4.24 FISH VALUES

The Environmental Impact Statement (EIS) analysis area includes watersheds and downgradient aquatic habitats that could be affected by project components from streams to marine waters. Potential direct and indirect impacts to fish and aquatic habitat and aquatic invertebrates include:

- Physical loss of stream, lake, estuarine, and marine habitat.
- Blockage of stream channels preventing fish or other aquatic species passage.
- Aquatic habitat effects due to instream flow reductions from mine water withdrawal or capture and redirection of groundwater.
- Sedimentation of aquatic habitat due to surface erosion of mine and port access roads, stockpiles, or other activities.
- Erosion from vegetation removal; shoreline erosion associated with ship or ferry wakes; benthos disturbance/mortality from docks and pipelines.
- Changes of freshwater and marine water quality such as temperature, turbidity, pH, dissolved oxygen, and metal or chemical contaminants.
- Injury or mortality of fish or other aquatic species.

Permit compliance requirements, including standard and special terms and conditions, best management practices (BMPs), and environmental monitoring, would be established by regulatory agencies and landowners with permitting authority. These requirements would be implemented as part of construction management and facility operations to avoid, minimize, and control risks to fish and aquatic habitat in the project area. Specific measures proposed by the Pebble Limited Partnership (PLP) to mitigate impacts are discussed in Chapter 5, Mitigation.

The EIS analysis area for the mine site includes the North Fork Koktuli (NFK), South Fork Koktuli (SFK), and Upper Talarik Creek (UTC) watersheds, and a 1,000-foot buffer around the mine site to account for blasting disturbance. This area includes all aquatic habitats potentially impacted by changes in streamflow from the diversion, capture, and release of water associated with the project that result in a modeled reduction in streamflow greater than 2 percent. The EIS analysis area for the port, and transportation and natural gas pipeline corridors, includes all aquatic habitats within 0.25 mile of the infrastructure. This is the area where potential effects are expected to occur from construction and operations under all alternatives.

Potential direct and indirect effects are assessed according to four distinct factors as listed in Section 4.25, Threatened and Endangered Species (TES). For aquatic resources, the magnitude of impact from the project depends on the specific species' sensitivity to the type of disturbance; the potential of impacts is how likely the project impacts will overlap with species habitat; and the duration and geographic extent of impacts depends on the location and season in which the disturbance occurs (e.g., during salmon migrations). Duration of recovery considers four distinct categories:

- Temporary – Recovery days to weeks
- Short-term – Recovery less than 3 years
- Long-term – Recovery less than 3 years to less than 20 years
- Permanent – Recovery greater than 20 years

The evaluation of potential direct and indirect effects for each alternative is categorized by major project component, including the mine site, transportation corridor, natural gas pipeline corridor, and port.

Scoping comments addressing impacts to fish were numerous. Commenters were concerned about the effects of ferry traffic on resident and migrating fish; gravel pits on stream hydrology and fisheries; disruption of habitats that could affect nutrients; water withdrawal on fish habitat; potential contamination from spills or toxins, fugitive dust adding heavy metals to fish streams; dredging of Amakdedori Beach on salmon and Dolly Varden; and erosion from construction and mining on fish and fish habitat. Commenters also requested that potentially impacted cataloged anadromous streams be discussed, and also anadromous streams that are not currently catalogued. Impacts from bridge and culvert placement were also of concern to commenters.

4.24.1 No Action Alternative

Under the No Action Alternative, the Pebble Project would not be undertaken. No construction, operations, or closure activities would occur. Therefore, no additional future direct or indirect effects on aquatic resources would be expected. Although no resource development would occur under the No Action Alternative, permitted resource exploration activities currently associated with the project may continue (ADNR 2018-RFI 073). PLP would have the same options for exploration activities that currently exist. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration. Impacts on fish values from these ongoing exploration activities would be expected to occur at current levels.

PLP would be required to reclaim any remaining sites at the conclusion of their exploration program. If reclamation approval is not granted immediately after the cessation of reclamation activities, the State may require continued authorization for ongoing monitoring and reclamation work as deemed necessary by the State of Alaska. Although these activities would also cause some disturbance, reclamation would benefit fish values overall.

4.24.2 Alternative 1 – Applicant's Proposed Alternative

The following sections describe the potential impacts of Alternative 1 on habitat loss, fish displacement, injury and mortality, stream flow, stream productivity, stream sedimentation and turbidity, fish migration, and water temperature. The Essential Fish Habitat (EFH) Assessment, referred to below, is provided in its entirety as Appendix I. The impacts of individual project components (mine site, including material sites, transportation corridor, Amkadedori port, and natural gas pipeline) are discussed by watershed or impact area in each of the impact subsections. The impacts of alternative variants, the Summer-Only Ferry Operations Variant, the Kokhanok East Ferry Terminal Variant and the Pile-Supported Dock Variant are discussed below.

4.24.2.1 Habitat Loss

<u>Mine Site</u>

In terms of magnitude and extent of impacts, project construction, operations, and closure at the mine site would have a footprint of 8,806 acres (10.7 square miles), of which 3,458 acres are wetlands or other waters. Duration of impacts to these affected areas would be long term, lasting throughout the life of the project, and they would be certain to occur if the project is permitted and constructed. Direct habitat loss is described for each watershed: NFK, SFK, and UTC. Indirect impacts are also described in the following sections.

North Fork Koktuli

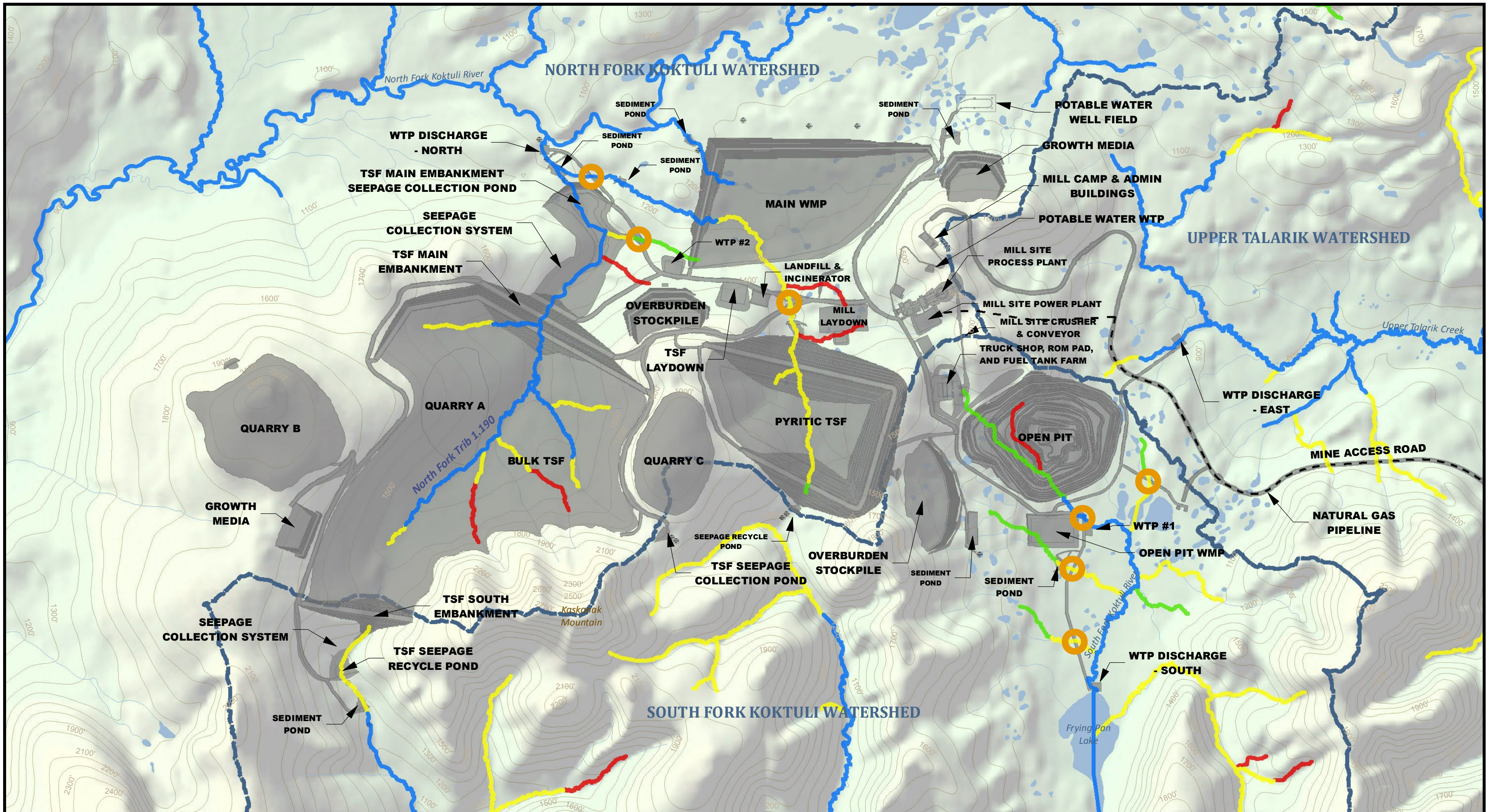
As described in Chapter 3, Affected Environment, approximately 82 percent of the mine site footprint would be in the NFK River drainage (Figure 4.24-1). In terms of magnitude, extent, and duration of impacts, approximately 7.5 miles of anadromous habitat would be permanently removed in Tributary 1.190 and its sub-tributaries by the construction of the bulk tailings storage facility (TSF). As described in Section 3.24, Fish Values, Tributary 1.190 is an incised coarse gravel, cobble, and boulder bed stream with a slope of 2 to 3 percent. Channel habitat features are dominated by short rapids/riffle reaches and irregularly spaced scour pools. These impacts would be certain to occur if the project is permitted and constructed.

Adult coho salmon have been documented in 4.3 miles of Tributary 1.190, although only during one aerial survey, and in low numbers (27 fish) compared to other NFK tributaries (1,746 fish) (Owl Ridge et al. 2019). Spawning has not been documented in Tributary 1.190 for any other salmon species. The majority of adult fish and spawning observations for all adult salmon occurred downstream of waters that would be directly affected by mine facilities. Within the NFK River, the majority of salmon adults and spawners were observed in the lower portions of the rivers (R2 et al. 2011), suggesting the presence of higher-quality habitat, or simply adequate quantities of suitable habitat are readily available to accommodate the numbers of salmon entering the streams without the need to distribute further upstream.

Rearing coho salmon have been documented throughout the drainage, although in lower densities (1.24 fish per 100 square meters [m^2]) than in the mainstem NKF (25.33 fish/100m^2), indicating overall lower habitat quality, or adequate quantity and quality habitat in other areas of the drainage. Rearing Chinook salmon have been documented in 2.9 miles of Tributary 1.190 in low densities (0.11 fish/100m^2) compared to the mainstem NFK (4.88 fish/100^2). Rearing has not been documented in Tributary 1.190 for any other salmon species.

