. This includes the pipeline-only portions of the natural gas pipeline. Overall, the magnitude and extent of impacts would be less compared to the Alternative 1a, where 233 streams and rivers are crossed.

Project roads would cross stream habitat that supports five species of Pacific salmon (Chinook, chum, coho, pink, and sockeye) and numerous resident fish species, including rainbow trout and Arctic grayling. Anadromous and resident fish species known to occur in the affected area are listed in Table 3.24-11.

Potential impacts to fish values along the transportation and natural gas pipeline corridors are similar to those described for Alternative 1a: direct loss of aquatic habitat at stream crossings, and along the natural gas pipeline crossings and across Cook Inlet. Alternative 2 would avoid crossing Iliamna Lake and as such no direct impacts are expected. Other impacts include fish displacement, injury, and mortality at these locations; changes in stream surface water flows; increased sedimentation and turbidity at crossings and terminal sites; and potential impacts to fish migration. Impacts to EFH from development of the transportation and natural gas pipeline corridors are quantified, and described in Appendix I, EFH Assessment.

Direct Loss of Aquatic and Marine Habitat

Mine and Port Access Roads and Overland Gas Pipeline

The transportation corridor on the north side of Iliamna Lake and the natural gas pipeline corridor from the mine site to Diamond Point are described in Chapter 2, Alternatives. The magnitude, duration, and extent of habitat loss from development of the transportation corridor and onshore portions of the natural gas pipeline would be the removal of 3.8 miles of streambed habitat and 7.2 acres of riverine wetland habitat. The corridor would cross 55 waterbodies documented to support fish, 25 of which support Pacific salmon. The mine access road under Alternative 2 is the same as for Alternative 1a—mine site to Eagle Bay ferry terminal. The port access road would connect the Pile Bay ferry terminal with Diamond Point port. The magnitude, duration, extent, and likelihood of aquatic resource impacts associated with the road segments from the mine site to Eagle Bay, and Pile Bay to Diamond Point port (see Figure 2-49 and Figure 2-50) would be similar to the types of impacts described for Alternative 1a, except the road length under Alternative 2 is less than Alternative 1a.,

In terms of magnitude and extent of impacts, Alternative 2 would impact more streams and have one less anadromous and resident fish stream crossings (55) compared to the Alternative 1a (56) (Table 4.24 1); however, the loss of streambed habitat would be less. Under Alternative 2, all anadromous fish stream crossings would be in the Iliamna Lake/Kvichak and Cook Inlet watersheds. There are 34 fish streams with 1,000 feet of blasting locations on the Alternative 2 corridor, and impacts would be similar to those described under Alternative 1a. The duration and likelihood of impacts would be the same as Alternative 1a.

Iliamna Lake—Ferry Terminals

Adult and juvenile sockeye were documented along the northern and southern shorelines of the Eagle Bay ferry terminal location (see Section 3.24, Fish Values). Spawning surveys indicate heavy use of the northeastern arm of Iliamna Lake, with highest densities associated with the main island archipelagos: Knutson Bay, Pedro Bay, and Pile Bay. Lower densities of spawning have been observed near Eagle Bay or in the eastern extremity of Pile Bay. The magnitude, duration, extent, and likelihood of habitat loss would be the same as described for Alternative 1a (Table 4.24-1). There is no gas pipeline across Iliamna Lake under Alternative 2.

Pipeline-Only Overland Portion of the Natural Gas Pipeline

Based on field-verified stream mapping as described in Section 3.22, Wetlands and Other Waters/ Special Aquatic Sites, the overland pipeline-only portion of the natural gas pipeline would cross 133 streams under Alternative 2. Impacts on fish and fish habitat would be similar to those described for the mine access roads under Alternative 1a, and include loss and alteration of habitat, fish displacement and injury, and changes in stream productivity. Impacts are expected to be short-term in duration and limited to the disturbed area.

Cook Inlet Portion of the Natural Gas Pipeline

The pipeline across Cook Inlet would be constructed as described for the Applicant's Preferred Alternative, but the western landfall would be at Ursus Cove. The magnitude, duration, extent, and likelihood of impacts to marine habitat would be less than the Alternative 1a (75 miles of pipeline in Cook Inlet compared to 104 miles for the Alternative 1a) for the portion of the pipeline from the Anchor Point to Ursus Cove. Approximately 638 acres of marine substrate would be temporarily disturbed from trenching activities between Anchor Point and Ursus Cove. This does not include potential seabed disturbance from anchor placement. Anchor placement can scar the substrate each time an anchor is set, and the scraping or sweeping of the seafloor from the movement of the anchor cables across the seafloor (cable sweep). Substrate footprint scars in dynamic substrate areas would be expected to recover quickly and marine organisms are likely adapted to the constant rearrangement of the substrate. Habitat losses resulting from pipeline installation would range from temporary to short-term and would be minimal in the context of existing habitat in lower Cook Inlet unaffected by this activity. Benthic habitat would be expected to recover relatively quickly, ranging from days to weeks. Submerged boulder areas or isolated rocks and rock outcrop areas could include greater biomass than sandy substrates, making for a longer recovery time ranging from months to years.

