4.23 WILDLIFE VALUES

The following section provides a description of the potential environmental consequences from the project to non-federally listed birds, terrestrial wildlife, and marine mammals and their habitats. Impacts to federally listed wildlife species are discussed in Section 4.25, Threatened and Endangered Species. Direct and indirect impacts from the project may include the following:

- Behavioral disturbance, including:
  - Noise
  - Presence of humans, vehicles and equipment, vessels, and aircraft
- Injury and mortality, including:
  - Collision with vehicles and equipment, vessels, aircraft, facilities/structures (including disorientation from lighting)
  - Exposure to contamination from pit lake or other project attractants
  - Defense of life and property
  - Spills (see Section 4.27, Spill Risk)
- Habitat changes, including:
  - Habitat loss (including vegetation removal and fill of wetlands)
  - Avoidance of nearby habitat
  - Fragmentation
  - Spills (see Section 4.27, Spill Risk)
  - Fugitive dust impacts (see Section 4.14, Soils; Section 4.22, Wetlands and Other Waters/Special Aquatic Sites; Section 4.26, Vegetation; and Appendix K4.24, Fish Values)
  - Invasive species introduction or spread (see Section 4.26, Vegetation)
  - Changes in water quality and air quality (see Section 4.18, Water and Sediment Quality; and Section 4.20, Air Quality)

Potential direct and indirect impacts are assessed according to four distinct factors: magnitude, duration, extent, and likelihood of occurrence. For wildlife resources, the magnitude of impacts depends on the specific species' sensitivity to the disturbance or change, and the type of disturbance or change. The magnitude for direct impacts to species habitat is presented as the acreage of habitat impacts from the project (the combined acreage of the project footprint for all mine components). The duration of potential impacts is how long the impact persists, which may be for the life of the project or beyond, and may depend on the season in which the impact occurs. Habitat impacts from the project would be temporary and permanent. If habitat impacts would last for the life of the project, they were considered permanent. Temporary habitat impacts would occur throughout the life of the project, such as during the installation of the natural gas pipeline. The extent of impacts varies depending on the specific area of impact in relation to the species' range that may be affected. The Environmental Impact Statement (EIS) analysis area was designed to encompass the full extent of impacts that species may experience from the project while present in the EIS analysis area. The likelihood of impacts is the potential that the impact would occur to the species or habitat if the alternative or variant were to be constructed and operated. Generally, impacts were considered likely to occur, if the project were to be constructed.

Impacts to vegetation, wetlands, and waterbodies are not detailed herein, but described where appropriate as they relate to impacts to wildlife habitat. Impacts to vegetation communities are detailed in Section 4.26, Vegetation; and impacts to wetlands are detailed in Section 4.22, Wetlands and Other

Waters/Special Aquatic Sites. Some impacts to vegetation and wetlands that may indirectly impact wildlife species, such as impacts from fugitive dust and invasive species, are discussed below.

Additionally, several potential spill scenarios were evaluated for their impacts on biological resources. Spill risk was evaluated for the following substances: diesel fuel, natural gas, copper-gold ore concentrate, chemical reagents, bulk and pyritic tailings, and untreated contact water. The substances analyzed do not include all of the hazardous materials that would be used for the project. The substances selected were based on their spill potential and potential spill consequences. Potential impacts to wildlife resources (including the interrelated impacts to prey resources) from various spill scenarios are not discussed in this impact analysis, but are detailed in Section 4.27, Spill Risk.

Impacts to fish are not detailed herein, but described where appropriate as they relate to impacts to fish habitat. Impacts to fish and habitat are detailed in Section 4.24, Fish Values. These impacts to fish would directly impact wildlife species that rely on them.

4.23.1 Analysis Area

The EIS analysis area for wildlife includes the project footprint for each alternative and the extended geographic area where impacts to wildlife are considered for the life of the project. The analysis area generally encompassed the extent of potential project impacts apart from those related to spills, which are discussed in Section 4.27, Spill Risk. Potential impacts from various spill scenarios have a different analysis area that is detailed in Section 4.27, Spill Risk.

The EIS analysis area for wildlife varied depending on the species and project component due to differences in species biology and potential impacts from different project components. Table 4.23-1 details the analysis area per species group and project component. Various buffers that have been placed around the project components are defined as the radial distances of the outermost extent of the project component footprint, and encompass both permanent and temporary impacts. It is understood that large terrestrial wildlife and marine mammals have large home ranges. The analysis area is not meant to encompass the home range of all species. Rather, wildlife that occur in and transit through the analysis area may be exposed to a variety of impacts from the project, and then move beyond/outside of the analysis area. All project components and alternatives in the marine environment of Cook Inlet have the same analysis area.

Table 4.23-1: Analysis Area per Species/Group and Project Component

Species Group	Mine Site	Transportation and Natural Gas Pipeline Corridor	Port	Lightering Locations
Raptors	10-mile radius	3-mile radius	3-mile radius	1-mile radius
Waterbirds[1]	10-mile radius	1-mile radius	1-mile radius	1-mile radius
Landbirds and Shorebirds	10-mile radius	1-mile radius	1-mile radius	1-mile radius
Terrestrial Mammals	10-mile radius	3-mile radius	3-mile radius	None
Marine Mammals	None	The western portion of lower Cook Inlet south to Cape Douglas plus three shipping routes (6.4 nautical miles [7.4 miles] in width) from the mouth of lower Cook Inlet south and west out to the edge of the exclusive economic zone. For harbor seals in Iliamna Lake, a 1-mile buffer around the ferry and natural gas pipeline routes was selected as the analysis area.		

Note:

[1] Because waterbirds occur both in the terrestrial environment and the marine environment, the analysis area for waterbirds in Cook Inlet encompasses the same area as marine mammals: Kamishak Bay south to Cape Douglas.