In terms of magnitude, extent, and duration of impacts, approximately 0.7 mile of anadromous habitat would be permanently removed from Tributary NFK 1.200 during construction of the main water management pond and pyritic TSF. These impacts would be expected to occur if the mine is permitted and constructed. Fish sampling in Tributary NFK 1.200 in 2018 found mean juvenile Chinook salmon densities of 0.08 fish/100m^2 and 2.24 fish/100m^2 for coho salmon (Owl Ridge et al. 2019). Resident fish species, including rainbow trout, Dolly Varden, Arctic Grayling, and sculpin, have been documented in 12.7 miles of tributaries and sub-tributaries habitat that would be permanently removed by the construction of the mine site facilities. In summary, the magnitude and extent of impacts would be that approximately 20 miles of fish-bearing streams would be blocked or filled by mine components in the NFK drainage, including approximately 8.2 miles of anadromous waters.

Approximately 2.3 miles of Tributary 1.190 mainstem and sub-tributary stream channels would remain free-flowing between the TSF and the water seepage pond. This habitat would not be accessible to anadromous fish due to blockage by the downstream seepage collection pond dam, but may continue to provide spawning and rearing habitat for resident species. In addition to the remaining free-flowing channels, approximately 1.4 miles of stream channel would be converted to reservoir habitat (seepage collection pond).



Sources: PLP 2018; HDR 2012

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

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

Other Features
- River/Stream
- Lake/Pond
- Watershed
- 100' Contour (Existing)

US Army Corps of Engineers

0.5 0 0.5 1
Miles

FISH AND AQUATICS MINE SITE IMPACTS

PEBBLE PROJECT EIS

FIGURE 4.24-1

The 8.2 miles of anadromous habitat permanently removed within tributaries 1.190 and 1.200 represent 11 percent of the total documented 72.7 miles of anadromous habitat in NFK River. When compared to the total mileage of documented anadromous waters in the three main tributaries associated with the mine site (i.e., the NFK, SFK, and the UTC), this loss represents a 4 percent and 3 percent of spawning and rearing habitat for coho salmon, respectively; and 3 percent of Chinook salmon rearing habitat. The entire Bristol Bay drainage has 9,816 miles of documented anadromous waters. Therefore, the loss of tributaries 1.190 and 1.200 represents an 0.08 percent reduction of documented anadromous stream habitat.

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 total estimated mileage of anadromous waters in Bristol Bay drainage is likely much higher. The mine site area is one of the few areas in the Bristol Bay drainage where numerous small channels and tributaries have been surveyed.

In terms of magnitude, extent, and duration, approximately 276 acres of riparian wetland would be directly and permanently impacted by the mine site footprint; predominately in the NFK watershed. These impacts would be certain to occur if the project is permitted and constructed, and include reduced surface water infiltration, retention, and groundwater flow; increased surface water runoff; and reduced water quality functions. Changes in riparian wetlands would likely not be detectable downstream from the mine site.

The duration of direct impacts of the removal of anadromous habitat would be permanent. However, considering the low use of habitat to be removed (based on densities of juvenile Chinook and coho captured within these habitats), and the few numbers of coho spawning in these reaches, measurable impacts to populations of salmon from these direct habitat losses would be unlikely.

South Fork Koktuli River

In terms of magnitude, extent, and duration, the open pit and related mine facilities are expected to directly and permanently impact approximately 2.0 miles of fish habitat in the upper mainstem SFK and a tributary of SFK 1.190. Approximately 0.75 mile of low-density coho and sockeye salmon rearing habitat would be permanently removed within the mine site footprint upstream from Frying Pan Lake. No adult salmon were observed within this reach during aerial surveys flown from 2004 through 2008. Habitats that would be removed exhibited some of the lowest-density use by coho salmon juveniles within the SFK drainage, suggesting there is low overall quality habitat or low abundance of quality habitat in unaffected areas. The loss of 0.75 mile of upper SFK River habitat represents 1 percent of SFK River total anadromous habitat. The other affected stream channels are not classified as anadromous, but provide habitat for populations of resident fish, including sculpin, Arctic grayling, and stickleback. The extent of these direct habitat impacts would be limited to waters in the mine site footprint. The impacts would be long term to permanent in duration, and would be certain to occur if the project is permitted and constructed.

Upper Talarik Creek

The open mine pit and access road are expected to extend to the western edge of the UTC drainage; the only mine site components that would occur in the UTC drainage are the mine access road, the buried natural gas pipeline, and the eastern water treatment plant discharge pipe and facility (Figure 4.24-1). No aquatic habitat would be directly lost in the UTC due to mine construction, operations, or closure.

Summary

Direct impacts of habitat removal would be permanent. However, as described above, considering the low quality and low use of coho and Chinook rearing habitat, the lack of spawning in SFK east reaches impacted, and the low level of coho spawning in NFK Tributary 1.190, measurable impacts to salmon populations would be unlikely. As discussed below, modeling indicates that indirect impacts associated with mine operations would occur at the individual level, and be attenuated upstream of the confluence of the NFK and SFK with no measurable impacts to salmon populations.

Transportation Corridor

In terms of magnitude and extent of impacts, project construction, operations, and closure of the transportation corridor would have a footprint of 892 acres, of which 86 acres are wetlands or other waters. These impacts would be long term in duration, and certain to occur if the project is permitted and constructed. Three of these acres are wetland habitats that support resident and anadromous fish.

Road/Pipeline

In terms of magnitude and extent, the road and pipeline would cross 16 anadromous (including Kokhanok East Ferry Terminal Variant) and 36 resident fish streams. Bridge and culvert design, stream flows, and habitat loss would be reviewed and verified by Alaska Department of Fish and Game (ADF&G) during the permitting process. Single-span bridge crossings would be designed to maintain a riparian buffer between the bridge abutments and the active channel. There would be a permanent loss of streambed habitat within the footprint of bridge piers on the Newhalen and Gibraltar rivers. Permit stipulations may include seasonal restrictions on instream activities to avoid impacts to habitat during species critical life stages (e.g., spawning and egg development). Free passage of resident and anadromous fish may be temporarily interrupted, but would continue unimpeded after construction is complete. 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.

Ferry Terminals/Iliamna Lake Pipeline

Docking facilities for the ice-breaking ferry at the north and south ferry terminals are expected to include rock and gravel ramps extending approximately 40 feet into Iliamna Lake. The magnitude and extent of impacts are such that the two terminals would remove 0.8 acre and 923 feet (0.2 mile) of approximately 300 miles of existing littoral zone. Rip-rap placed around the landing ramp would be similar in size and character to the boulder habitats currently present in both locations, and would not represent a novel habitat feature. Rip-rap 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.

Horizontal directional drilling (HDD) and trenching from lay barges would be used to install the pipeline segments from the lakeshore into waters deep enough to avoid navigational hazards. There would be temporary impacts to near-shore benthic habitats during construction, and permanent impacts to benthic habitat beneath the footprint of the pipeline in deeper waters. These deeper affected areas do not constitute quality benthic habitat due to the water depth, lack of light, and oligotrophic status of Iliamna Lake. To the extent these benthic habitats are impacted, the lake habitat under the pipe would be permanently lost, but the natural gas pipeline itself would provide areas for colonization of lake organisms. These impacts would be certain to occur if the project is permitted and the natural gas pipeline is installed.

Amakdedori Port

The magnitude and extent of impacts would be that construction would remove and/or fill 11.3 acres of nearshore habitat, including 2.5 acres of beach complex and 8.8 acres of subtidal mixed-gravel habitat. The duration of impact would be such that 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 are less productive than other areas sampled in Kamishak Bay (GeoEngineers 2018a, 2018b). 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, 2018b). These impacts would be certain to occur if the project is permitted and the Amkadedori port is built. Rip-rap placed on the causeway slopes would be similar in size and character to the boulder habitats currently present in both locations, and would not represent a novel habitat feature. Rip-rap would be colonized in the short term, and subsequently used by prey organisms.

Natural Gas Pipeline

The magnitude and extent of impacts from project construction, operations, and closure of the natural gas pipeline would have a footprint of 40 acres, of which 6 acres are wetlands or other waters. Less than 1 acre is wetland habitats that support anadromous and resident fish.

The construction phase would include installation of a 104-mile-long, 12-inch-diameter natural gas pipeline on the floor of Cook Inlet from between the Kenai Peninsula and Amakdedori port. HDD would be used to install the pipeline segments from the shoreline into waters deep enough to avoid navigational hazards. These activities may involve displacement of some substrate material along with the associated organisms. Generally, the submarine portions of the natural gas pipeline would be constructed using heavy-wall steel pipe placed on the seafloor. This would introduce a solid material, and represents a change from the natural, softer substrate to the artificial substrate of the pipeline itself, for a combined area of approximately 11.5 acres. It is expected that the pipeline would be colonized by marine life in the short term. In soft substrate areas, the colonized natural gas pipeline would provide a new habitat type, while hard substrate habitat would be similar.

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. 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 typical sea anchor footprint is generally small, but the depression could be 7 to 8 feet in soft bottom. The weight of the anchor and potential depth of the scar could potentially result in disruption to the habitat structure within the footprint of the scar. These scars would be short term, because they would fill in with marine sediments.

Habitat losses resulting from the natural gas pipeline installation would range from temporary to short term. Habitat may be disturbed or displaced, but would likely return to its prior state after the activity ceases.

4.24.2.2 Fish Displacement, Injury, and Mortality

Mine Site

North Fork Koktuli and South Fork Koktuli

Fish displacement, injury, and mortality would occur during project construction in the NFK and SFK. In terms of extent, direct mortality of fish would most likely occur in stream habitats removed during mine site construction, as described above in the Habitat Loss section. Timing of construction in anadromous fish streams (May 15 to July 15) would reduce the numbers of fish injured or killed. If issued, the ADF&G Fish Habitat Permit stipulations would be designed to minimize impacts to all life stages, including eggs, juveniles, and adults. Fish capture and relocation would be implemented according to ADF&G Aquatic Resource Permit (ARP) requirements to reduce impacts to resident fish. Stipulations contained in the ARP would determine timing, capture methods, and relocation protocols. Surveys documented low densities and wide distributions of resident and anadromous fish throughout adjacent reaches in the NFK. Species diversity and abundance data indicate there is sufficient available habitat for relocation without impacts to existing populations. 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 limited to waters in the vicinity of the mine site footprint, and may not be observed downstream from the affected stream channel.

Blasting would be necessary to construct the mine site, and would be ongoing during operations as the mine pit is developed. Blasting 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).

The estimated pressure and vibration forces generated by a blast would be included in the project's blasting plan. The blasting plan would be developed in consultation with ADF&G, and in compliance with guidelines and BMPs outlined in the ADF&G publication "Technical Report No. 13-03 – Alaska Blasting Standard for the Proper Protection of Fish." The magnitude of impacts from blasting on fish and fish habitat would depend on the proximity of the blast to fish habitat and the life stage of fish present in the affected area. The duration and extent of impacts would be temporary, and limited to the affected area. In general, fish would be temporarily disturbed, and could avoid the area for a period of time, but are expected to return with the cessation of blasting activities. Low levels of mortality are expected. These impacts would be expected to occur if the project is permitted and blasting is enacted, as planned for the mine site.

Upper Talarik Creek

No fish displacement or mortality would be expected in the UTC due to mine construction, operations, or closure.