Displacement, Injury, and Mortality of Fish and Benthic Organisms

Mine and Port Access Roads and Overland Gas Pipeline

In terms of magnitude, Alternative 2 would cross the same number of fish streams (55) as Alternative 1a, but would impact more acres of riverine wetlands (9.5 acres, compared to 3.5 acres) (Table 4.24-1). The impacts regarding displacement, injury, or mortality to fish during construction activities such as culvert installation, stream diversion, water withdrawals, and pipeline trenching would be similar to those described in Alternative 1a. The duration and likelihood of impacts would be the same as Alternative 1a.

Iliamna Lake—Ferry Terminals

The magnitude, duration, extent, and likelihood of impacts to benthic organisms would be the same as described in Alternative 1a for ferry terminal construction and operation. The slightly longer ferry route under Alternative 2 (29 miles versus 27 miles) and the route through the eastern basin of Iliamna Lake, including island archipelagos and abundant anadromous fish tributaries, would increase the likelihood of interaction between the ferry and sockeye salmon. Impacts from ferry operations would be the same as previously described for Alternative 1a.

There would be no natural gas pipeline crossing of Iliamna Lake under Alternative 2, so there would be no impacts as compared to Alternative 1a.

Cook Inlet Portion of the Natural Gas Pipeline

The magnitude, duration, and extent of displacement, injury, and mortality on marine organisms would be less compared to Alternative 1a due to the shorter route across Cook Inlet. Adult fish species would be expected to avoid the altered habitats during construction, but would be expected to return once the activity ceases and habitats recover. Approximately 132 acres of weathervane scallop habitat would be impacted by installation of the pipeline. Unlike most adult fish that are mobile and able to actively avoid direct impacts, weathervane scallops may not be able to avoid the area, which could potentially result in weathervane scallop mortality; however, considering the extent of the disturbance relative to the available habitat for weathervane scallops, the magnitude of this impact would not be expected to result in measurable changes to weathervane scallop populations. The construction of the natural gas pipeline would avoid the fished scallop bed in Cook Inlet (see Section 4.6, Commercial and Recreational Fisheries). Appendix I, EFH Assessment, provides more details on the potential impacts to weathervane scallop EFH from construction of the natural gas pipeline.

Changes in Surface Water Flows, Productivity, Sedimentation, and Turbidity

Mine and Port Access Roads and Overland Natural Gas Pipeline

In terms of magnitude and extent, Alternative 2 would cross the same number of fish streams (55) as Alternative 1a (Table 4.24-1), resulting in similar potential for streamflow and productivity impacts and increased turbidity during construction activities such as culvert installation, stream diversion, water withdrawals, and pipeline trenching, as described in Alternative 1a. The duration and likelihood of impacts would be the same as Alternative 1a.

Iliamna Lake—Ferry Terminals

The magnitude, duration, extent, and likelihood of impacts to streamflow, productivity, sedimentation, turbidity, water temperature, and water chemistry would be the same as Alternative 1a for the Eagle Bay ferry terminal. The Pile Bay ferry terminal would impact 0.24 fewer acres of benthic habitat compared to the south ferry terminal under Alternative 1a.

Cook Inlet Portion of the Natural Gas Pipeline

The pipeline across Cook Inlet would be constructed as described for Alternative 1a, but the alignment would come ashore at Ursus Cove. The magnitude, duration, extent, and likelihood of impacts to marine habitat would be less (75 miles of pipeline in Cook Inlet compared to 104 miles for Alternative 1a) than Alternative 1a for the portion of the pipeline beginning on the Kenai Peninsula and crossing Cook Inlet to Kamishak Bay. The magnitude, duration, extent, and likelihood of impacts on water quality would less than described under Alternative 1a for the portion of the pipeline from the Kenai Peninsula to Kamishak Bay.

Impacts to Fish Migration

The impacts to fish migration from development of the transportation corridor would be similar to those for Alternative 1a.

Mine and Port Access Roads and Overland Gas Pipeline

Impacts would be the same as Alternative 1a.

Iliamna Lake—Ferry Terminals

Impacts would be the same as Alternative 1a.

Cook Inlet Portion of the Natural Gas Pipeline

Impacts would be the same as Alternative 1a.

Changes to Surface Water Temperature and Chemistry

The same number of streams would be crossed in Alternative 2 as described for Alternative 1a, although in different geographical locations along the northern shore of Iliamna Lake. Changes to surface water temperature and water chemistry in streams, Iliamna Lake, or Cook Inlet would not be expected. The magnitude, duration, extent, and likelihood of impacts on water temperature and water chemistry would be the same as Alternative 1a.