For the mine site, a 10-mile-radius buffer was applied as the analysis area to encompass impacts such as noise from project activities (including blasting), light pollution, fugitive dust, loss and alteration of habitat, and other impacts. For the transportation and natural gas pipeline corridor and port, a 3-mile-radius buffer was applied for raptors and terrestrial mammals due to their large home ranges and potential impacts from noise, and loss of nesting, denning, migrating, and foraging locations. Waterbirds, landbirds, and shorebirds had a 1-mile-radius buffer in the transportation and natural gas pipeline corridor analysis area due to their smaller home range sizes.

All project components and alternatives in the marine environment of Cook Inlet and beyond have the same analysis area. The analysis area includes all activities associated with pipeline construction, operation, maintenance/repair, and monitoring, as well as potential project-related vessel and aircraft routes. Specifically for marine mammals, the analysis area includes marine waters crossed by concentrate bulk carriers traveling from Cook Inlet through Shelikof Strait and the Aleutian Islands, and marine line haul barges from Cook Inlet to West Coast ports traveling either through the Pacific Ocean, or near the coast through the Gulf of Alaska and southeast Alaska. The shipping lanes are approximately 6.4 nautical miles wide (7.4 miles), and include the area of ensonification from vessels during all project activities. The shipping lanes are defined in PLP 2020-RFI-163 and buffered to include an area of ensonification. The analysis area for non-Threatened and Endangered Species (TES) of marine mammal is the same for TES of marine mammal; specific details for how the analysis area in the marine environment was determined are provided in Section 4.25, Threatened and Endangered Species. The analysis area for waterbirds in Cook Inlet encompasses the same area as marine mammals: Kamishak Bay south to Cape Douglas.

The analysis area in Cook Inlet includes a vessel corridor from Nikiski south to Kamishak Bay, and most of the western portion of lower Cook Inlet. The analysis area encompasses Kamishak Bay and includes all marine components during all phases of the project (construction, operations, and closure). This includes installation of the natural gas pipeline, projected flight paths in and out of the airstrip at Amakdedori, and project-related vessel traffic between the port and lightering locations. The analysis area excludes eastern lower Cook Inlet, where there are well-established shipping lanes for non-project-related vessel traffic (Nuka and Pearson 2015). The analysis area does not change regardless of the alternative or variants considered, and encompasses the extent of potential project-related impacts that are reasonably expected to occur. Many wildlife species have a much larger range than the analysis area; however, this section focuses on species that have the potential to be present in the area during project construction, operations, and closure.

The analysis area for wildlife species varies slightly depending on the geographic extent of the alternative variants considered. That is, the radius buffer area was expanded slightly to accommodate each variant, thereby increasing the analysis area. A figure of the variants is provided in Chapter 2, Alternatives, and the variants are shown on figures in Section 3.23, Wildlife Values. There are no variants considered for Alternative 1a. For Alternative 1, there are three variants (Summer-Only Ferry Operations Variant, Kokhanok East Ferry Terminal Variant, and Pile-Supported Dock Variant); for Alternative 2—North Road and Ferry with Downstream Dams, there are three variants (Summer-Only Ferry Operations Variant, Newhalen River North Crossing Variant, and Pile-Supported Dock Variant); and for Alternative 3 —North Road Only, there is one variant (Concentrate Pipeline Variant). Potential direct and indirect impacts to wildlife species from the specific variants are discussed at the end of each alternative section. Impacts to all wildlife species from each variant are discussed collectively, and not subdivided based on species grouping (birds, terrestrial wildlife, and marine mammals), because many of the impacts from the variants would be similar across species groups.

Scoping comments were received related to potential impacts to wildlife (including terrestrial and marine mammals), and on potential impacts to migratory birds and waterfowl populations; abundance, diversity, migratory patterns, and potential for displacement; and attraction of birds to tailing ponds. Specific comments related to bears included concerns for human safety from bears that move between Amakdedori port and McNeil River State Game Refuge and Sanctuary; that the road and Amakdedori port and the mine access roads could change brown bear (*Ursus arctos*) migration and result in brown bear habitat fragmentation and mortalities; and bears could become food conditioned, resulting in bear mortality. Regarding marine mammals, comments expressed concerns that the ferry could strike harbor seals (*Phoca vitulina*) in Iliamna Lake; the EIS should incorporate traditional knowledge on harbor seals in the lake; and that the transportation of mining materials across Cook Inlet and Iliamna Lake could affect local marine mammals due to increased underwater noise. Specific concerns regarding birds were that birds could be exposed to contaminants in tailing ponds, and that bald eagles (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*) would be impacted by the project, along with seabird colonies in Kamishak Bay. Caribou (*Rangifer tarandus*) were also a concern for commenters; specifically, traditional calving grounds for the Mulchatna caribou herd, which are in the analysis area. Comments also expressed concern that exploration activities at the site have caused caribou to avoid the area.

4.23.2 Summary of Key Issues

Table 4.23-2 summarizes the key issues for wildlife resources from each alternative and their variants. The direct loss of habitat acreages from all project components is provided in Table 2-2 of Chapter 2, Alternatives, and summarized at the end of the table below. Impacts to marine mammals and waterbirds would be similar to those detailed for federally listed marine mammals and birds described in Section 4.25, Threatened and Endangered Species.