Transportation Corridor

Bridge, Culvert, and Natural Gas Pipeline Installation

The magnitude of direct impacts from installation of bridges, culverts, and the natural gas pipeline would be that mortality of fish could occur from construction activities at stream crossings and the ferry terminals. Temporary water diversions or dewatering of stream reaches during construction could result in direct mortality due to fish stranding and desiccation. The magnitude of impacts from fish entrainment or impingement at screens during pumping would be potential direct mortality or injury. The duration of impacts would be that fish passage may be temporarily impeded during construction.

The capture/relocation program would be conducted according to established ADF&G practices, and permit stipulations could include seasonal restrictions on instream activities to reduce or avoid impacts during species critical life stages (e.g., spawning and egg development periods).

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. In terms of magnitude and extent, potential direct impacts from HDD activities include loss of fluid through subsurface fractures (frac-out) and unconsolidated gravel or coarse sand. Drilling mud (fluid) used in HDD is non-toxic 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 gills. Monitoring would be conducted throughout the HDD process to determine whether a subsurface fluid loss occurs. Details regarding prevention, detection, and response to a potential frac-out or drilling fluid release would be addressed in the HDD and Stormwater Pollution Prevention plans. These impacts would be expected to occur if the project is constructed and the natural gas pipeline is installed.

Iliamna Lake Pipeline

The construction phase would include installation of an 18-mile-long natural gas pipeline on the floor of Iliamna Lake between the north and south ferry terminals. HDD and extended-reach backhoes would be used to install the pipeline segments from the lakeshore into waters deep enough to avoid navigational hazards. The magnitude of impacts is such that these activities would displace 1.3 acres of substrate material along with the associated organisms. There would be permanent, direct mortality of benthic organisms beneath the pipeline footprint on the bottom of Iliamna Lake.

Sockeye salmon are known to use shoreline habitat for spawning, and therefore could be potentially affected; however, documented spawning areas are more than 0.5 mile from the ferry terminals and primary entry points of the pipeline into the lake (EPA 2014). Investigations by PLP have documented that nearshore lake habitat at the ferry terminal is lightly used by juvenile salmonids, and is not used for adult spawning (Paradox NR 2018a). Nearshore trenching at Iliamna Lake has the potential to 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.

Ferry Terminals

Docking facilities for the ice-breaking ferry at the north and south ferry terminals are expected to include rock and gravel ramps extending approximately 40 feet into Iliamna Lake. The magnitude, extent, and duration of impacts would be permanent, direct mortality to benthic organisms within the approximately 1-acre total ramp footprints. These impacts are certain to occur if the project is permitted and the ferry terminals are constructed.

Ferry Operations

Propeller Entrainment or Injury

Direct impacts of propeller-induced injury or mortality to anadromous or resident fishes by motorboat propellers are not frequently assessed, and are limited to a few studies (Holland 1986; Killgore et al. 2011; Whitfield and Becker 2014). These studies primarily involved non-salmonid species; the paucity of field studies has been largely due to physical constraints imposed by sampling behind towboats (Killgore et al. 2011). A review of these publications indicated a number of biotic factors may affect fish strike rates by ferry propellers at Iliamna Lake, including:

- Life history traits of a species (pelagic versus nest or redd builders)
- Coincidence in timing of emigration and migration/movement of specific life stages with the path of a moving ferry
- Distribution of fish size/species in the water column relative to ferry draft
- Spawning behavior
- Fish avoidance behavioral responses to ferry noise/turbulence
- Number, speed, and configuration of propeller blades (horizontal versus vertical)
- Fish size

Table 3.24-2 in Section 3.24, Fish Values, shows the estimated seasonal presence and activity of life stages of common species that may be exposed to ferry/boat transiting between the north and south ferry terminals. Documented sockeye lake spawning is concentrated towards the northeastern portion of the lake (see Section 3.24, Fish Values); likely due to numerous islands and abundant sheltered habitats. As discussed below under wake stranding, the ferry terminals are on exposed, high-energy beaches with no documented sockeye beach spawning habitat in the immediate vicinity; therefore, ferry operations impacting adult sockeye salmon is not expected. 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.

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 of the project. 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, and are expected to detect and avoid propeller-related impacts. Although unlikely, 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

Analysis of juvenile salmon stranding data from the lower Columbia River by Pearson et al. (2006) identified the following factors that affect stranding:

- Fish availability in the shallow nearshore zone along the beach
- Nearshore ship-wake properties and wave run-up characteristics (wave height and period), as well as direction and extent of wave draw-down and run-up on the beach
- River elevation (river stage and tidal height)
- Beach characteristics (slope, distance to navigation channel)

Pearson et al. (2006) also 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.

The ferry terminal locations are relatively exposed, short beaches unprotected from wave energy. Numerous small storm berms are present on the beach faces, indicative of changing seasonal water levels. In contrast to studies conducted on rivers, stranding of fry from ferry wakes 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. Consequently, any impacts on juvenile and adult fish due to boat wake would be limited in scale—both spatially and temporally.

Amakdedori Port

Short-term effects on both migratory and non-migratory marine fish species may occur during construction of the port. Fish are 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 the ADF&G determines that pile driving would occur in a location and during a timeframe to cause impacts to a managed species, a noise monitoring and mitigation plan would be required to mitigate the potential impacts. The duration of impact would be temporary: fish may be disturbed or displaced, but 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 Amakdedori port is constructed. No shellfish have been documented at the port location, but other benthic organisms beneath the facility footprint as described in Section 3.24, Fish Values would experience direct mortality.

Propeller Entrainment or Injury

Various propeller-driven tugs and other ships would be accessing Amakdedori port to transport equipment and personnel during project construction, operations, and closure. The magnitude, extent, duration, and likelihood of impacts are similar to those described for the Iliamna Lake ferry operations. This disturbance is expected to be chronic, but infrequent in duration, and limited in geographic extent to the lake crossing and immediate vicinity of the port. The likelihood of impacts would be certain if the project is permitted and the Amakdedori port is built and used.

Wake Impacts

The magnitude of impacts during mine 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. 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.

Natural Gas Pipeline

There would be permanent, direct mortality of benthic organisms beneath the natural gas pipeline footprint on the bottom of Cook Inlet during pipeline installation. In terms of magnitude, extent, and duration, approximately 6.8 acres of weathervane scallop beds would be permanently impacted by placement of the pipeline. Unlike most adult fish that are mobile and able to actively avoid direct impacts from pipe laying activities, weathervane scallops may not be able to avoid the area, which could potentially result in weathervane scallop mortality. The area of weathervane scallop beds permanently affected (6.8 acres) is only 0.014 percent of the weathervane scallop range in Cook Inlet (approximately 49,000 acres). The impacts on weathervane scallop beds would be certain to occur if the project is permitted and the natural gas pipeline is constructed.

Potential impacts from the placement of anchors for the pipe lay barge include benthic fauna mortality. 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). Assuming an average anchor scar of 360 square feet with up to a 12-anchor array, and resetting the anchors twice per mile, for the 104.5-mile length of the submarine pipeline, the magnitude and extent of anchor scarring would be to temporarily impact approximately 21 acres of benthic habitat. 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.

4.24.2.3 Stream Flow

Mine Site

Operation of the mine site is expected to result in an overall net reduction in available water for release into downstream channels. Reductions of instream flows in the mainstem and select tributary reaches of the NFK, SFK, and the UTC, due to filling of stream channels by the TSF or other stockpiles, excavation of channels, and capture of groundwater at the mine pit, or the retention of surface runoff from mine facilities, would result in direct impacts to aquatic habitat and fish species. The duration of streamflow reductions would be long term, beginning during project construction, and would continue through operations and post-closure.

During project construction and operations, a network of seepage and sedimentation ponds would collect runoff and seepage from stockpiles, the mine pit, and other mine components (e.g., roads, embankments, and construction sites). Runoff and seepage water would be routed into the mill for ore processing and reuse, or routed to one of two water treatment plants for use in dust control or power plant cooling. Water would also be treated and released into stream channels at three locations: 1) NFK Tributary 1.190 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 below its headwaters (Figure 4.24-1). The water would be treated before discharge in compliance with water quality standards to protect aquatic life, as specified in an Alaska Pollutant Discharge Elimination System (APDES) permit, if issued. Treated water would be discharged via buried infiltration chambers designed to provide energy dissipation, erosion control, and freeze protection.

The magnitude and extent of impacts from the reduction in stream flows would be to directly change the quantity and quality of instream habitat for upstream migration of adult salmonids, spawning and egg incubation, and rearing habitat for juvenile fish. Reductions in flows could also directly alter available habitat for benthic macroinvertebrate (BMI) production, which is important for fish growth and survival. The magnitude and extent of impacts as described below 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.

Fish Habitat Changes Associated with Stream Flow

Downstream of the project footprint, habitat changes—as measured by weighted usable area—vary by species and life stage; drainage basin and reach; and for wet, average, and dry years (R2 Consultants 2018). Treated water releases from mine site facilities would be optimized to benefit priority species and life stages for each month and stream.

In general, the magnitude and duration of the impact on most species would be larger-percentage reductions in usable spawning habitat in reaches just below the mine site than further downstream during project operations and post-closure. The percentage reductions in habitat would generally decrease in a downstream direction until reaching the confluence of the NFK and the SFK (with a few exceptions). In terms of extent, rainbow trout, chum, sockeye, Dolly Varden, and Arctic grayling would have habitat decreases only in the headwater tributaries. Table 4.24-1 shows the priority species and life stages used to determine habitat flow needs in the mine site area. Chinook and coho spawning habitat would decrease throughout the NFK and SFK drainages. Once the mainstem of the Koktuli is reached, flow changes would not be detectable. Therefore, the downstream extent of habitat impacts associated with flow reductions would lie downstream of the confluence of the NFK and the SFK; and upstream of the mainstem Koktuli River confluence with the Swan River (the end of the model domain). These impacts associated with stream flow would be certain to occur if the project is permitted and built.

Table 4.24-1: Priority Species and Life Stages used to Determine Habitat Flow Needs in the Mine Site Area

Month	Priority Species/Life Stages		
	SFK	NFK	UTC
Jan	Chinook Juvenile Rearing	Chinook Juvenile Rearing	Coho Juvenile Rearing
Feb			
Mar			
Apr	Arctic Grayling Spawning	Arctic Grayling Spawning	Arctic Grayling Spawning
May			
Jun	Rainbow Spawning	Rainbow Spawning	Rainbow Spawning
Jul	Chinook Spawning	Chinook Spawning	Sockeye Spawning
Aug			
Sep	Coho Spawning	Coho Spawning	Coho Spawning
Oct			
Nov			
Dec	Chinook Juvenile Rearing	Chinook Juvenile Rearing	Coho Juvenile Rearing

Spawning Habitat

In terms of magnitude and extent throughout the mine site area in average precipitation years, Chinook and coho available spawning habitat would be reduced; while chum, sockeye, rainbow, Dolly Varden, and Arctic grayling available spawning habitat generally would be increased (Table 4.24.2). In wet years, water levels would be higher and the decreases in available habitat would be lower, and the increases greater; conversely, in dry years, water levels would be lower and the habitat decreases would be greater and the increases would be lower. These impacts would be long term in duration, lasting throughout the life of the project and closure. Post-closure, flow reductions would be lower than during mining, resulting in smaller reductions and increases in habitat. In terms of likelihood, these impacts would be expected to occur if the project is permitted and built.