4.24.7.3 Diamond Point Port

The port site at Diamond Point would be at the intersection of Iliamna and Cottonwood bays. Effects on marine organisms and habitat at the Diamond Point Port component include habitat loss, displacement, and mortality of individuals, alterations in habitat, noise disturbance, and sedimentation. As described in Section 3.24, Fish Values, 41 fish species were captured by beach seine in nearshore sandy/cobble habitats; however, not all species were captured at all stations and months. The presence of both juvenile and larger salmonids indicates that species use the nearshore locations as migration corridors between marine and freshwater environments. A total of 45 species were captured in otter trawl surveys, dominated by snake prickleback, yellowfin sole, starry flounder, Pacific herring, and walleye pollock. In gill nets, Pacific herring (multiple-year classes) dominated the catch in both sampling periods. Trammel nets mostly captured starry flounder (PLP 2012).

Direct Loss of Marine Habitat

In terms of magnitude and extent, construction of the dock and port facilities at Diamond Point would have a greater spatial and temporal direct impact on marine fisheries and benthic invertebrates than at Amakdedori port (PLP 2018-RFI 072) under Alternative 1a. The benthic footprint of the Diamond Point port would remove 14 acres of benthic habitat and would require maintenance channel dredging. The channel maintenance dredging is expected to disturb 56 acres of benthic habitat every 5 years. This would result in a reoccurring impact to 56 acres of benthic habitat for the life of the project (Table 4.24-1). Measurable changes in marine productivity are not expected to occur with this loss of habitat, considering the magnitude of impact compared to the abundance of available nearshore habitat.

Sedimentation and Turbidity

Channel dredging during construction and maintenance would cause turbidity impacts, with a reoccurring turbidity impact to 58 acres of benthic habitat for the life of the project, compared to no dredging impacts associated with Alternative 1a. As described in Section 4.18, Water and Sediment Quality, dredging would temporarily increase suspended solids in the water column, which would be redeposited on marine substrate. Fish surveys indicate that the beach complex and subtidal mixed-gravel habitat at the port site are less productive than other areas sampled in Kamishak Bay (GeoEngineers 2018a, b). Most adult fish are mobile and would avoid areas of increased suspended sediment (Wagner at al. 2017). Increased turbidity in the water column could result in physical impairment of fish species, causing potential turbidity-induced clogged gills (i.e., suffocation or abrasion of sensitive epithelial tissue) and alteration of foraging behavior for visual predators. The extent of these effects to would range from localized, to beyond the mouth of Iliamna Bay, depending on tides, wave conditions, and winds. Sedentary species that occur in soft substrate, such as bivalves and polychaetes, would likely be more affected by dredging activities, and mortalities are expected. Habitat characteristics would be expected to return to near baseline conditions after dredging ceases.

Displacement, Injury, and Mortality of Fish and Benthic Organisms

Short-term effects on both migratory and non-migratory marine fish species may occur during construction of the caisson dock port. The use of the caisson design effectively eliminates in-water impact noise that might adversely affect sensitive marine species. The duration of impacts would be temporary: fish may be disturbed or displaced, but direct mortalities would not be expected, and fish behavior would be expected to return to prior conditions after the activity ceases. The impacts would be expected to occur if the project is permitted and the Diamond Point port is constructed. Benthic organisms beneath the facility footprint would experience direct mortality. Riprap placed on the causeway slopes would be similar in size and character to the boulder habitat currently present in both locations and would likely be recolonized in the short-term.

The development of Diamond Point port would have a greater impact on Pacific herring spawning and rearing habitat compared to the development of Amakdedori port under the Alternative 1a. As described in Section 3.24, Fish Values, Pacific herring spawning surveys in 2018 identified a light density of herring eggs in eelgrass and rockweed in the study area (Geoengineers 2018a). The capture of young Pacific herring suggests that these species use areas of the Iliamna and Iniskin bay estuaries and Ursus Cove for rearing. Depending on timing, dredging could interfere with Pacific herring spawning and egg survival. However, past and present surveys suggest this is a minor contribution to Pacific herring spawning in Cook Inlet (Owl Ridge et al. 2019). The potential effects from the development of Diamond Point port on Pacific herring include displacement, mortality, and habitat alterations. Effects are expected to be short-term and localized in extent. Any mortalities would be permanent, but are not expected to result in a measurable population loss to Pacific herring based on the magnitude, duration, and extent of this impact.

Because of the permeable nature of the caisson-supported dock, the port is not expected to prevent or delay the migration of fish.

Propeller Entrainment or Injury

Various propeller-driven tugs and other vessels would access Diamond Point port to transport equipment and personnel during project construction, operations, and closure. The magnitude, duration, extent, and likelihood of direct impacts to fish from vessel propellers would be similar to those described for the Iliamna Lake ferry operations. This disturbance is expected to be limited in duration and in geographic extent to the immediate vicinity of the port. The likelihood of impacts would be certain if the project is permitted and the port is developed.

Wake Impacts

The magnitude of impacts during operations would be that marine barges or lightering vessels would make up to 33 trips per year between the port and the offshore anchored bulk carriers (see Chapter 2, Alternatives) The barge's low transit speeds (5 to 7 knots), minimal draft (3 to 8 feet), distance from shoreline to jetty mooring locations (approximately 1,500 feet), and the presence of naturally occurring waves in Kamishak Bay are all expected to limit wake-induced impacts on fish.