Table 4.23-2: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Mine Site				
Behavioral changes	Avoidance of the mine site by terrestrial wildlife and bird species during construction, operations, and closure. Some species may return to formerly used and newly created habitats during and after various components have been reclaimed. There would be no behavioral changes from any of the variants at the mine site. This impact does not apply to marine mammal species because they do not occur in the mine site.			
Injury and mortality	During construction, operations, and closure, direct mortality to some terrestrial wildlife and bird species may occur through vegetation clearing and collisions with vehicles, equipment, and structures. Potential exists for bears to be killed in defense of life and property. Additional mortality may occur due to altered predator and prey relationships. There would be no additional injury or mortality from any of the variants at the mine site. This impact does not apply to marine mammal species because they do not occur in the mine site.			
Habitat changes	Direct loss of 8,390 acres of habitat. Indirect loss of additional habitat surrounding the mine site. project-related noise, lighting, fugitive dust (estimated as a	Loss of 8,390 acres of habitat. *Summer-Only Ferry Operations Variant* would result in loss of 8,424 acres. *Kokhanok East Ferry Terminal Variant* and *Pile-Supported Dock*	Loss of 8,497 acres of habitat. *Summer-Only Ferry Operations Variant* would result in loss of 8,530 acres. *Newhalen River North Crossing Variant* and *Pile-Supported Dock*	Loss of 8,390 acres of habitat. *Concentrate Pipeline Variant* would result in loss of 8,392 acres. Indirect loss of additional habitat surrounding the mine site due to behavioral

Table 4.23-2: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	330-foot buffer around the mine site), etc.	*Variant* would not result in additional changes at the mine site. Indirect loss of additional habitat surrounding the mine site due to behavioral avoidance from project-related noise, lighting, fugitive dust (estimated as a 330-foot buffer around the mine site), etc.	*Variant* would not result in additional changes at the mine site. Indirect loss of additional habitat surrounding the mine site due to behavioral avoidance from project-related noise, lighting, fugitive dust (estimated as a 330-foot buffer around the mine site), etc.	avoidance from project-related noise, lighting, fugitive dust (estimated as a 330-foot buffer around the mine site), etc.
Transportation Corridor				
Behavioral changes	Traffic volumes, at 35 round-trip truck trips per 24-hour day (approximately one vehicle passing in one direction every 21 minutes if evenly spaced running 24 hours) would be anticipated to disturb wildlife while vehicles are passing. Vehicles may travel in groups, therefore, intervals between vehicles may be greater. There would be additional light vehicle traffic (i.e., vehicles other than large trucks transporting concentrate, fuel, and consumables) along the transportation corridor, which would add an unknown number of additional daily vehicle trips. Terrestrial wildlife would avoid the project components due to increased noise, vehicle, fugitive dust, and human presence. In particular, brown bears may den farther away from the transportation corridor, especially the port access road.	Similar to Alternative 1a with a slightly longer road. Physical presence of vessels over 18 miles of travel, and aircraft, may displace harbor seals that inhabit Iliamna Lake. *Summer-Only Ferry Operations Variant* would result in traffic volumes at 70 round-trip truck trips per 24-hour day (one vehicle every 10 minutes) plus an unknown amount of additional light vehicle traffic. *Kokhanok East Ferry Terminal Variant* would not result in additional behavioral changes; however, due to the difference in geographical area covered by this variant, behavioral changes would be shifted north around Kokhanok. Physical presence of vessels over 27 miles of travel, and aircraft, may displace harbor seals that inhabit Iliamna Lake.	Similar to Alternative 1a but with a shorter road. Physical presence of vessels over 29 miles of travel, and aircraft, may displace harbor seals that inhabit Iliamna Lake. *Summer-Only Ferry Operations Variant* would result in traffic volumes at 70 round-trip truck trips per 24-hour day (one vehicle every 10 minutes). *Newhalen River North Crossing Variant* would not result in additional behavioral changes, although any impacts to wildlife would be shifted slightly north.	Similar to Alternative 1a, but no impacts to Iliamna Lake seals due to lack of ferry in Iliamna Lake but a longer road. *Concentration Pipeline Variant* would result in a reduction of truck trips to 18 per 24-hour day, which equates to one vehicle per 40 minutes, plus an unknown amount of additional light vehicle traffic.

Table 4.23-2: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Physical presence of vessels has the potential to cause disturbances to mother and pup pairs of harbor seals which can lead to pup abandonment and death of the pup. Physical presence of vessels over 28 miles of travel, and aircraft, may displace harbor seals that inhabit Iliamna Lake.			
Injury and mortality	Underwater noise from vessels may exceed disturbance thresholds as defined by regulatory agencies.			
	Potential for terrestrial wildlife collisions with vehicles across 74 miles of road. Potential for harbor seals that inhabit Iliamna Lake to collide with vessels during construction and operation over 28 miles of travel across Iliamna Lake.	Potential for terrestrial wildlife collisions with vehicles across 77 miles of road. Potential for harbor seals that inhabit Iliamna Lake to collide with vessels during construction and operations over 18 miles of travel across Iliamna Lake. *Summer-Only Ferry Operations Variant* may increase collisions for wildlife species (such as brown bears) because traffic would be doubled, but may reduce injury and mortality for species such as moose, which are easier to see during the summer (because there would be no truck traffic in winter). Either one large ferry making two round-trips; or two ferries making one round-trip per day. *Kokhanok East Ferry Terminal Variant* would reduce total length of road to 70 miles, and therefore reduce the potential for collisions. However, it would increase the length of	Potential for terrestrial wildlife collisions with vehicles across 54 miles of road. Potential for harbor seals that inhabit Iliamna Lake to collide with vessels during construction and operations over 29 miles of travel across Iliamna Lake. *Summer-Only Ferry Operations Variant* may increase collisions for wildlife species (such as brown bears) because traffic would be doubled, but may reduce injury and mortality for species such as moose, which are easier to see during the summer (because there would be no truck traffic in winter). There would be no change in the ferry route; however, there would be either one large ferry making two round-trips per day on average; or two ferries making one round-trip each per day. This may increase the potential for harbor seal impacts during summer months.	Potential terrestrial wildlife collisions with vehicles across 83 miles of road. There would be no impact to harbor seals that inhabit Iliamna Lake due to lack of a ferry. *Concentrate Pipeline Variant* would reduce the number of truck-trips, and therefore reduce the potential for injury and mortality for all terrestrial species.