Table 4.24-2 Average Precipitation Year Spawning Habitat for all Streams and Species in the Mine Site Area Pre-mine, During Operations, and Post-Closure

	Habitat Available			Change in Available Habitat			
	Pre-Mine	During Operations	Post-Closure	During Operations		Post-Closure	
Species	(acres)	(acres)	(acres)	(acres)	(% diff)	(acres)	(% diff)
Chinook	*82.54*	*79.51*	*81.14*	*-3.02*	*-3.7%*	*-1.40*	*-1.7%*
Coho	*105.56*	*102.87*	*104.21*	*-2.69*	*-2.6%*	*-1.34*	*-1.3%*
Chum	*180.10*	*181.07*	*180.84*	*0.97*	*0.5%*	*0.74*	*0.4%*
Sockeye	*133.00*	*133.73*	*133.65*	*0.73*	*0.5%*	*0.65*	*0.5%*
Rainbow	*98.46*	*101.40*	*100.01*	*2.94*	*3.0%*	*1.55*	*1.6%*
Dolly Varden	*203.58*	*204.02*	*203.90*	*0.44*	*0.2%*	*0.32*	*0.2%*
Arctic Grayling	*132.24*	*135.59*	*133.10*	*3.34*	*2.5%*	*0.86*	*0.7%*

North Fork Koktuli

The trends in habitat change modeled in the mine area are shown in the changes in NFK spawning habitat. In terms of magnitude, extent, and duration in average precipitation years during mine operations, salmonid habitat availability would decrease by 2.01 acres (8.1 percent) for spawning Chinook, and 1.86 acres (5.5 percent) for coho; while it would increase by 2.12 acres (5.8 percent) for spawning rainbow trout, 1.42 acres (4.4 percent) for sockeye, and 1.95 acres (5.5 percent) for Arctic grayling. Post-closure, habitat changes are predicted to be reduced to a 2.7 percent loss in Chinook, and 2.1 percent loss for coho. The likelihood of these impacts is certain if the project is permitted and constructed.

South Fork Koktuli

The trends in habitat change modeled indicate there would be a reduction in sockeye spawning habitat in the SFK. In terms of magnitude, extent, and duration in average precipitation years, salmonid habitat availability would decrease by 1.02 acres (2.8 percent) for spawning Chinook, 0.82 acre (2.4 percent) for coho, and 0.69 acre (1.3 percent) for sockeye. Habitat would increase by 0.80 acre (2.4 percent) for spawning rainbow trout, and 1.18 acres (2.6 percent) for Arctic grayling. Habitat changes for Dolly Varden and chum salmon would be less than 1 percent. The likelihood of these impacts is certain if the project is permitted and constructed.

Upper Talarik Creek

Due to low-magnitude flow changes in the UTC basin, the magnitude, extent, and duration of spawning habitat changes for all species would be less than 1 percent during both mining operations and post-closure.

Juvenile Habitat

Juvenile salmonid habitat would be affected by the reduced flows associated with both mining operations and post-closure. Flow reductions lower stream velocities, which can result in increased juvenile rearing habitat. In general, the magnitude and extent of impacts would be such that Chinook and rainbow trout juvenile habitat would be reduced, while sockeye juveniles (and the other salmonid species, to a lesser extent) would generally benefit from reduced flows associated with the mining operations. Sockeye juvenile habitat increases would generally be associated with the SFK-C reach (Table 4.24-3), where the magnitude, extent, and duration of habitat increase would be 0.76 acre (44 percent) over the long term (during mining operations); while rainbow habitat losses would be greatest in SFK-190, where habitat would decrease by 0.15 acre (13.3 percent) during operations.

Changes in habitat for juveniles would be reach-specific. The changes in habitat availability would be less associated with upstream or downstream reach locations, and more dependent on reach-specific habitat features. For example, beginning at the mine site in the NFK drainage, moving downstream in average years, juvenile coho habitat would alternate between increases and decreases in habitat in each reach (NKF-190, NFK-C, NFK-B, NFK-A).

Table 4.24-3 Average Precipitation Year Juvenile Habitat for all Streams and Species in the Mine Site Area Pre-Mine, During Operations, and Post-Closure

	Habitat Available			Change in Habitat Available			
	Pre-Mine	During Operations	Post-Closure	During Operations		Post-Closure	
Species	(acres)	(acres)	(acres)	(acres)	(% diff)	(acres)	(% diff)
Chinook	*57.44*	*57.40*	*57.23*	*-0.05*	*-0.1%*	*-0.22*	*-0.4%*
Coho	*55.47*	*55.58*	*55.43*	*0.11*	*0.2%*	*-0.03*	*-0.1%*
Chum	--	--	--	--	--	--	--
Sockeye	*41.11*	*41.85*	*41.20*	*0.75*	*1.8%*	*0.09*	*0.2%*
Rainbow	*56.01*	*55.70*	*55.59*	*-0.31*	*-0.6%*	*-0.42*	*-0.8%*
Dolly Varden	*62.97*	*63.25*	*63.06*	*0.27*	*0.4%*	*0.09*	*0.1%*
Arctic Grayling	*101.06*	*101.91*	*101.39*	*0.85*	*0.8%*	*0.33*	*0.3%*

North Fork Koktuli

The magnitude and extent of impacts during average precipitation years would be an increase in juvenile salmonid habitat availability for all species of 0.03 acre, or 0.2 percent (sockeye) and 0.96 acre or 2.9 percent (Arctic grayling). There would be a decrease in rainbow trout habitat of 0.02 acre (0.2 percent). These impacts would be long term, lasting throughout the operation of the mine, and certain to occur if it is permitted and built. Post-closure, habitat changes would be reduced to less than 1 percent for all species. As mentioned above, the habitat changes would vary based on reach-specific conditions, with the largest percentage of changes occurring in small tributary NFK-190. However, in a downstream direction, reaches would alternate between habitat gains and losses for several species.

South Fork Koktuli

In terms of magnitude and extent of impacts, in average precipitation years, juvenile salmonid habitat availability would decrease for all species by between 0.07 acre, or 0.2 percent (Arctic grayling), and 0.31 acre, or 1.5 percent (rainbow trout); the exception would be an increase in sockeye juvenile habitat of 0.73 acre (7.1 percent). These impacts would be long term, lasting throughout the operation of the mine, and likelihood or occurrence would be certain if it is permitted and built. Post-closure, habitat changes would be less than 1 percent for all species, except for a decrease in rainbow trout habitat of 0.27 acre (1.3 percent), and an increase in sockeye habitat of 0.14 acre (1.3 percent). The largest changes in habitat in the SFK area are associated with rainbow trout habitat, which increased in the SFK-C reach.

Upper Talarik Creek

Due to low-magnitude flow changes in the UTC basin, juvenile habitat changes for all species would be less than 1 percent during both mining operations and post-closure.

Transportation Corridor

Road Construction

Except temporarily during construction, potential impacts on stream flows are not expected to occur at bridge and culvert crossings. All work in fish-bearing streams would be subject to design considerations, restoration requirements, and timing windows, as specified by ADF&G Title 16 Fish Habitat Permits (AS 16.05.841-871), if issued. In accordance with ADF&G criteria, bridge and culvert construction activities in anadromous waters would occur from May 15 to June 15, to avoid impacts to migrating salmon. The magnitude, extent, and duration of impacts to fish passage would be the creation of short-term barriers at stream crossings using culverts due to temporary blockage. 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 fish passage or downstream habitat. More stringent monitoring and maintenance standards may be required by ROW lease stipulations from state and local governments.

Water withdrawals would occur at lakes, ponds, and streams along the road corridor, according to Alaska Department of Natural Resources (ADNR) and ADF&G permit conditions for dust control and hydrostatic testing during the summer construction seasons; and would not be expected to impact overwintering fish or habitat. Withdrawals from fish-bearing waters would use pump screens certified by ADF&G to prevent fish impingement. Disposal methods for hydrostatic test water would be developed in accordance with APDES General Permit AKG320000 for energy dissipation and sediment control. No chemicals would be added to the hydrostatic test waters.

Natural Gas Pipeline

The final configuration of the natural gas pipeline would generally be within the prism of the access road. Stream crossings would be open cut or HDD at culvert crossings, and attached to bridges at major river crossings. This configuration would reduce the risk of ponding, interception of surface water flows, and sedimentation, as related to the pipeline ditch.

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. The duration of impacts could extend beyond the life of the project, because the pipeline would be abandoned in place, and likelihood of the impact is certain if the project is permitted and the pipeline is constructed. Ditch plugs are typically installed to intercept shallow groundwater flows. 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). Ditch dewatering and hydrotest water would be discharged to approved sites as per

Alaska Department of Environmental Conservation (ADEC) requirements. All work in fish-bearing streams would be subject to design considerations, restoration requirements, and timing windows, as specified by ADF&G Title 16 Fish Habitat Permits (AS 16.05.841-871).

4.24.2.4 Stream Productivity

Mine Site

The loss of connection between Tributary 1.190 and the mainstem NFK due to stockpile embankments and pond dams would result in permanent, direct effects on the quantity of spawning habitat by interrupting gravel transport into the mainstem NFK. Geomorphic studies conducted as part of the environmental baseline effort concluded that most instream gravel is recruited from local streambank erosion, rather than transported from upstream reaches, (Environmental Baseline Document [EBD] Chapter 3, Geology and Mineralization); however, a source like Tributary 1.190 would also be expected to contribute gravel into mainstem reaches. Two other sizeable tributaries (NFK Tributaries 1.17 and 1.12) meet the mainstem NFK within 5 miles below the mine site, so the extent of effects of reduced gravel recruitment would likely be limited in area. Spawning surveys conducted from 2004 to 2008 indicated the heaviest spawning by coho and chum salmon was concentrated in the mainstem NFK in the 9-mile reach immediately below the mine site and Tributary 1.190. In contrast, Chinook and sockeye salmon spawning areas were concentrated in the mainstem NFK 10 to 20 miles downstream of the mine site, where potential impacts of upstream gravel interruptions are less likely.

Baseline concentrations of dissolved organic carbon in the surface waters in the project area ranged from 1 milligram per liter (mg/L) to 2 mg/L; concentrations of nitrate+nitrite ranged from 0.1 to 0.3 mg/L; and mean concentrations of total phosphorous ranged from 0.02 to 0.04 mg/L, indicative of oligotrophic nutrient status in the aquatic ecosystem. This is consistent with the characteristics of headwater stream orders 1, 2, and 3; with existing riparian vegetation providing low inputs of organic matter. The lack of a mature deciduous overstory likely contributes to the oligotrophic conditions, and is unique to headwater streams in the project area; specifically, the NFK and SFK. 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 from the affected stream channel.

The loss of connection between Tributary 1.190 and the mainstem NFK due to embankments and pond dams could result in permanent, direct effects on the quantity and quality of invertebrate productivity transported downstream into the mainstem NFK. In terms of magnitude and extent, the loss of connection could also directly impact available habitat for BMI production, which is critical for fish growth and survival. Macroinvertebrate studies conducted as part of the environmental baseline effort concluded that a range of macroinvertebrates and periphyton exist in Tributary 1.190 that would contribute via drift to the food web into downstream reaches. Two other sizeable tributaries (NFK Tributaries 1.17 and 1.12) meet the mainstem NFK within 5 miles below the mine site, 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.