4.24.7.4 Alternative 2 Variants

Summer-Only Ferry Operations Variant

Ferry operations from Eagle Bay to Pile Bay would have the same impacts described under Alternative 1a.

Pile-Supported Dock Variant

In terms of magnitude and extent, a pile-supported dock at Diamond Point would result in a smaller footprint of 3.68 acres (Table 4.24-1) and fewer direct impacts to benthic habitat and organisms than a fill causeway, because piles would be driven through vibratory and hammer methods, and require no fill (PLP 2018-RFI 072). In terms of magnitude and extent, during construction, noise levels may be higher during pile-driving activities, as opposed to construction of an earthen causeway and wharf. Noise impacts from pile installation during construction could cause injury or mortality to fish and benthic organisms. Short-term and limited suspended sediment impacts would be expected to occur during construction of the pile-supported dock. The duration would last for the life of the project until the port is removed, and the extent would encompass the marine portion of the port. If this variant is permitted and constructed, a reduction in impacts compared to an earthen causeway port would be expected to occur.

Newhalen River North Crossing Variant

Under this variant, the crossing of Newhalen River would be north of the crossing location under Alternative 1a. The bridge design under this variant would be similar to the base case, requiring five spans. Impacts would be similar to those described for the south crossing under Alternative 1a.

4.24.7.5 Summary of Alternative 2 Impacts

For mine site, transportation and overland pipeline corridors, and the Iliamna Lake Eagle Bay ferry terminal, direct effects on fish values under Alternative 2 would be the same as those described for Alternative 1a. Direct impacts on fish in Iliamna Lake and Cook Inlet would be the same as those described under Alternative 1a.

The pipeline trench has the potential to impact benthic and intertidal habitats in Ursus Cove and Cottonwood Bay during construction. There would not be a gas pipeline across Iliamna Lake under this alternative, so impacts to lake benthic habitat would not occur. The pipeline across Cook Inlet would have similar effects as those described under Alternative 1a on marine habitat, with the exception that weathervane scallop beds would not be directly impacted.

In terms of magnitude and extent, construction of dock facilities at Diamond Point would have a greater spatial and temporal direct impact on marine fisheries and benthic invertebrates than at Amakdedori port.

Indirect effects of the transportation and natural gas pipeline components would be the same as those described for Alternative 1a.

4.24.8 Alternative 3—North Road Only

Alternative 3 would eliminate the need for ferry transportation across Iliamna Lake.

Impacts along the pipeline corridor and at the Diamond Point port would be similar to those described under Alternative 2, but would be constructed with a slightly wider corridor to accommodate the greater road width for use by trucks hauling concentrate. The Cook Inlet natural gas pipeline crossing would be the same as described in Alternative 2.

The following sections describe impacts from Alternative 3 and its variant.

4.24.8.1 Mine Site

The magnitude, duration, extent, and likelihood of direct and indirect impacts to fish, aquatic habitat, streamflow, productivity, sedimentation and turbidity, and fish migration from construction and operations at the mine site would be the same as described for Alternative 1a.

4.24.8.2 Transportation Corridor and Natural Gas Pipeline Corridor

Based on field-verified stream mapping as described in Section 3.22, Wetlands and Other Waters/ Special Aquatic Sites, the Alternative 3 transportation and natural gas pipeline corridor would cross 205 waterbodies. This includes the pipeline-only portions of the natural gas pipeline, 74 of these waterbodies have been confirmed to support fish. Twenty-two waterbodies crossed have been documented to support Pacific salmon. The magnitude and extent of habitat loss from development of the transportation corridor and onshore portions of the natural gas pipeline under Alternative 3 would eliminate 5.7 miles of streambed habitat and 7.7 acres of riverine wetland habitat. Project roads would cross stream habitat that supports five species of Pacific salmon (Chinook, chum, coho, pink, and sockeye) and numerous resident fish species, including rainbow trout and Arctic grayling. Anadromous and resident fish species known to occur in the affected area are listed in Table 3.24-11. Although Alternative 3 would have a larger project footprint compared to Alternative 1a, there would be no ferry crossing of Iliamna Lake; therefore, impacts to aquatic habitat and species in the lake would not occur under Alternative 3. The route would cross less waterbodies (205) compared to Alternative 1a (233). Compared to other alternatives, there are fewer fish-bearing streams (16) within 1,000 feet of blasting locations along the corridor than under Alternative 1a.

4.24.8.3 Diamond Point Port

The port site at Diamond Point would be at the intersection of Iliamna and Cottonwood bays, but would be situated north of the proposed location under Alternative 2, and would use a caisson dock design. In terms of magnitude and extent, construction of the caisson dock and port facilities at Diamond Point would have a greater spatial and temporal direct impact on marine fisheries and benthic invertebrates than at Amakdedori port (PLP 2018-RFI 072) under Alternative 1a. Development of the Diamond Point port would permanently remove 3 acres of benthic habitat. The channel maintenance dredging is anticipated to occur during operations on a 5-year recurrence interval. This would result in a reoccurring impact to 76 acres of benthic habitat for the life of the project (Table 4.24-1). Measurable changes in marine productivity are not expected to occur with this loss of habitat considering the magnitude of impact and the abundance of available nearshore habitat.