Table 4.23-2: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
		the ferry crossing to 27 miles, and would be closer to harbor seal locations in Iliamna Lake.	There would be no impact to harbor seals from an ice-breaking ferry during the winter because it would not operate during the winter. *Newhalen River North Crossing Variant* would not result in additional injury and mortality.	
Habitat changes	Loss of 1,193 acres (inclusive of 380 acres from material sites and 30 acres from the ferry terminals) of terrestrial wildlife and bird habitat. Additional terrestrial wildlife avoidance of surrounding habitat. Small amount of habitat loss along the shore of Iliamna Lake from ferry terminals for harbor seals. Potential impacts to prey species as a result of turbidity from construction and routine operations of the ferry terminals.	Loss of 1,171 acres (inclusive of 251 acres from material sites and 27 acres from the ferry terminals) of terrestrial wildlife and bird habitat. Additional terrestrial wildlife avoidance of surrounding habitat. Small amount of habitat loss along the shore of Iliamna Lake from ferry terminals for harbor seals. Potential impacts to prey species as a result of turbidity from construction and routine operations of the ferry terminals. *Summer-Only Ferry Operations Variant* and *Pile-Supported Dock Variant* would not change the amount of habitat impacted. *Kokhanok East Ferry Terminal Variant* would result in 1,205 acres (inclusive of 358 acres from material sites and 19 acres from the ferry terminals) of habitat loss.	Loss of 912 acres (inclusive of 321 acres from material sites and 25 acres from the ferry terminals) of terrestrial wildlife and bird habitat. Additional terrestrial wildlife avoidance of surrounding habitat. Small amount of habitat loss along the shore of Iliamna Lake from ferry terminals for harbor seals. Potential impacts to prey species as a result of turbidity from construction and routine operations of the ferry terminals. *Summer-Only Ferry Operations Variant* would increase habitat loss to 934 acres (inclusive of 321 acres from material sites and 25 acres from ferry terminals). *Pile-Supported Dock Variant* would not change the amount of habitat impacted. *Newhalen River North Crossing Variant* would result in 932 acres of impacts (inclusive of 338 acres from material sites and 25 acres from ferry terminals).	Loss of 1,641 acres (inclusive of 604 acres from material sites) of terrestrial wildlife and bird habitat. Additional terrestrial wildlife avoidance of surrounding habitat. *Concentrate Pipeline Variant* would result in additional habitat loss from increasing width of the access road by 3 feet.

Table 4.23-2: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Port				
Behavioral changes	Terrestrial wildlife avoidance of area. Underwater noise from construction, operations, and closure may exceed disturbance thresholds for marine mammals as defined by the USFWS and NMFS. Physical presence of vessels and aircraft (mainly during construction) may displace marine species, including disturbances to harbor seal mother and pup pairs.	Same as Alternative 1a. *Pile-Supported Dock Variant* would not result in additional behavioral changes.	Same as Alternative 1a. Maintenance dredging of the navigation channel would cause disturbance to nearby marine mammals during dredging activities. *Pile-Supported Dock Variant* would not result in additional behavioral changes.	Same as Alternative 1a. Maintenance dredging of the navigation channel would cause disturbance to nearby marine mammals during dredging activities. *Concentrate Pipeline Variant* would not result in additional behavioral changes.
Injury and mortality	Potential for terrestrial wildlife to be killed in defense of life and property at the port. Potential for bird species to collide with port infrastructure (including the lighted navigation buoys and the communications tower), and vessels. Potential for vessels to collide with marine mammals. Potential for disturbance to harbor seal mother and pup pairs, which can lead to pup abandonment and death of the pup.	Similar to Alternative 1a. The underwater noise from construction (sheet pile-driving) may exceed injury thresholds for marine mammals as defined by the USFWS and NMFS. *Pile-Supported Dock Variant* construction would have a potential to result in injury and mortality to marine mammals.	Similar to Alternative 1a, except there would be no lighted navigation buoys at Diamond Point port, and therefore no collision hazard. The underwater noise from construction (sheet pile-driving) may exceed injury thresholds for marine mammals as defined by the USFWS and NMFS. *Pile-Supported Dock Variant* construction would have a potential to result in injury and mortality to marine mammals.	Similar to Alternative 1a, except there would be no lighted navigation buoys thereby reducing the collision hazard for birds. *Concentrate Pipeline Variant* would not result in changes to injury and mortality.
Habitat changes	Loss of 22 acres of terrestrial wildlife habitat (including the port facilities and airstrip) and 2 acres of benthic marine habitat.	Loss of 22 acres of terrestrial wildlife habitat (port facilities and airstrip) and 11 acres of benthic marine habitat. *Summer-Only Ferry Operations Variant* would result in 49 acres of habitat loss to the terrestrial environment	Loss of 41 acres of terrestrial wildlife habitat and 70 acres of benthic marine foraging habitat. Maintenance dredging approximately every 5 years of the navigation channel would cause habitat disturbance. *Summer-Only Ferry Operations Variant*	Loss of 32 acres of terrestrial wildlife habitat and 79 acres of benthic marine foraging habitat. Maintenance dredging approximately every 5 years of the navigation channel would cause habitat disturbance. *Concentrate Pipeline*

Table 4.23-2: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
		and 11 acres of benthic marine habitat. *Kokhanok East Ferry Terminal Variant* would not cause any habitat changes. *Pile-Supported Dock Variant* would result in less than 0.1 acre of benthic marine habitat loss in addition to the 22 acres of terrestrial wildlife habitat loss.	would not cause any habitat changes. *Pile-Supported Dock Variant* would result in 102 acres of impact.	*Variant* would result <1 acre larger port footprint.
Lightering Locations and Lighted Navigation Buoys				
Behavioral changes	Avoidance of lightering locations and the immediate vicinity while vessels are moored and loading concentrate. There would be no changes from any of the variants.			*Concentrate Pipeline Variant* would be similar to the other Alternatives, except there would be fewer lightering barge trips, and therefore a reduced potential for behavioral changes.
Injury and mortality	Potential for entanglement with anchor mooring buoy cables at lightering locations. Potential for injury or mortality during all project phases while vessels transit to and from the lightering locations. During operations, 27 concentrate vessel shipments would depart the lightering locations annually. Each concentrate vessel would be moored for 4 to 5 days and require 10 lightering trips to fill each concentrate vessel. An additional 33 supply barges (inclusive of 4 fuel barges) would be required annually to supply consumables, fuel, reagent, etc. This equates to 330 annual project-related vessel trips in the analysis area. There would also be oceanic tugboats to pull the supply barges and port-based tugboats to assist the bulk carrier with mooring and to move the lightering barges. There would be no changes from any of the variants.			Potential for entanglement with anchor mooring buoy cables at the lightering location in Iniskin Bay. The likelihood of entanglement would be less compared to other alternatives due to one less lightering location. Potential for injury or mortality during all project phases while vessels transit to and from the lightering location in Iniskin Bay. The same number of concentrate vessels, supply barges, lightering trips, and tugboats as the other alternatives. *Concentrate Pipeline Variant* Each concentrate vessel requires between 5 and 6 lightering trips to fill each concentrate vessel. An additional 33 supply barges (inclusive