The importance of marine-derived nutrients in Bristol Bay watershed lakes from returning salmon is well documented, as noted in Section 3.24, Fish Values. As shown in the baseline data above, marine-derived nutrients do not appear to influence the nutrient availability in the Koktuli or uppermost reaches of the Upper Talarik watersheds in the project area. This may be due 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 for carcass retention. The extent or scope of any 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. These impacts on stream productivity would be expected to occur if the project is permitted and built.

Transportation Corridor

Road and Pipeline

The road and pipeline would cross 16 anadromous and 36 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. This could reduce terrestrial inputs and downstream productivity, and the duration would be for the life of the project. Loss of riparian vegetation can result in increased erosion and stream sedimentation and reduction in stormwater retention capacity, and can increase flows and alter instream functions, including productivity. In terms of magnitude and extent, the road/pipeline footprint and associated crossing structures would impact approximately 13.5 acres of riparian vegetation, and interrupt floodplain connectivity in certain locations. However, additional riparian habitat is available that would not be impacted throughout the watersheds. The duration of the impact to riparian vegetation would be for the life of the project, and would be expected occur if the project is permitted and built. BMPs such as road fill drain culverts may be considered during design and permitting to maintain floodplain connectivity, and to maintain riparian habitat function.

Iliamna Lake Pipeline

HDD would be used to install the natural gas pipeline segments from the lakeshore into waters deep enough to avoid navigational hazards, then laid and secured on the lake bottom. In terms of magnitude, extent, and duration of impacts, approximately 2.18 acres of available benthic habitat in Iliamna Lake would be permanently impacted. This is only 0.0003 percent of the approximately 647,000 acres of available benthic habitat in the lake. However, the impact to these acres would be certain to occur if the project is permitted and constructed.

Ferry Terminal and Operation

Docking facilities for the ice-breaking ferry at the north and south ferry terminals are expected to include rock and gravel ramps extending approximately 40 feet into Iliamna Lake. Consequently, in terms of magnitude, extent, and duration, there would be short-term, indirect disturbance effects from ramp construction along the shoreline; and permanent, direct impacts due to loss of approximately 1 acre of benthic habitat under the north and south ferry terminals' footprints combined. Rip-rap placed around the landing ramps would be similar in size and character to the boulder habitats currently present in both locations, and would not represent a novel habitat feature. Rip-rap would be colonized in the short term, and subsequently used by prey organisms. The 1 acre of benthic habitat permanently impacted is less than 0.000002 percent of of available benthic habitat in Iliamna Lake (approximately 234 miles of shoreline/647,000 acres).

Amakdedori Port

The magnitude and duration of project impacts at the port site would be the removal and/or fill of 11.3 acres of nearshore habitat, including 2.5 acres of beach complex and 8.8 acres of subtidal mixed-gravel habitat. 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 are less productive than other areas sampled in Kamishak Bay. Rip-rap placed around the landing ramp would be similar in size and character to the boulder habitats currently present in both locations, and would not represent a novel habitat feature.

Rip-rap would be colonized in the short term, and subsequently used by prey organisms. 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 to Kamishak Bay.

Cook Inlet Natural Gas Pipeline

In terms of magnitude, extent, and duration, construction of the natural gas pipeline would permanently impact approximately 6.8 acres of the northern Kamishak Bay weathervane scallop bed. This impact would occur if the project is permitted and the pipeline is built.

4.24.2.5 Stream Sedimentation and Turbidity

The effects of stream sedimentation on fish could occur during all three phases of the project: construction, operations, and closure/post-closure. Mine site activities have the potential to release particulates and sediment into drainages and tributaries from a range of activities and sources, including:

- The placement of fill material below the ordinary high water mark of streams for the construction of the project components.
- Soil disturbance, compaction, and vegetation removal.
- Wetland in-filling that reduces sediment retention and exposes soils to erosive forces of wind and/or water.
- Stream erosion from increased flows released as a result of inter-basin diversions and transfers.
- Rock fracturing/processing activities.
- Runoff from constructed roads, pipeline, and materials sites.

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 refuge for juvenile fish; reduce overall fish-carrying capacity; and decrease fish food (BMI) availability (Limpinsel et al. 2017). Although sediment transport and deposition are natural stream processes, major 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).

Elevated turbidity in streams from suspended sediments can have adverse impacts on fish and other aquatic organisms through several mechanisms, such as reduced foraging efficiency of drift-feeding fish, elevated water temperature through increased light absorption, reduced primary production, and damage to gill membranes under conditions of severe turbidity (Bash et al. 2001; Newcombe and Jensen 1996).

The magnitude and extent of mine site construction would be the disturbance of 8,130 acres of surface soil. Components of the mine site that could release sediment into waterways include the 13 embankments for various stockpiles (TSF, overburden, etc.) and ponds (seepage, sedimentation, and water management); parking, laydown and construction sites; materials sites; and haul, access, and service roads. During construction and operation of the mine, surface runoff would be captured by drainage ditches that would route runoff into ponds for treatment at one of two water treatment facilities before discharge into downstream waters. Likewise, seepage from stockpiles would drain into ponds for subsequent treatment and discharge.

The magnitude and extent of stream sedimentation that could result from such disturbance would depend on the effectiveness of required state-of-the-process BMPs under stormwater pollution prevention regulations implemented, monitored, and maintained during all phases of the project. BMPs are designed to mitigate the intensity of surface runoff, erosion, and sediment loads in stream channels. A range of BMPs, including silt fences, bale check dams, sediment retention basins, cross bars and ditches, runoff interception and diversions, gabions and sediment traps, mulching of disturbed surfaces and stockpiles, and other measures, would be implemented and monitored along the mine site road corridors and at all bridge and culvert crossings to ensure minimization of potential impacts from erosion and sedimentation. BMPs would also be employed to minimize impacts of surface runoff and erosion at materials sites (Knight Piésold 2018a). Detailed BMPs are described in Section 4.16, Surface Water Hydrology.

The extent of 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 duration of sedimentation impacts would be temporary short term, only occurring during construction. 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.

Mine Site

Development and operation of the mine site and its associated facilities (e.g., roads, embankments, and housing) are expected to result in increased surface runoff, which—if not captured and re-routed to treatment facilities—can 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. BMPs would be implemented and maintained during construction and maintenance of all mine facilities to minimize surface runoff. All effluent discharged from water treatment plants 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 permit exceedance conditions and initiate remediation procedures. The magnitude and extent of impacts to turbidity would be within the mine site footprint; particularly when extreme weather events coincide with ground-disturbance activities. The duration of impacts would be long term, 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.

Transportation Corridor

In terms of magnitude, extent, duration, 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; alteration of water temperature; delays or barriers to fish migration at culverts; changes in streamflow and hydrologic processes; and introduction of invasive plant species (Limpinsel et al. 2017). Surface erosion can also 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).

The road would be constructed through existing bedrock and glacial fluvial surface geology using locally processed materials with low erosion potential. Therefore, the indirect effects of erosion and sedimentation are expected to be limited to bridge or culvert crossings. The duration of construction-related sedimentation would be temporary and short term, due mitigation and control measures, permit stipulations, and timing windows. Additional monitoring, BMPs, and maintenance standards may be required by ROW lease stipulations from state and local governments.

The design of the natural gas pipeline would be within the prism of the access road, and attached to bridges at river crossings. This configuration would reduce the risk of ponding, interception of surface water flows, and sedimentation, as related to the pipeline ditch.

In terms of magnitude, 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. See Section 4.20, Air Quality, for additional discussion on extent and magnitude of fugitive dust generation. Implementation of dust suppression and enforcement of slow speed limits at all stream crossings would minimize dust-related impacts to aquatic ecosystems. The duration of impacts would be through the life of the project, and the likelihood is certain if the project is permitted and built.

Road and Pipeline

Potential impacts on stream turbidity are not expected to occur at bridge or culvert crossings, except of temporary duration during construction. The extent of impacts would be limited to the immediate location of the drainage structure. Bridge and culvert construction activities in anadromous waters would occur from May 15 to June 15 to avoid impact to migrating salmon, according to ADF&G criteria. As stated above, routine inspection and maintenance of culverts, bridges, and roads would be regularly conducted, in compliance with permit conditions to ensure that drainage-structure–related erosion, wash-out, or debris blockage do not result in impacts to water quality or downstream habitat.

Ferry Terminals

Docking facilities for the ice-breaking ferry at the north and south ferry terminals are expected to include rock and gravel ramps extending approximately 40 feet into Iliamna Lake. Consequently, in terms of magnitude, extent, duration, and likelihood, there would be local, short-term turbidity effects on fish and benthic organisms during construction. These impacts would be expected to occur if the project is permitted and constructed.

Amakdedori Port

Temporary increases in turbidity would occur during construction of the Amakdedori port. Turbidity and deposition of suspended sediments in the nearshore environment at the port site could impact marine benthos. 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 magnitude of impacts of sediment deposition on aquatic vegetation could be a reduction of potential spawning habitat for species such as Pacific herring.

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). The duration impacts from port construction are expected to be short term, lasting only during construction, but would be certain to occur if the project is permitted and constructed.

4.24.2.6 Fish Migration

Mine Site

The mine access road and spur roads would cross seven fish-bearing streams, not including road crossings where channels enter stockpile embankments or the open pit (Figure 4.24-1). In terms of magnitude and extent, two of the stream crossings involve anadromous streams, four cross non-resident salmonid streams, and one crosses a sculpin-bearing stream. The anadromous crossing in the NFK drainage is over a branch of Tributary 1.190. The duration of impacts to this stream would permanent, because it would be blocked to anadromous fish during project construction and operations. The second anadromous crossing is in the headwaters of the mainstem SFK, approximately 1,000 feet below the southern edge of the mine pit. Implementation of BMPs would minimize the magnitude of impact on fish migration resulting from such disturbances. The design of the seven culverts would be reviewed and verified by ADF&G during the permitting process (if permits are issued). Impacts to these streams would be certain to occur if the project is permitted and built.

Transportation Corridor

Access Roads and Pipeline

Potential impacts on fish passage are not expected to occur at bridge crossings, except temporarily during bridge construction. Bridge and culvert design, stream flows, and habitat loss would be reviewed and verified by ADF&G during the permitting process. Permit stipulations may include seasonal restrictions on instream activities to avoid impacts to habitat during species critical life stages (e.g., spawning and egg development). The duration of impact would be that free passage of fish may be temporarily interrupted, but would continue unimpeded after construction is complete. Migration disturbance from construction effects would be short term, lasting only during the construction phase. The magnitude and extent of impacts would be such that fish may be disturbed or displaced, but would return to their prior state after the activity ceases; functional changes to habitat are not expected. Routine inspection and maintenance of culverts, bridges, and mine and port access roads would be regularly conducted and reported, in compliance with permit conditions (if permits are issued), to ensure that culvert-related erosion, wash-out, or debris blockage do not result in acute or chronic impacts to fish passage or downstream habitat. Impacts would be expected to occur if the project is permitted and the access roads and pipeline are constructed.

Ferry Terminal

As stated above, docking facilities for the ice-breaking ferry at the north and south ferry terminals are expected to include rock and gravel ramps extending approximately 40 feet into Iliamna Lake. There are no anticipated impacts to fish migration associated with these structures due to existing migratory habitat available in Iliamna Lake.