4.24.8.4 Concentrate Pipeline Variant

There are two options considered under this variant: one for the concentrate pipeline only, and another for a return water pipeline with the concentrate pipeline concept. The concentrate pipeline (and optional water return pipeline) would be co-located with the road corridor in a single trench with the natural gas pipeline. Methods of waterbody crossings would be the same as described for Alternative 1a. This variant would result in no additional project footprint at Diamond Point and preclude the need for the discharge of treated water into Cook Inlet (see Section 4.18, Water and Sediment Quality). The Concentrate Pipeline Variant would eliminate the need for a WTP at the port; and instead, would require a return water pump station of appropriate capacity (PLP 2018-RFI 066). This option would result in negligible change in footprint at the port site as compared to Alternative 3, and there would be no additional impact to aquatic resources as a result of the pump station footprint.

The concentrate pipeline from the mine site to the port would result in a small increase in fill placement over stream substrate in an NFK east tributary (PLP 2018-RFI 066). This variant would result in approximately 1 to 2 percent less discharge of treated water (PLP 2018-RFI 066) than Alternative 3. In turn, this could result in slight reductions of water temperature effects, aquatic habitat availability, and turbidity at treated water discharge locations.

The concentrate pipeline variant would result in a slightly greater impact in magnitude to fish and fish habitat than Alternative 3. The concentrate pipeline would be buried during road construction, and the mine access road corridor would be widened by less than 10 percent for inclusion of the pipeline. This could result in a small increase in water quality impacts during construction, and fill placement over riparian wetlands. Because only the molybdenum concentrate (2.5 percent of the total concentrate production) would be trucked from the mine site to the port, a large reduction in road traffic would be anticipated, thereby reducing some potential impacts from dust, erosion, and runoff. The duration and likelihood of impacts would be the same as the Alternative 3.

4.24.8.5 Summary of Alternative 3 Impacts

Direct and indirect effects on aquatic habitat and fish at the mine site, along the natural gas pipeline corridor, and at Diamond Point port (and variants) would be similar to Alternative 2, with the exception of increased impacts to riverine wetlands due to the width of the road/pipeline corridor. There would be no ferry crossing of Iliamna Lake under Alternative 3 and therefore no direct and indirect impacts to fish and habitat in Iliamna Lake.

The north access road would cross one less fish stream compared to Alternative 1a, and the impacts would be similar to those discussed under Alternative 2.

4.24.9 Cumulative Effects

Impacts to fish values are based on impacts to fish habitat and aquatic resources, and include physical loss of habitat, blockage of stream channels preventing fish or other aquatic species passage, upstream streamflow reductions, sedimentation due to surface erosion, erosion from vegetation removal, changes in water quality, or injury or mortality of fish or other aquatic species. The cumulative effects analysis area for fish includes the project footprint, including alternatives and variants; the expanded mine scenario footprint (including road, pipeline, and port facilities); other reasonably foreseeable future actions (RFFAs) in the vicinity of the project that would result in potential synergistic and interactive effects; and the extended geographic area where direct and indirect effects to fish could be expected from construction and operations. This area includes watersheds and downgradient aquatic habitat, from streams to marine waters. Past actions, present actions, and RFFAs have the potential to contribute cumulatively to impacts on fish and aquatic habitat as described in Section 4.1, Introduction to Environmental Consequences.

4.24.9.1 Past and Present Actions

Past and present actions that have, or are currently, affecting fish in the analysis area include infrastructure development, marine transport, oil/gas and mineral exploration, residential activities, and sport, subsistence, and commercial fishing. Most of the analysis area is undisturbed by human activity, with a few small villages and roads. There are currently no major development projects underway. With the exception of fishing, these activities have had, and are having, minimal impacts on fish.

The primary human activity affecting fish in the analysis area is fishing. The marine harvest of salmon has been estimated at 70 percent of the salmon returning to spawn (EPA 2014). However, none of the salmon stocks in Alaska have been determined to be "overfished" (NOAA 2018g). During the past decade, the numbers of pink, chum, and sockeye salmon have increased, due to a combination of generally favorable climatic conditions in the ocean and increased hatchery production (Schoen et al. 2017); whereas Chinook and coho salmon populations have decreased (Urawa et al. 2016). ADF&G (2018v) attributes the decline in Chinook numbers to poor smolt survival in the ocean. Decadal-scale cycles in Chinook and coho salmon productivity in North America, including the recent downturn, have been associated with an indicator of marine climatic conditions known as the North Pacific Gyre Oscillation (Kilduff et al. 2015; Ohlberger et al. 2016).

Several of the RFFAs detailed in Section 4.1, Introduction to Environmental Consequences, are considered to have no potential for cumulatively impacting fish in the analysis area. These include non-industrialized point-source activities that are unlikely to result in any appreciable impact on fish beyond a temporary basis (such as tourism, recreation, fishing, and hunting); other RFFAs removed from further consideration include those outside the analysis area.