Table 4.23-2: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
				of 4 fuel barges) would be required annually to supply consumables, fuel, reagent, etc. This equates to approximately 222 annual project-related vessel trips during operations in the analysis area, which is a reduction compared to the other alternatives.
Habitat changes	Loss of 0.15 acre of benthic marine habitat from the two lightering location mooring buoy anchors and minor loss of habitat from lighted navigation buoy anchors. There would be no changes from any of the variants.			Loss of 0.07 acre of benthic marine habitat from the single lightering location mooring buoy anchors. No lighted navigation buoys are necessary for the Diamond Point port. There would be no changes from the variant.
Natural Gas Pipeline and Fiber-Optic Cable				
Behavioral changes	Avoidance of 193 miles during construction for wildlife species. Physical presence of vessels and aircraft may displace marine species.	Similar to Alternative 1a with avoidance of 187 miles during construction for wildlife species. *Summer-Only Ferry Operations* and *Pile-Supported Dock Variants* would not result in additional behavioral changes. *Kokhanok East Ferry Terminal Variant* would be 185 miles long.	Similar to Alternative 1a with avoidance of 164 miles during construction for wildlife species. *Summer-Only Ferry Operations*, *Newhalen River North Crossing Variant*, and *Pile-Supported Dock Variants* would not result in additional behavioral changes.	Similar to Alternative 1a with avoidance of 164 miles during construction for wildlife species. *Concentrate Pipeline Variant* would not result in additional behavioral changes.
Injury and mortality	Potential for wildlife to collide with vessels and equipment during construction and pipeline installation. During construction, underwater noise levels (which would vary with different dredging technologies) may exceed the disturbance thresholds as defined by USFWS and NMFS.	Same as Alternative 1a with the same pipeline and fiber-optic cable installation techniques. *Summer-Only Ferry Operations*, *Kokhanok East Ferry Terminal*, and *Pile-Supported Dock Variants* would not result in additional injury and mortality.	Similar to Alternative 1a, but to a lesser extent because the pipeline and fiber-optic cable are shorter. *Summer-Only Ferry Operations*, *Newhalen River North Crossing Variant*, and *Pile-Supported Dock Variants* would not result in additional injury and mortality.	Same as Alternative 2. *Concentrate Pipeline Variant* would not result in additional injury and mortality.

Table 4.23-2: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Habitat changes	Loss of 3 acres of permanent habitat (from compressor station and Iliamna Lake crossing) plus temporary impacts during pipeline trenching.	Loss of 7 acres of permanent habitat (from compressor station and Iliamna Lake crossing) plus temporary impacts during pipeline trenching. *Summer-Only Ferry Operations* and *Pile-Supported Dock Variants* would not result in additional habitat changes. *Kokhanok East Ferry Terminal Variant* would have a slightly different pipeline alignment, but acreage of impacts would be similar.	Loss of 308 acres of permanent habitat (from compressor station and material sites) plus temporary impacts during pipeline trenching. *Summer-Only Ferry Operations*, *Newhalen River North Crossing Variant*, and *Pile-Supported Dock Variants* would not result in additional habitat changes.	Loss of 13 acres of permanent habitat (from compressor station and material sites) plus temporary impacts during pipeline trenching. *Concentrate Pipeline Variant* would not result in additional habitat loss.
Total Direct Impacts				
Total Direct Impact Footprint	***Alternative 1a*** 9,611 acres	***Alternative 1*** 9,600 acres ***Alternative 1—Kokhanok East Variant*** 9,635 acres ***Alternative 1—Summer-Only Ferry Operations Variant*** 9,661 acres ***Alternative 1—Pile-Supported Dock Variant*** 9,589 acres	***Alternative 2*** 9,763 acres ***Newhalen River North Crossing Variant*** 9,783 acres ***Alternative 2—Summer-Only Operations Variant*** 9,819 acres ***Alternative 2—Pile-Supported Dock Variant*** 9,753 acres	***Alternative 3*** 10,130 acres ***Alternative 3—Concentrate Pipeline Variant*** 10,132 acres

Notes:

NMFS = National Marine Fisheries Service
USFWS = US Fish and Wildlife Service

4.23.2.1 Mitigation

Potential project impacts were evaluated based on Pebble Limited Partnership (PLP)'s committed measures, which are detailed in Chapter 5, Mitigation, in Table 5-2. Mitigation measures related to wildlife include the following:

General Wildlife Measures:

- A Wildlife Interaction Plan (WIP) would be developed and implemented to minimize human-wildlife interactions and resolve any potential conflicts. The goal of the plan would be to prevent problems resulting from human-wildlife interactions to a manageable and acceptable level, and to ensure that wildlife can continue to thrive in the project area. This plan would be managed through an adaptive management approach. Wildlife report sightings and interactions reported would be used to assess the effectiveness of mitigation measures, or guide project personnel in the establishment of additional mitigation measures as required. This plan would describe education and training for project personnel and contractors, control measures to avoid and minimize human-wildlife interactions deterrence and hazing procedures for reporting wildlife sightings and interactions, and an adaptive management approach. Measures from RFI 122 would be incorporated into the project's WIP (PLP 2019-RFI 122).