Amakdedori Port

In terms of magnitude and extent, the Amakdedori port causeway and jetty would extend 1,900 feet into Cook Inlet and would 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. Prevention or delay of fish migration is not anticipated from the port structure.

Natural Gas Pipeline

The magnitude of impact of the natural gas pipeline on migration of macroinvertebrates (e.g., crabs) would be that the diameter and height of the pipe would be in the natural range of seafloor topography and would not be expected to hinder marine macroinvertebrate migration patterns. HDD would be used to install the pipeline at the terrestrial-marine interface with Cook Inlet to a depth that would prevent navigational hazards. ADF&G permit conditions (if issued) would likely stipulate timing windows for construction to avoid impacting migrating anadromous fish in Cook Inlet. As described in Section 4.6, Commercial and Recreational Fisheries, the salmon fishery occurs within the top 30 feet of the water column; and once in place, the pipeline would not be expected to directly interact with commercial fisheries.

4.24.2.7 Water Temperature and Quality

Construction and operations of the mine site may lead to changes in several water quality parameters in area streams that have the potential to impact fish. The 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 incubation. Ambient water temperatures monitored from 2004 to 2009 frequently exceeded the ADEC 15°C criteria in many stream reaches (ADEC 2018b). In each year of study, the daily maximum water temperature in the NFK immediately upstream of the mine site exceeded the 20°C criteria on about 28 percent of all instantaneous readings during the summer months. The lower temperature thresholds for migration and rearing (15°C) were exceeded on 78 percent of summer readings; and the spawning and egg incubation criteria (13°C) were exceeded on 89 percent of summer readings.

Summer baseline water temperatures also exceeded ADEC thresholds in several reaches of the SFK, and to a lesser degree in the UTC. Maximum daily water temperatures exceeded the general 20°C criteria in 17 percent of measurements at multiple stations in the SFK, but daily maxima remained below the threshold in the UTC. Exceedance percentages for the 15°C migration and rearing thresholds for the SFK and UTC were 76 percent and 44 percent, respectively; whereas comparable exceedance values for the 13°C spawning and egg incubation criteria were 93 percent of summer readings in the SFK, and 59 percent of readings in the UTC.

Winter water temperature changes from mine operations could impact eggs and alevins within spawning gravels primarily through increased metabolism, growth, and changes in time of emergence. However, current winter temperatures in NFK River and UTC, and likely SFK River, are below the optimum egg incubation ranges found for Pacific salmon species in the analysis area. Weber-Scannell (1991) reports the following ranges of optimum egg incubation temperatures from the literature: Chinook, 39.2 to 53.6°F (4.0°C to 12.0°C); coho, 41°F to

51.8°F (5.0°C to 11.0°C); sockeye, 39.9°F to 55.0°F (4.4°C to 12.8°C); chum, 39.9°F to 55.9°F (4.4°C to 13.3°C); and pink salmon, 41.0°F to 57.2°F (5.0°C to 14.0°C).

In terms of magnitude, the predicted increase in winter discharge water temperatures would not raise river temperatures to the lower limits of optimum egg survival for any species, and would not affect egg survival. Increases in water temperatures during alevin development can substantially increase development rates and associated yolk conversion rates, potentially leading to faster yolk depletion and early emergence from the gravel at overall smaller sizes. Fry could emerge too early at suboptimal periods of the year and experience poor feeding, growth, and survival. 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 35.6°F and 41.0°F (2.0°C and 5.0°C), while chum and Chinook salmon length at emergence increased between 41.0°F and 46.4°F (5.0°C and 8.0°C), then decreased with higher temperatures (Weber-Scannell 1991). NFK River habitats could warm to near the optimum alevin development temperatures for coho salmon, or could be slightly higher. It is unlikely that increases in winter water temperatures would warm adequately to enhance or adversely affect developing alevins in the SFK River or UTC; and within the NFK River, post-mining water temperatures may increase to within the optimal ranges for alevin development of slightly warmer (Owl Ridge et al. 2019).

Although the water temperature regimes in the project area frequently exceeded the ADEC criteria during the 2004-2009 sampling period, adult and juvenile salmon and resident trout remained abundant. However, any reduction in stream flows during the summer base-flow period may have a direct impact on salmonids through increased water temperatures; and potentially, through decreased temperatures during the winter base-flow period. Direct impacts could affect egg/fry incubation and availability of prey species during low-flow events. Although the water temperature regimes in the project area frequently exceeded the ADEC criteria during the 2004-2009 sampling period, adult and juvenile salmon and resident trout remained abundant. Impacts associated with changes in water temperature are discussed below by drainage area.

North Fork Koktuli River

In terms of magnitude and extent, average changes in water temperature are expected to increase by approximately 1.2 °C during summer, and 2.8°C during winter within 0.5 mile downstream of the water discharge location. As described in Chapter 3, Affected Environment, Chinook and other salmon species have been observed spawning in this reach of the NFK. 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. Baseline winter water temperatures in this reach are just above 0°C. NFK River habitats could warm to near the optimum alevin development temperatures for coho salmon, or could be slightly higher. A 2.8°C increase in surface water temperature would be well below the ADEC threshold, and would not be expected to adversely impact incubating eggs, juveniles, or other overwintering resident fish. The duration of these changes would be long term, lasting though the life of the project; and they would be expected to occur if the project is permitted and built.

South Fork Koktuli River

In terms of magnitude and extent, average changes in water temperature are expected to decrease approximately 0.15°C during summer, with no change in winter water temperatures 1 mile downstream of the water discharge location. Sockeye and coho salmon have been documented using this reach of the SFK and Frying Pan Lake as rearing habitat. A decrease of 0.15°C in water temperature would not be expected to adversely impact rearing fish. It is unlikely that increases in winter water temperatures would warm adequately to enhance or adversely affect developing alevins in SFK. The duration of these changes would be long term, lasting though the life of the project; and they would be expected to occur if the project is permitted and built.

Upper Talarik Creek

The magnitude and extent of average changes in water temperature would be an increase of approximately 0.12°C during summer and 0.54°C in winter 3 miles downstream of the water discharge location. As described in Chapter 3, Affected Environment, Chinook, sockeye, and coho salmon use this reach of the UTC for spawning and rearing. 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 (PLP 2018-RFI 047). Baseline winter water temperatures in this reach are just above 0°C. A 0.54°C increase in surface water temperature would be well below the ADEC threshold, and would not be expected to adversely 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 permitted and built.

Water Chemistry

Baseline natural water quality conditions have been documented throughout the project area, and can be referenced in Section 3.18, Water and Sediment Quality. Stream samples collected proximal to the Pebble deposit contained elevated concentrations of copper, molybdenum, nickel, zinc, and sulfate, sometimes 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 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 below its headwaters (Figure 4.24-1; see Section 3.18 and Section 4.18, Water and Sediment Quality). Such permitted discharges would be in compliance with APDES permit; that is, discharge process water would have been treated to achieve the water quality criteria that are protective of aquatic life. Therefore, release of metals to surface water via point discharges of process water are not expected to cause metals toxicity (lethal and sub-lethal) on fish and aquatic invertebrates. Refer to Section 4.27, Spill Risk, for an analysis of impacts associated with upset conditions. As described in Section 4.18, fugitive dust would contribute metals to surface water, but would not exceed the water quality standards.

The ADEC regulates wastewater discharges from hard-rock mining facilities through various permits, including:

- APDES Individual Permit for point source discharge into wetlands and other waters
- Integrated Waste Management Permit for solid waste disposal and wastewater discharge not into wetlands and other waters
- APDES Multi-Sector General Permit for stormwater discharge
- Domestic Wastewater Discharge Permit

State of Alaska regulations require that the condition of these permits ensure compliance with the state water quality standards that are based on the use classification for the water body receiving discharge, and the state's anti-degradation policy. Some water bodies may also have site-specific water quality criterion. For constituents that exceed criteria in background surface water and groundwater (see Section 3.18.1 and Appendix K3.18), there are currently no plans to incorporate site-specific background levels of constituents into discharge limits (ADEC 2018-RFI 064a).

4.24.2.8 Essential Fish Habitat

EFH Assessment is included as Appendix I.

4.24.2.9 Alternative 1 Variants

Summer-Only Ferry Operations Variant

The Summer-Only Ferry Operations Variant is described in Chapter 2, Alternatives. Except for impacts noted below for fish displacement, injury, and mortality, the magnitude, extent, duration, and potential for impacts on habitat loss, stream flow, stream productivity, steam sedimentation and turbidity, fish migration, and water temperature associated with this variant would be the same as described under Alternative 1.

Fish Displacement, Injury, and Mortality

The ferry vessel would be larger than in 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 in Alternative 1.

Kokhanok East Ferry Terminal Variant

The route for the Kokhanok East Ferry Terminal Variant avoids the need for a bridge across the Gibraltar River, a major river crossing under Alternative 1. As described in Section 3.24, Fish Values, adult salmon have been documented migrating along the shoreline in proximity to the terminal location, but no beach spawning was observed.

Habitat Loss

The variant portion of the road (Kokhanok east spur road) and pipeline corridor would cross 7 non-anadromous channels requiring culverts, and 1 bridge crossing 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 is 6 miles shorter than Alternative 1, and would have 18 fewer stream crossings. Six of the Alternative 1 crossings provide resident fish habitat, and 5 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 due to the reduction in stream crossings under this variant, as compared to Alternative 1 without the variant. The duration and likelihood of impacts would be the same as Alternative 1 without the variant.

Fish Displacement, Injury, and Mortality

As described above, fewer stream crossings would result in fewer associated impacts during construction, including culvert installation, stream diversion, water withdrawals, and pipeline trenching. The magnitude and extent of impacts due to displacement, injury, or mortality would be reduced, compared to Alternative 1 without the variant. The duration and likelihood of impacts would be the same as Alternative 1 without the variant.

Stream Flow, Productivity, Sedimentation, and Turbidity

The reduction in the number of stream crossings would reduce the magnitude and extent of stream flow, productivity, sedimentation, and turbidity impacts in the transportation corridor, as described in Alternative 1. The duration and likelihood of impacts would be the same as Alternative 1 without the variant.

Fish Migration

The reduction in the number of stream crossings would reduce the magnitude and extent of impacts to fish migration because the number of stream crossings and streams crossed by culverts would be fewer than those described for Alternative 1 without the variant, compared to impacts in the transportation corridor, as described in Alternative 1.

Pile-Supported Dock Variant

The Pile-Supported Dock Variant is described in Chapter 2, Alternatives. The magnitude, extent, duration, and likelihood of impacts on fish migration and water temperature associated with this variant would be the same as described under Alternative 1. Impacts would be different for the following parameters.

Habitat Loss

The magnitude and extent of loss of benthic habitat under this variant would be less, 0.07 acre, compared to approximately 14 acres under Alternative 1. Approximately 2,000 lineal feet of large rocky substrate provided by rip-rap armoring in Alternative 1 would be eliminated. The duration and likelihood of impacts would be the same as Alternative 1 without the variant.

Fish Displacement, Injury, and Mortality

Approximately 518 dock piles would be installed in the intertidal area under this variant. Potential for displacement, injury, and mortality would increase compared to Alternative 1 due to duration and intensity of noise impacts during construction. These impacts would be expected to occur if this variant is chosen, and the project is permitted and built.