4.24.9.2 Reasonably Foreseeable Future Actions

RFFAs that could contribute cumulatively to both marine and freshwater aquatic resource impacts are those activities that would occur in the Nushagak River or Kvichak River drainages, or in other waterbodies intersected by the transportation corridor in the Cook Inlet drainage. These RFFAs include the Pebble Project expansion scenario; mining exploration activities for Pebble South, Big Chunk South, Big Chunk North, Fog Lake, and Groundhog mineral prospects; Igiugig Hydrokinetic Project, Cook Inlet Oil and Gas Development, Alaska Liquefied Natural Gas, Alaska Stand Alone Pipeline Project, Drift River Oil Facility Demobilization, Lake and Peninsula Borough road improvements, and the continued development of the Diamond Point Rock Quarry.

RFFAs, combined with natural events, have the potential to contribute to adverse effects on aquatic resources by altering flow regimes and drainage patterns; direct habitat loss; diminishing water quality from riverbank erosion, turbidity, and sedimentation; changes in water chemistry; fish displacement and injury; impacts to fish migration; and degrading the extent of productive habitat conditions.

RFFA contribution to cumulative effects on aquatic resources are summarized by alternative in Table 4.24-4.

Table 4.24-4: Summary of Cumulative Effects for Fish Values

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Pebble Project expansion scenario	**Mine Site**: The mine site footprint would have a larger open pit and more facilities to store tailings and waste rock, and collect and store water. The primary potential future impacts to fish from the Pebble Project expansion scenario would be direct loss of habitat; fish displacement and injury; habitat degradation; sedimentation; and changes in the natural flow regime. These impacts would be similar to the direct and indirect impacts described previously in this section. At the mine site, an additional 35 miles of anadromous stream habitat would be lost in the SFK and UTC drainages, including the entire footprint of Frying Pan Lake, which would inundated by the south collection pond, potentially affecting sockeye, coho, chum, and Chinook salmon. As described in Section 3.24, Fish Values, there is a 10-mile reach of the SFK that frequently exhibits zero or intermittent flows during the winter and summer months. **Other Facilities:** A north access road and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment, and extended to a deepwater port site at Iniskin Bay. The additional compressor station would be at Diamond Point port instead of Amakdedori port. The mine access road would be extended east from the Eagle Bay ferry terminal to the Pile Bay terminus of the Williamsport-Pile Bay Road. Concentrate and diesel pipelines would be constructed along the Alternative 3 road corridor and extended to a new deepwater port site at Iniskin Bay. All facilities east of the Eagle Bay terminal would be new construction. Additional fish stream crossings would be	**Mine Site**: Same as Alternative 1a. **Other Facilities**: Impacts would be similar to Alternative 1a. The portion of the access road from the north ferry terminal to the existing Iliamna area road system would already be constructed. The new pipelines would involve disturbing an undisturbed area, and would require construction of an access road. **Magnitude:** The duration and extent of cumulative impacts to fish values would be similar to the duration and extent of Alternative 1a, including the number of new stream crossings, although affecting a slightly larger amount of acreage because a slightly longer road corridor north of Iliamna Lake would be required. **Duration/Extent:** Same as Alternative 1a, although affecting a slightly larger amount of acreage. **Contribution:** The contribution to cumulative effects would be slightly greater than Alternative 1a.	**Mine Site**: Same as Alternative 1a. **Other Facilities:** The north access road would be extended east from the Eagle Bay ferry terminal to the Iniskin Peninsula. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay, and the additional compressor station would be located at the Diamond Point port instead of the Amakdedori port. Because the natural gas pipeline and portions of the road would already exist under Alternative 2, there would be fewer additional stream crossings necessary for mine expansion under Alternative 2 compared to Alternative 1a and Alternative 1. **Magnitude**: Overall expansion would affect impact 9 fewer acreage fish streams than Alternative 1a. Given that a portion of the north road and all of the gas pipeline would already be constructed). Impacts to soils	**Mine Site:** Same as Alternative 1a. **Other Facilities:** Overall expansion would utilize the existing north access road; concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay. The additional compressor station would be located at the Diamond Point port instead of the Amakdedori port. The concentrate (Concentrate Pipeline Variant) and diesel fuel pipelines to Iniskin Bay would be added to the natural gas pipeline trench along the existing north access road. Because the natural gas pipeline and most of the road would already exist under Alternative 3, the amount of additional disturbance resulting from the expansion would be less than under Alternative 1a, Alternative 1, or Alternative 2. **Magnitude:** Overall expansion would affect less new acreage than Alternative 1a given that the North Road and gas pipeline would already be