  Amakdedori Port Wildlife Safety (specific to Alternative 1a and Alternative 1):

  - The port facility would be fenced-in using chain-link fences and possibly electrical fences. The road entrance would have a gate, and the fence would extend onto the causeway as needed to limit access from the intertidal zone.

  Transportation Corridor Wildlife Safety:

  - Wildlife present on the road would be given the right-of-way. Traffic would stop, if necessary, to allow the safe passage of wildlife (e.g., a bear or moose crossing, or walking along, the road).
  - The maximum speed limit for the road system would be set at 35 miles per hour (mph). Speed limits would be reduced as required in areas of high seasonal wildlife use and at known crossing points. Vehicle speeds would be posted along the road, and all drivers would be monitored using mobile global positioning system (GPS) fleet tracking technology to ensure compliance.
  - As practical, snowbank height during the winter would be minimized to increase driver visibility.
  - Any wildlife injuries or mortalities would be immediately reported as appropriate. The carcasses of any road-killed animals would be removed and disposed of in a timely manner so that they do not serve as an attractant to bears or other wildlife. PLP would coordinate with the Alaska Department of Fish and Game (ADF&G) on the salvage of fresh, useable game species for community food.

  Food and Garbage Management:

  - Feeding and attracting of wildlife by project personnel would be prohibited.
  - Food would be kept inside buildings and only permitted inside vehicles for short periods, when workers are unable to use the dining facilities. Food and garbage would be disposed of in dedicated trash containers at each site, and routinely emptied to limit buildup of odors that could attract wildlife.
  - Trash containers inside fenced areas would be located away from the fence line to minimize wildlife attraction.

  - Any food wastes that could attract wildlife would be temporarily stored in enclosed containers, and periodically backhauled to the mine site for incineration and disposal.

- Employees and contractors would be instructed on relevant rules and regulations that protect wildlife. See the US Fish and Wildlife Service (USFWS) webpage on regulations and policies (https://www.fws.gov/birds/policies-and-regulations.php).
- Specific wildlife awareness training would be required for drivers operating in the area.
- Winter management of snow berms along roadways would include periodic breaks or cleared areas in snow berms to allow wildlife to get off the road during the approach of oncoming vehicles.
- PLP would evaluate the use of wildlife detection systems at identified high-traffic animal crossings. Animal detection systems use sensors to detect large animals that approach the road. Once a large animal is detected, warning signals are activated to inform the drivers that a large animal may be on or near the road at that time.
- PLP prepared an Invasive Species Management Plan (ISMP) (PLP 2019-RFI 133). PLP would implement the ISMP through training and communicating with project personnel and contractors throughout the life of the project, including during planning, construction, operations, reclamation, and closure. The goal of the ISMP is to prevent, minimize, and control the spread of invasive species. It includes training requirements, development of a Hazard Analysis and Critical Control Point plan prior to construction, prevention measures, early detection and rapid response, and control treatment options.
- A conceptual Fugitive Dust Control Plan (FDCP) has been prepared to identify project design features and best management practices (BMPs) that would be implemented to minimize fugitive dust emissions (PLP 2019-RFI 134).
- The project would have a no hunting, fishing, or gathering policy for non-local employees.
- To detect changes to water quality and its effects to fish and wildlife, water quality would continue to be monitored on a regular basis until the mine reclamation is complete. Results would be reported to the State of Alaska in compliance with permit requirements and management plans.
- The project would provide for controlled use of the road corridor and ferry for local residents, improving the supply of goods and reducing the cost of importing goods. Controlled use could include scheduled convoys for the transport of private vehicles and supplies, qualification and limited-use authorization of third-party vehicles and drivers using the access infrastructure, or other similar arrangements.

Measures Specific to Brown Bears:

- A detailed bear interaction plan designed to minimize conflicts between bear and humans would be incorporated into the WIP. PLP would coordinate with ADF&G on development of this plan.
- Bear-proof containers and bear-proof trash receptacles would be used for food and garbage. Food would only be left inside vehicles or other unsecured locations when staff are present and can remove the food source in response to wildlife attracted to the food source.
- PLP would consult with ADF&G on additional wildlife surveys that may be required prior to construction. Bear denning surveys would be updated prior to construction.
- Encounters with an occupied brown bear den that has not previously been identified by ADF&G would be reported to the Division of Wildlife Conservation, ADF&G, within 24 hours. Mobile activities would avoid such discovered occupied dens by 0.5 mile unless

alternative mitigation measures are approved with concurrence from ADF&G. Non-mobile facilities would not be required to relocate. Before commencement of any activities, PLP would consult with ADF&G to identify locations of brown bear den sites. Additional surveys may be required pre- and post-construction to determine denning areas and changes in denning use due to project impacts.

- Mandatory training would be required for mine workers on ethical behavior around brown bear populations (e.g., strict use of bear-safe trash cans; strict prohibition of bear feeding and harassing).

Measures Specific to Aircraft and Helicopter Use:

- PLP would employ protocols to ensure that helicopters and fixed-wing planes do not harass wildlife. These protocols, listed below, would remain in place throughout construction and the life of the mine.
    - Do not harass or pursue wildlife.
    - Fly 500 feet above ground level, or higher when possible and safe to do so.
    - When wildlife (especially bears, caribou, moose, wolves, raptor nests, flocks of waterfowl, seabirds, or marine mammals) are observed, avoid flying directly overhead and maximize lateral distance.
    - Appropriate flight restrictions (e.g., elevation restrictions) would be established to reduce caribou hunting impacts.