Stream Productivity

Reducing the dock footprint acreage would not result in additional impacts to benthic stream productivity compared to existing baseline conditions. However, potential additional habitat productivity provided by 2,000 feet of rip-rap armoring in Alternative 1 would be eliminated. These impacts would be expected to occur if this variant is chosen, and the project is permitted and built.

Stream Sedimentation and Turbidity

The magnitude and extent of sedimentation and turbidity impacts would be reduced to the immediate footprint of the piles during construction, as compared to Alternative 1. These impacts would be likely to occur if this variant is chosen, and the project is permitted and built.

4.24.3 Alternative 2 – North Road and Ferry with Downstream Dams

4.24.3.1 Mine Site

The expanded footprint of Alternative 2 would not result in an increase of impacts to fisheries resources. The magnitude, extent, duration, and likelihood of impacts to habitat, stream flow, productivity, sedimentation and turbidity, and fish migration due to construction and operation activities at the mine site would be same as those described for Alternative 1.

4.24.3.2 Transportation Corridor

Habitat Loss

Access Roads/Pipeline

The transportation corridor includes the mine site road, two spur roads to ferry terminals on Iliamna Lake, and the natural gas pipeline corridor from the mine site to Diamond Point. The transportation corridor under Alternative 2 would include a total of 117 waterbody crossings, including 24 crossings of anadromous habitat and 32 crossings over resident fish habitat. Of this total, 82 drainages, including 34 fish stream crossings (15 over anadromous waters), would be crossed by the pipeline only (i.e., no adjacent road).

In terms of magnitude and extent, Alternative 2 increases the number of anadromous fish stream crossings from 16 to 24 compared to Alternative 1. The increased number of crossings would increase the transportation corridor footprint and resultant loss of anadromous stream habitat compared to Alternative 1. Resident fish stream crossings compared to Alternative 1 would remain the same. All anadromous fish stream crossings would be in the Iliamna Lake/Kvichak watershed, compared to Alternative 1, which could result in increases to cumulative impacts for the watershed. The duration and likelihood of impacts would be the same as Alternative 1.

Ferry Terminals and Operation

As described in Section 3.24, adult sockeye were documented along the north and south shorelines of the Eagle Bay ferry terminal location, but no spawning was observed. The magnitude, extent, duration, and likelihood of habitat loss would be the same as described in Alternative 1.

Diamond Point Port

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 Alternative 1; because the footprint of these structures would cover roughly 58 more acres of benthic habitat due to channel dredging than the Amakdedori port (PLP 2018-RFI 072). Maintenance dredging is anticipated to be ongoing during operations on a 5-year recurrence interval. This would result in a reoccurring impact to 58 acres of benthic habitat for the life of the project, compared to Alternative 1.

Fish Displacement, Injury and Mortality

Access Road/Pipeline

In terms of magnitude, Alternative 2 has eight additional stream crossings that would result in increased potential displacement, injury, or mortality impacts during construction, including culvert installation, stream diversion, water withdrawals, and pipeline trenching, as compared to Alternative 1. The duration and likelihood of impacts would be the same as Alternative 1.

Ferry Terminals and Operation

The magnitude, extent, duration, and likelihood of impacts to benthic organisms would be the same as described in Alternative 1.

Iliamna Lake

Impacts associated with the installation of the natural gas pipeline would be avoided under Alternative 2.

Diamond Point Port

Construction and operations of the Diamond Point port would result in a permanent loss of 58 acres of benthic habitat for the life of the project.

Stream Flow, Productivity, Sedimentation, and Turbidity

Access Road/Pipeline

In terms of magnitude and extent, Alternative 2 has eight additional stream crossings that would result in increased potential for stream flow and productivity impacts and increased turbidity during construction, including culvert installation, stream diversion, water withdrawals, and pipeline trenching, as described in Alternative 1. The duration and likelihood of impacts would be the same as Alternative 1.

Ferry Terminals and Operations

The magnitude, duration, extent, and likelihood of impacts to stream flow, productivity, sedimentation, and turbidity would be the same as Alternative 1.

Diamond Point Port

The magnitude of impacts to benthic productivity would increase by 58 acres throughout the life of the mine compared to Alternative 1. Channel dredging during construction would cause an increase in the magnitude of turbidity impacts as compared than Alternative 1. Maintenance dredging is anticipated to be ongoing during operations on a 5-year recurrence interval. This will result in a reoccurring turbidity impact to 58 acres of benthic habitat for the life of the project, compared to Alternative 1.

Fish Migration

Access Roads/Pipeline

In terms of magnitude and extent, Alternative 2 has eight additional stream crossings that would result in increased migration impacts during construction, including culvert installation, stream diversion, water withdrawals, and pipeline trenching, as compared to Alternative 1.

Diamond Point Port

The magnitude, extent, duration, and likelihood of impacts to fish migration are the same as Alternative 1.

Water Temperature and Chemistry

The mine site and transportation corridor have the same footprint in Alternative 2 as Alternative 1. The magnitude, extent, duration, and likelihood of impacts on water temperature and chemistry would be the same as Alternative 1.

4.24.3.3 Natural Gas Pipeline

The magnitude, extent, duration, and likelihood of impacts to fish habitat stream flow and water quality would be the same as described under Alternative 1 for the portion of the pipeline beginning on the Kenai Peninsula and crossing Cook Inlet to Kamishak Bay, with the exception that the pipeline would avoid impacting 6.8 acres of weathervane scallop bed habitat described in Alternative 1. Impacts would be the same as described under Alternative 3 – transportation corridor, for the portion from Diamond Point to the mine site.

The pipeline corridor through Ursus Cove to Diamond Point would cross two additional anadromous fish stream crossings with associated impacts to fish and fish habitat, similar to other sections of the natural gas pipeline corridor. Additionally, the pipeline trench has the potential to impact benthic and intertidal habitats in Ursus Cove during construction.

4.24.3.4 Alternative 2 Variants

Summer-Only Ferry Operations Variant

Ferry operations from Eagle Bay to Pile Bay would have similar magnitude, extent, duration, and likelihood of impacts to fish and fish habitat as ferry operations described under Alternative 1.

Pile-Supported Dock Variant

In terms of magnitude and extent, construction of a pile-supported dock at Diamond Point would result in less direct impact 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). Noise impacts from pile installation during construction could cause injury or mortality to fish and benthic organisms. Short-duration and limited suspended sediment impacts would be expected to occur during construction of the pile structure.

4.24.4 Alternative 3 – North Road Only

Under Alternative 3, the magnitude, extent, duration, and likelihood of impacts to fish values along the pipeline corridor and the Diamond Point port would be the same as those described under Alternative 2, while impacts to the mine site would be the same as those described under Alternative 1.

The following sections describe impacts for the transportation corridor and port that would be different under Alternative 3.

4.24.4.1 Transportation Corridor

Although Alternative 3 would increase the project footprint, fisheries impacts associated with the ferry crossing of Iliamna Lake would be eliminated. The north access road only route would result in an increase of 15 anadromous stream crossings, and a reduction of four resident stream crossings relative to Alternative 1, with a corresponding increase in fish habitat and riparian wetlands impacts (described under Alternative 1).

4.24.4.2 Natural Gas Pipeline

The magnitude, extent, duration, and likelihood of impacts to fish habitat and water quality parameters would be the same as those described under Alternative 2 for the portion of the natural pipeline beginning on the Kenai Peninsula, and crossing Cook Inlet to Kamishak Bay. Impacts would be the same as described under Alternative 2 – transportation corridor, for the natural gas pipeline portion from Diamond Point to the mine site.

4.24.4.3 Concentrate Pipeline Variant

The concentrate pipeline from the mine to the port under Alternative 3 would require an electric pump station at the mine site, which would require a small increase in fill placement over stream substrate in an NFK east tributary (PLP 2018-RFI 066). This alternative would also reduce the amount water treatment plant water released at discharge locations at the mine site by approximately 1 to 2 percent (PLP 2018-RFI 066), which could result in slight reductions of temperature effects, aquatic habitat availability, and turbidity or erosional effects at treated water discharge locations

Inclusion of a concentrate pipeline under this alternative would result in a slightly greater impact in magnitude to fish and fish habitat than Alternative 3 without the concentrate pipeline. The concentrate pipeline would be buried at the same time as road construction, and the mine access road corridor widened by less than 10 percent for inclusion of the pipeline, which could result in a marginal 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 Alternative 3 without the variant.

4.24.5 Summary of Key Issues

A summary of key issues is provided below in Table 4.24-4.

Table 4.24-4: Summary of Key Issues for Fish and Aquatics

Impact-Causing Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Mine Site			
Mine Site Construction and Operations	**Habitat Loss:** NFK: Permanent loss of 8 miles of anadromous fish stream habitat and 20 miles of resident fish stream habitat. SFK: Permanent loss of 0.75 mile of anadromous stream habitat. Riparian Habitat: Approximately 276 acres of riparian wetland habitat would be permanently removed within the mine site footprint. **Fish Displacement and Mortality:** Anadromous and resident fish mortality in streams within the footprint of the mine site during construction.	Footprint of impacted aquatic resources would remain the same in the mine mite. Impacts the same as Alternative 1.	Footprint of impacted aquatic resources would remain the same in the mine site. Impacts the same as Alternative 1. *Concentrate Pipeline Variant* – mine site footprint increased by 0.7 acre with potential impact on aquatic habitat.

Table 4.24-4: Summary of Key Issues for Fish and Aquatics

Impact-Causing Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Stream Flow: Stream flow will be permanently removed from Tributary NFK 1.190, sections of NFK 1.120 and SFK 1.0 **Stream Productivity:** Fisheries, invertebrate, and riparian productivity would be permanently removed from Tributary NFK 1.190, sections of NFK 1.120, and SFK 1.0. **Stream Sedimentation and Turbidity** Temporary impacts from sedimentation and turbidity during construction of mine site. **Fish Migration** Fish migration would be permanently blocked from Tributary NFK 1.190, sections of NFK 1.120, and SFK 1.0. **Water Temperature** Increases in water temperature within ADEC water quality standards in NFK, SFK, and UTC for life of the mine. **Water Chemistry** No noticeable changes in water chemistry above background levels.		
Transportation Corridor			
Transportation Corridor Construction and Operations	**Habitat loss:** Permanent loss of approximately 13.5 acres of riparian habitat within 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. **Stream Flow:** Temporary impacts to stream flow during bridge and culvert installation. Temporary and localized impacts to shallow groundwater during pipeline 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.	Impacts would be similar to those described in Alternative 1, although greater in geographic extent due to the increased number of waterbodies crossed by the road corridor. **Access Road/Pipeline Stream Crossings** Total: 117 Anadromous: 23 Resident: 32	Impacts would be the same as those of Alternative 2. *Concentrate Pipeline Variant* – increased area of disturbance as the road corridor would be widened for pipeline inclusion.