Table 4.24-4: Summary of Cumulative Effects for Fish Values

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	necessary in the expansion scenario. The additional compressor station at Amakdedori port is not expected to affect fish or aquatic habitat. **Magnitude:** The Pebble Project expansion scenario footprint would impact approximately 31,892 acres, compared to 9,612 acres, and require 39 more fish stream crossings than under Alternative 1a. The expansion scenario would increase the magnitude and duration of disturbance impacts, and potential for aquatic resource impacts would increase. The expansion would also require additional design features to capture and treat impacted water to maintain existing aquatic habitat functions in non-impacted stream reaches. **Duration/Extent:** With expansion, the duration of these impacts would be extended by an additional 58 years of mining and 20 years of additional milling, extending the intermittent impacts and increasing the likelihood of impacts from spills. The geographic extent of impacts would be localized. The extent of impacts would add the expansion, the north access road/pipeline corridor, and Iniskin Bay port site. **Contribution**: The Pebble Project expansion scenario would extend operations, and extend impacts along a second linear corridor on the north shore of Iliamna Lake (as compared to Alternative 1a) and increase fish stream crossings. The construction and operation of a deepwater port in Iniskin Bay would affect fish and aquatic habitat by direct loss of nearshore habitat and discharge of fill that would affect benthic habitat, and disturbance, injury, or mortality. Iniskin Bay is		fish streams from mine expansion would be fewer. **Duration/Extent:** The duration and extent of cumulative impacts to fish values would be similar to duration and extent of Alternative 1a and Alternative 1, but would affect a smaller amount of acreage and stream crossings associated with the south access road. The duration of cumulative impacts would be extended by another 78 years, extending ongoing impacts, and increasing the likelihood of impacts from spills. The geographic extent of impacts would be localized. **Contribution:** The contribution to cumulative impacts would be similar to Alternative 1.	constructed. The expansion scenario under Alternative 3 would not require any new stream crossings. The magnitude of impacts from this alternative would be the lower than either Alternative 1a, Alternative 1, or Alternative 2. The duration of cumulative impacts would be extended by another 78 years, extending ongoing impacts, and increasing the likelihood of impacts from spills. The geographic extent of impacts would be localized. **Duration/Extent**: The duration and extent of cumulative impacts to fish values would be similar to the duration and extent of Alternative 1a, Alternatives 1, and Alternative 2, although affecting a smaller amount of acreage, and with no new access road stream crossings. **Contribution:** The contribution to cumulative impacts would be similar to less than Alternative 1a. Alternative 1 and Alternative 2, although affecting a smaller amount of acreage and new access road stream crossings.

Table 4.24-4: Summary of Cumulative Effects for Fish Values

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	designated as EFH for all five species of Pacific salmon and several other pelagic and groundfish species. Pacific herring spawn in Iniskin Bay, particularly on the eastern side (ADNR 2001) Past and present surveys suggest that the Iniskin Bay represents a minor contribution to Pacific herring spawning in Cook Inlet (Owl Ridge et al. 2019). Due to low stock size, the commercial fishery for herring roe in Kamishak Bay has been closed since 1999 (Hollowell et al. 2017). However, the capture of young Pacific herring and salmonids suggests that these species use these areas for rearing.			
Other Mineral Exploration Projects	**Magnitude**: Mining exploration activities would include additional borehole drilling, road and pad construction, and development of temporary camp facilities. Some RFFAs associated with mineral exploration activities (e.g., Pebble South, Big Chunk North, Big Chunk South, Fog Lake, and Groundhog) could have some limited aquatic resource impacts, primarily water quality, in watersheds common to the project (e.g., drill pads, camps); however, permit conditions that avoid or minimize impacts to fish-bearing waters, including water withdrawal, would be required; and the impacts would be seasonally sporadic, temporary, and localized, based on remoteness. **Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected within a specific mineral prospect. Table 4.1-1 in Section 4.1, Introduction to Environmental Consequences, identifies seven mineral	**Magnitude**: Mining exploration activities would include additional borehole drilling, road and pad construction, and development of temporary camp facilities. Some RFFAs associated with mineral exploration activities (e.g., Pebble South, Big Chunk North, Big Chunk South, Fog Lake, and Groundhog) could have some limited aquatic resource impacts, primarily water quality, in watersheds common to the project (e.g., drill pads, camps); however, permit conditions that avoid or minimize impacts to fish bearing waters, including water withdrawal would be required and the impacts would be seasonally	Same as Alternative 1a.	Same as Alternative 1a.

Table 4.24-4: Summary of Cumulative Effects for Fish Values

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	prospects in the analysis area where exploratory drilling ins anticipated (four of which are within relatively close proximity of the Pebble Project). **Contribution**: Exploration activities are considered to have limited aquatic resource impacts cumulatively.	sporadic, temporary, and localized, based on remoteness. **Duration/Extent:** Same as Alternative 1a. **Contribution**: Same as Alternative 1a.		
Oil and Gas Exploration and Development	**Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration, and in limited cases, exploratory drilling. Seismic exploration would involve temporary overland activities, with permit conditions that avoid or minimize impacts to fish-bearing waters, including water withdrawal. Should it occur, exploratory drilling would involve the construction of temporary pads and support facilities, with permit conditions to minimize impacts on fish-bearing waters and restore drill sites after exploration activities have ceased. Cook Inlet RFFAs, including Alaska Stand Alone Project, Alaska Liquefied Natural Gas, and Cook Inlet lease sales, would increase shipping traffic, and result in temporary disturbance to aquatic resources. Loss of fish habitat associated with new ports and drill rigs would be minimal in the context of Cook Inlet. Construction and operations of these projects would increase the likelihood of a spill; however, this is considered unlikely due to the BMPs and regulatory requirements. **Duration/Extent:** Geophysical survey exploration and exploratory drilling are typically single-season temporary activities. The 2013 Bristol Bay Area Plan amended	Same as Alternative 1a.	Same as Alternative 1a.	Same as Alternative 1a.