Measures Specific to Avian Species:

- BMPs and design guidelines would incorporate avian protection for all powerlines.
- PLP would follow BMPs with respect to powerline design and placement to minimize the potential for bird collisions. This could include the use of flight diverters and other deterrent devices.
- The 100- to 150-foot-tall monopole communications tower at the port would be marked with high-visibility paint bands and may include flashing red lights at the top (if required), in accordance with Federal Aviation Administration (FAA) and USFWS guidance.
- PLP would follow USFWS Land Clearing Timing Guidance for Alaska to avoid destruction of active bird nests.
    - https://www.fws.gov/alaska/pages/nesting-birds-timing-recommendations-avoid-land-disturbance-vegetation-clearing

Measures Specific to Marine Mammals:

- All project-related vessel traffic would be restricted to 10 knots or less when west of the vertical line 153°15′0″ W (Kamishak Bay) to minimize the potential for impacts with marine wildlife.
- Additional measures would be developed through the consultation process with the USFWS and the National Marine Fisheries Service (NMFS) (for threatened and endangered species), which would also benefit non-listed wildlife species, especially marine mammals. The measures detailed in the draft biological assessments for USFWS and NMFS are included in Appendix G and Appendix H, respectively. The measures in the draft biological assessments are not final until the conclusion of the consultation process, and additional reasonable and prudent measures may be added.
- Additional measures would be developed during the application process for marine mammals protected by the Marine Mammal Protection Act (MMPA).

4.23.3 No Action Alternative

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

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

4.23.4 Alternative 1a

4.23.4.1 Birds

The project has the potential to directly and indirectly impact breeding, wintering, migrating, and staging bird populations through behavioral disturbance, injury and mortality, and habitat changes as detailed in the following sections. The magnitude, duration, extent, and likelihood of impacts to raptors, waterbirds, landbirds, and shorebirds would be anticipated to differ among individual species; however, impacts are discussed collectively herein for the majority of avian groups. Additionally, potential impacts at the mine site, transportation and natural gas pipeline corridors, and the Amakdedori port are discussed collectively under each project component. In terms of likelihood, impacts as described in the following sections would be expected to occur if the project is permitted and constructed.

<u>Behavioral Disturbance</u>

Noise

All project phases and components would result in elevated noise levels (above current ambient levels of 35 A-weighted decibels [dBA] day-night average sound levels) from a variety of sources (e.g., blasting activities in the open pit, aircraft, vehicles, construction equipment, barges and other oceanic vessels, operations-related noise), and would occur in varying levels throughout the life of the project. In terms of magnitude and extent, noise levels would be increased above present levels (detailed in Section 4.19, Noise) during all phases of the project because there are currently no recurrent anthropogenic noise sources in the mine site. Blasting would occur on a regular basis during construction as needed at several material sites to construct the access roads and other infrastructure, and during operations in the mine pit (as outlined in Chapter 2, Alternatives). A detailed analysis of the impacts of noise on birds is provided in the following paragraphs.

Birds may experience a wide range of impacts from noise sources in the mine site, transportation corridor, at the ferry terminals, at the port, and the natural gas compressor station on the Kenai Peninsula. In terms of duration, some of the noise sources would occur over the short-term, (such as noise from construction of the mine facilities, installation of the natural gas pipeline, blasting in the road bed and material sites, and aircraft noise at Amakdedori port, among others), while others would occur during operations (blasting in the pit), and some for the life of the project (vehicle/ equipment [such as the compressor station on the Kenai Peninsula]/vessel noise).

A wide range of avian studies has been conducted to assess the impacts of various noise sources on different bird species. Loud noises from short-term events (e.g., blasting) are known to startle nearby birds and may cause them to leave the area, and can also lead to nest abandonment. Bird use of otherwise suitable habitat may be reduced due to sensitivity to noise. The degree of disturbance would vary among individuals, species, and time of year. Noise can change the composition of avian communities in favor of more noise-tolerant species, thereby reducing nesting species richness (number of species), although not necessarily density. Predatory birds may avoid noisy areas because it could mask their calls or make it more difficult to locate prey, thereby causing nests in noisier areas to be safer from predators (Francis et al. 2009). Birds migrating through the area may avoid the project vicinity during noisy periods rather than stopping over during migration. In terms of magnitude, noise may impact birds through changes in behavior (such as altered nesting and foraging locations and patterns), ability to communicate with conspecifics, ability to detect and recognize predators, decreased hearing sensitivity (both temporarily and permanently), increased stress that may lead to altered reproductive success, and potential interference with breeding individuals and populations (Dooling and Popper 2007). Some bird species are sensitive, at least during the breeding season, to noise levels; and the extent of impacts from disturbance can vary from several feet to more than 2 miles (Kaseloo and Tyson 2004).

Birds have a wide range of hearing capabilities, which varies by species. In general, optimal hearing range is between 1 and 5 kilohertz (kHz), with most sensitive hearing at frequencies of 2 to 4 kHz. In comparison, the optimal range for humans is from 20 Hertz (Hz) to 20 kHz, a much broader range than most birds, and is most sensitive at 0.5 to 4.0 kHz (Dooling and Popper 2007). Permanent physical damage to a bird's ability to hear can occur over time, or from short blasts of loud sounds that exceed 140 dBA for single blasts or 125 dBA for multiple blasts, or from continuous (greater than 72 hours) noise at levels above 110 dBA (Dooling and Popper 2007). A temporary threshold shift in hearing can last from seconds to days depending on the intensity and duration of the noise, with the shift occurring from approximately 93 dBA to 110 dBA for continuous noise. Therefore, understanding the level of noise produced by various project components is necessary to determine buffer thresholds to avoid physical damage to birds' hearing. The magnitude and extent of noise from blasting would be an estimated 109 dBA maximum equivalent sound level (L_{max}) at 50 feet. Therefore, single, non-continuous blasts would not be expected to result in permanent hearing loss for birds within 50 feet.

Noise may also cause chronic stress, which can alter hormone levels and lead to weight loss, decreased disease resistance, and reduced reproductive success (Ortega 2012). Increased noise above ambient levels can reduce the time spent foraging near noise sources, as well as make it more difficult for birds to detect predators or find food sources (e.g., some raptor species that rely on hearing to detect prey). Birds may experience increased difficulty advertising and attracting a mate due to increased noise, and some have been shown to alter their vocalizations to compensate for masking. These include changes in song or call frequency, amplitude, song components, and even temporal shifts to avoid noisy periods (Ortega 2012).