Table 4.24-4: Summary of Key Issues for Fish and Aquatics

Impact-Causing Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Fish Migration Temporary and localized impacts to fish migration during culvert and bridge construction. **Water Temperature** No impacts to water temperature above background levels. **Water Chemistry** No noticeable changes in water chemistry above background levels. <u>Stream Crossings</u> Total: 95 Anadromous: 16 Resident: 33		
Kokhanok East Ferry Terminal Variant	Reduced number of anadromous and resident fish stream crossings would result in reduction of impacts described in Alternative 1. <u>Stream Crossings</u> Total: 77 Anadromous: 6 Resident: 28	Not included in this alternative.	Not included in this alternative.
Ferry Construction and Operations	**Habitat Loss:** Permanent loss of approximately 1 acre benthic habitat below ordinary high water (OHW) beneath footprint of ferry terminal. **Fish Displacement and Mortality:** Permanent loss of benthic organisms within the footprint of the ferry terminal. Temporary and localized impacts of propeller and wake disturbances during operation. **Stream Flow:** No impacts to stream flow. **Stream Productivity:** Permanent loss of approximately 1 acre 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 above background levels.	Impacts similar to Alternative 1.	No ferry terminals or operations under this alternative. Impacts described under Alternative 1 and 2 would be avoided.

Table 4.24-4: Summary of Key Issues for Fish and Aquatics

Impact-Causing Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Water Chemistry No noticeable changes in water chemistry above background levels.		
Kokhanok East Ferry Terminal Variant	Impacts the same as Alternative 1.	Not included in this alternative.	Not included in this alternative.
Summer-Only Ferry Operations Variant	**Fish Displacement and Mortality:** Larger vessel size may increase temporary and localized impacts of propeller and wake disturbances during operation. Other impacts same as Alternative 1.	Impacts would be the same as Alternative 1.	No ferry terminals or operations under this alternative.
		Port Site	
Port Site – Causeway fill/construction	**Habitat Loss:** Permanent loss of 14 acres of benthic habitat beneath footprint of causeway and jetty. Increase of approximately 2,000 feet of rocky rip-rap substrate along the port causeway. **Fish Displacement and Mortality:** Mortality impacts to benthic organisms within the footprint of the port site. Noise displacement and potential mortality during sheet pile installation. Temporary and localized impacts of propeller and wake during operation. **Stream Flow:** No impacts to stream flow. **Stream Productivity:** Permanent loss of 14 acres of benthic productivity. **Stream Sedimentation and Turbidity** Temporary sedimentation and turbidity impacts during construction. **Fish Migration** Temporary and localized impacts to fish migration during construction. No permanent impacts to fish migration.	**Habitat Loss:** Permanent loss of 15 acres of benthic habitat beneath dock footprint similar to Alternative 1. A permanent increase of 58 acres of benthic habitat loss associated with construction and maintenance channel dredging for the life of the mine. Other impacts similar to Alternative 1.	Impacts the same as Alternative 2.
Pile-Supported Dock Variant	**Habitat Loss:** Port footprint reduced to 0.1 acre of benthic habitat impact compared to 14 acres under Alternative 1. **Fish Displacement and Mortality:** Reduction of mortality to benthic organisms within the port footprint. Increased potential of noise-related	**Habitat Loss:** Reduction from 15 acres aquatic habitat loss beneath dock footprint to 0.1 acre. **Fish Displacement and Mortality:** Reduction of mortality to benthic organisms	Impacts the same as Alternative 2.

Table 4.24-4: Summary of Key Issues for Fish and Aquatics

Impact-Causing Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	disturbance and mortality during pile installation. Other impacts are the same as Alternative 1.	within the port footprint. Increased potential of noise-related disturbance and mortality during pile installation. Other impacts are the same as Alternative 1.	
Natural Gas Pipeline			
Construction and Installation of Natural Gas Pipeline	**Habitat Loss:** Permanent loss of 2.1 acres of benthic habitat beneath footprint in Iliamna Lake and 11.5 acres of benthic habitat in Cook Inlet. Approximately 6.8 acres of weathervane scallop habitat would be permanently removed. **Fish Displacement and Mortality:** Mortality impacts would occur to benthic organisms within the footprint of the pipe and anchor activities during construction. **Stream Flow:** No impacts to stream flow. **Stream Productivity:** Permanent loss of 11acres of benthic productivity. **Stream Sedimentation and Turbidity** Temporary sedimentation and turbidity impacts during construction. **Fish Migration** Temporary and localized impacts to fish migration during construction. No permanent impacts to fish migration.	**Habitat Loss**: This alternative avoids permanent and construction impacts to 6.8 acres of weathervane scallop habitat. Other impacts would be the same as Alternative 1.	Impacts the same as Alternative 2.

4.24.6 Cumulative Effects

The cumulative effects analysis area for fish includes the project footprint for each alternative, and the extended geographic area where direct and indirect effects to fish can be expected from project construction and operations. Past, present, and reasonably foreseeable future actions (RFFAs) in the cumulative impact study area have the potential to contribute cumulatively to impacts on fish and aquatic habitat. Section 4.1, Introduction to Environmental Consequences, details the past, present, and RFFAs considered for evaluation.

Past and Present Actions

Past and present actions that have, or are currently, affecting fish in the EIS analysis area include infrastructure development, marine transport, gas and mineral exploration, residential activities, and sport, subsistence, and commercial fishing. Most of EIS analysis area is undisturbed by human activity, with only a few small villages and roads. There are currently no major development projects under way. With the exception of fishing, these activities have, 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 has 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 (Irvine and Fukuwaka 2011). The 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—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 EIS analysis area. These would 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 (e.g., Donlin).

RFFAs that could contribute cumulatively to aquatic resource impacts, and are therefore considered in this analysis, 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.

The following RFFAs were identified in Section 4.1, Introduction to Environmental Consequences:

- Pebble Project buildout – develop 55 percent of the resource over an additional 78-year period
- Pebble South/PEB*
- Big Chunk South*
- Big Chunk North*
- Fog Lake*
- Groundhog*
- Cook Inlet Oil and Gas Development
- Alaska Liquefied Natural Gas (LNG)
- Alaska Stand Alone Pipeline Project
- Drift River Oil Facility Demobilization
- Lake and Pen Borough Transportation and Renewable Energy Initiatives
- Diamond Point Rock Quarry

*Indicates exploration activities only.

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; and degrading the extent of productive habitat conditions.

The Pebble mine expanded development scenario is the only mineral deposit RFFA considered for development, as explained in Section 4.1, Introduction to Environmental Consequences. All other mineral deposit RFFAs are considered for exploration only. The cumulative effects from the Pebble mine expanded development scenario are discussed below for each action alternative.

No Action Alternative

The No Action Alternative would not contribute to cumulative effects on fish.

Alternative 1 – Applicant's Proposed Alternative

Pebble Mine Expanded Development Scenario – The Pebble mine expanded development scenario is described in Section 4.1, Introduction to Environmental Consequences, Table 4.1-2, and illustrated in Figure 4.1-1. Expanded development and associated contributions to cumulative impacts would be the same for all alternatives at the mine site and the Iniskin Bay port; however, there would be differences among the alternatives in the transportation, pipelines, and natural gas compressor station footprints. This is because the additional expansion transportation/pipeline corridor under Alternative 1 would be located along the North Access Road, which would be used as the route for the additional diesel and concentrate pipelines associated with the expanded development. Under Alternative 1, the concentrate and diesel fuel pipelines to Iniskin Bay would have a larger footprint and would include an adjacent service road (because the North Access Road/pipeline corridor would not have been constructed). The Amakdedori port and transportation corridor to the mine would remain in operation, although with copper/gold concentrate truck traffic.

The primary potential future impacts to fish from the Pebble mine expansion would be direct loss of habitat; fish displacement and injury; habitat degradation; and changes in the natural flow regime. These impacts would be similar to those described previously in this section, but take place over a geographic area combining components of Alternatives 1 and 3. With the mine expansion, the duration of these impacts would be extended by an additional 58 years of mining and 20 years of additional milling.

At the mine site, an additional 35 miles of anadromous stream habitat would be lost in the SFK and UTC watersheds, including the entire footprint of Frying Pan Lake, which would inundated by the south collection pond, affecting sockeye, coho, chum, and potentially Chinook salmon. The additional acreage of disturbance at the mine site would be greater than Alternatives 1 and 2 combined, based on infrastructure build-out at the mine site. The expanded development 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 and waste streams to manage mine site impacts. In addition to direct habitat loss, the expanded mine site would also cause the same types of impacts, such as displacement, injury, or mortality, stream flow changes, and sedimentation that are described previously in this section.

The construction and operation of concentrate and diesel pipelines from the mine site to Iniskin Bay may require an undetermined number of additional stream crossings. The pipelines would follow the route of the north access road under Alternative 3. The new pipelines would involve disturbing an undisturbed area, and would require construction of an access road. Therefore, many more stream crossings would be necessary under Alternative 1, and the expanded development scenario compared to either of the other two alternatives. Also, the addition of a diesel fuel line would increase the likelihood of hydrocarbon spills along and at the terminals of the pipeline, potentially contributing to the cumulative impact of spills on aquatic resources.

The construction and operation of a deep-water 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 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).

The additional compressor station at Amakdedori port is not expected to affect fish or aquatic habitat.

Other Mineral Exploration Projects – 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, they would be seasonally sporadic, temporary, and localized, based on remoteness. Although exploration activities are considered to have minimal cumulative impacts to soil resources, there could be potential for greater surface water and substrate impacts from future development through transportation infrastructure co-use with the project.

Diamond Point Quarry – The footprint of the Diamond Point rock quarry overlaps with the Diamond Point port footprint under Alternatives 2 and 3. Cumulative impacts would be limited to a potential increase in localized aquatic resource impacts from commonly shared project footprints with the quarry site under Alternatives 2 and 3.

Oil and Gas Projects – Cook Inlet RFFAs, including Alaska Stand Alone Project, Alaska LNG, 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. Temporary effects from sedimentation during construction are likely, but expected to be minimal.

Community and Transportation Infrastructure Development – 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 highly localized, small in scale, and unlikely to have much impact on fish and 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. 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.

Alternative 2 – North Road and Ferry with Downstream Dams

At the mine site, the expanded development and associated contributions to cumulative impacts would be the same for all alternatives; however, there would be differences in the transportation, pipeline, and port facility components under Alternative 2.

Under Alternative 2, the additional compressor station would be located at the Diamond Point port instead of the Amakdedori port, and the concentrate and diesel fuel pipelines to Iniskin Bay would be added to the natural gas pipeline trench along the existing sections of the North Access Road. 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 1. The additional compressor station at the Diamond Point port is not expected to affect fish or aquatic habitat. The magnitude of impacts from this alternative would be the lower than Alternative 1, but higher than Alternative 3.

The duration of cumulative impacts would be extended by another 78 years, extending the intermittent impacts and increasing the likelihood of impacts from spills. The geographic extent of impacts would be localized.

Alternative 3 – North Road Only

At the mine site, the expanded development and associated contributions to cumulative impacts would be the same for all alternatives; however, there would be differences in the transportation, pipeline, and port facility components under Alternative 3.

Under Alternative 3, the additional compressor station would be located at the Diamond Point port instead of the Amakdedori port, and 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 expanded mine scenario would be less than the same scenario under Alternative 1 or Alternative 2.

The expanded development scenario project under Alternative 3 would not require any new stream crossings.

The additional compressor station at the Diamond Point port is not expected to affect fish or aquatic habitat.

The magnitude of impacts from this alternative would be the lower than either Alternative 1 or 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.

Other Mineral Exploration, Oil and Gas, and Community Development and Transportation infrastructure Projects – The contributions to cumulative impacts of these projects would be the same as those described under Alternative 1.

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