Table 4.24-4: Summary of Cumulative Effects for Fish Values

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	plan shows 13 oil and gas wells drilled on the western Alaska Peninsula, and a cluster of three wells near Iniskin Bay. It is possible that additional seismic testing and exploratory drilling could occur in the EIS analysis area, but based on historic activity, is not expected to be intensive. Temporary effects from sedimentation during construction are likely, but expected to be minimal. **Contribution**: Onshore oil and gas exploration activities would be required by permit conditions to avoid or minimize impacts to fish-bearing waters, including water withdrawal; the impacts would be seasonally sporadic, temporary, and localized to minimize surface disturbance, and would occur in the analysis area, but distant from the proposed project. The proposed project would have minimal contribution to cumulative effects.			
Road Improvement and Community Development Projects	**Magnitude:** Road improvements projects would take place in the vicinity of communities and have the potential for impacts through grading, filling, impeding fish passage, potential increased erosion, and sedimentation. Community development, transportation, and utility projects would have the potential to affect fish and aquatic resource habitat, injury/mortality, water quality/sedimentation, and fish migration. Potential impacts from community development projects would be subject to permit conditions that avoid or minimize impacts to fish-bearing waters, including water withdrawal; and the impacts would be highly localized, small in scale, and unlikely to have much impact on fish and	Same as Alternative 1a.	The footprint of the Diamond Point rock quarry in Alternative 1 coincides with the Diamond Point port footprint in Alternative 2 and Alternative 3. Cumulative impacts would likely be less under Alternative 2 as compared to Alternative 1a due to overlapping project footprint with the quarry site. Cumulative impacts would be limited to a potential increase in localized aquatic resource impacts from commonly shared project footprints with the quarry site under	Impacts would be less than Alternative 1a and similar to Alternative 2. The footprint of the Diamond Point rock quarry overlaps with the Diamond Point port.

Table 4.24-4: Summary of Cumulative Effects for Fish Values

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	aquatic resources. Transportation and utility projects, such as improvement to the Williamsport-Pile Bay Road and new road connections to Cook Inlet, would have potential direct and indirect impacts to those described for the project transportation corridors earlier in this section. Communities in the immediate vicinity of proposed project facilities, such as Iliamna, Newhalen, and Kokhanok, would have the greatest contribution to cumulative effects. Some limited road upgrades could also occur in the vicinity of the natural gas pipeline starting point near Stariski Creek, or in support of mineral exploration previously discussed. The footprint of the Diamond Point Rock Quarry does not overlap with any facilities under Alternative 1a. Cumulative impacts would be an increase in localized aquatic resource impacts at that location. **Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. Geographic extent would be limited to the vicinity of communities and Diamond Point. Impacts would be primarily limited to construction activities, and the immediate vicinity of a specific project and would be subject to the same BMPs and permit requirements described earlier in this section for direct and indirect impacts. **Contribution:** Road construction would be required to minimize surface disturbance, and would occur in the analysis area, but would have minimal contribution to cumulative effects.		Alternative 2 and Alternative 3.	

Table 4.24-4: Summary of Cumulative Effects for Fish Values

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Summary of Project Contribution to Cumulative Effects	Overall, the contribution of Alternative 1a to cumulative effects to aquatic resources, when taking other past, present, and RFFAs into account, would be minor to moderate in terms of magnitude, duration, and extent, given the documented habitat use by fish, existing habitat potential, and permit requirements regarding fish and aquatic habitat protection at stream crossings.	Cumulative impacts would be similar to Alternative 1a, although slightly more acreage would be affected by expansion. Overall, the contribution of the Alternative 1 to cumulative effects to aquatic resources, when taking other past, present, and RFFAs into account, would be minor to moderate in terms of magnitude, duration, and extent, given the limited documented habitat utilization by fish, existing habitat potential affected and permit requirements regarding soil disturbance and erosion, and aquatic habitat protection at stream crossings.	Cumulative impacts would be similar to Alterative 1a, although slightly less acreage and fewer new stream crossings would be affected by expansion.	Cumulative impacts would be similar to Alternative 1a, although fewer acreage and fewer new stream crossings would be affected by expansion than either Alternative 1 or Alternative 2.

Notes:

BMPs = best management practices
EFH = Essential Fish Habitat
RFFAs = Reasonably Foreseeable Future Actions
SFK = South Fork Koktuli
UTC = Upper Talarik Creek