Because it is difficult to determine the potential responses of each avian species to the range of noise levels potentially produced by the project, a conservative noise disturbance and impact threshold was established to be 60 dBA and above (Dooling and Popper 2007; Shannon et al. 2016). This level was determined based on noise levels above which sound masking could be caused. Therefore, noise levels above 60 dBA could produce behavioral disturbance to birds. Noise levels to the 60 dBA range were calculated for a variety of noise-producing project components, and the following distances were estimated as detailed in Table 4.23-3. The calculations that derived these distance estimates, and the list of assumptions to produce the estimates, are described in *Pebble Project-Noise Concepts and Methodology* (AECOM 2018c), and further detailed in Section 4.19, Noise.

Table 4.23-3: Distances to 60 dBA at Project Components during Project Phases

Project Component	Project Phase	Distance to 60 dBA L_{eq} (feet)[1]	Distance to 60 dBA L_{max} (feet)[1]
Mine Site	Construction	2,900	5,450
	Operations	3,350	6,500
Material Sites[2]	Construction	185	1,300
Access Road	Construction	740	1,130
	Operations	25	38
Ferry Terminals and Port	Operations of Ferry Terminal	140	140
	Operations of Port	890	1,410

Notes:

[1] The L_{eq} value for any given project phase is the energy sum for the individual L_{eq} values (for all equipment), all the calculated sound sources, all added together for the aggregate level. For the L_{max} level, the acoustical usage factor (percent time that a piece of equipment is operating at its full power) for all equipment was set to 100 percent, and therefore assumed that everything was operating at full power. In most cases, the noise source with the greatest L_{max} level (typically blasting) would dominate the combined L_{max}; but if several sources have the same or similar L_{max} values, the aggregate L_{max} could be higher than any individual source.

[2] The projected noise levels at material sites is based on roadway construction blasting with a reference level of 94 dBA L_{max} at 50 feet.

dBA = A-weighted decibel
L_{eq} = sound level equivalent
L_{max} = maximum equivalent sound level

In terms of the magnitude and extent of noise exposure to birds, normal operations of the mine could result in behavioral disturbance to birds between 3,350 and 6,500 feet from the mine site. This distance is a rough estimate based on a variety of assumptions related to the number and types of vehicles and equipment in operation, as well as the detailed blasting information, including the weight per charge, spherical divergence, atmospheric adsorption, ground attenuation, natural barrier effects, and others. This estimated distance may not be the case for all bird species, but initially some birds may avoid this buffer around the mine site, because it would represent a novel source of disturbance that they are not accustomed to. The same logic would apply to the other mine components, but to a lesser extent due to reduced levels of noise. Operational noise levels would be long-term, lasting throughout the life of the mine. Noise impacts during the project closure phase are not provided, because they are anticipated to be similar to the construction phase, but may vary depending on the type of equipment used.

Noise from the compressor station on the Kenai Peninsula would also be expected to cause behavioral avoidance. The compressor station would be constructed on 5 acres of private property east of the Sterling Highway in a residential area north of Anchor Point. In terms of magnitude and extent, noise levels generated by typical operation of the compressor station would equate to 55 dBA day-night sound level at 2,150 feet (Section 4.19, Noise). This area is already exposed to anthropogenic sources of noise from vehicle traffic and residential noise sources. As detailed in Section 3.23, Wildlife Values, common avian species that occur in this area based on North America Breeding Bird Survey data from the Anchor River (3.5 miles south) from 1983 to 2017 include orange-crowned warbler (*Vermivora celata*), varied thrush (*Ixoreus naevius*), fox sparrow (*Passerella iliaca*), American robin (*Turdus migratorius*), hermit thrush (*Catharus guttatus*), alder flycatcher (*Empidonax alnorum*), ruby-crowned kinglet (*Regulus* *calendula*), Wilson's warbler (*Cardellina pusilla*), golden-crowned sparrow (*Zonotrichia atricapilla*), and yellow-rumped warbler (*Setophaga coronata*) (Pardieck et al. 2018). These species are generally found in scrub and coniferous forest habitats, which are typical of the vegetation in this portion of the Kenai Peninsula. As with the mine site, these impacts would be long-term, lasting throughout the project life.

Practices to avoid disturbance to raptor nests (e.g., bald eagle) would be followed, and species-specific buffer zones and temporal restrictions would be established based on consultation with USFWS (USFWS 2007; and Richardson and Miller 1997).

There is the potential for noise disturbance of raptor nests during construction of bridge crossings over the Newhalen River. On July 2, 2019, a raptor nest helicopter survey was conducted for these bridge crossings that occur along the mine access road (ABR 2019d). Of the four bald eagle nests that were observed along the Newhalen River, none were within 0.5 mile of bridge locations. The closest nest was 0.9 mile south (downstream) of the southern bridge crossing (Figure 3.23-1; ABR 2019d). The closest nest to the northern bridge crossing was approximately 1.4 miles upstream (see Section 3.23, Wildlife Values). These distances should be adequate to avoid disturbance to bald eagle nest sites at bridge crossings along the Newhalen River, based on the National Bald Eagle Management Guidelines (USFWS 2007c).

Project-specific raptor surveys were also conducted in summer 2018 for areas south of Iliamna Lake along the port access road (Figure 3.23-9). There were no bald or golden eagle nests near the area of the bridge over the Gibraltar River. There is little suitable bald and golden eagle nesting habitat within 0.5 mile of the Gibraltar River along its length from the outflow of Gibraltar Lake to Iliamna Lake (ABR 2019e). The closest nests were over 4 miles from the bridge.

Disturbance from Vessels, Vehicles, and Aircraft

Vehicle traffic along the access roads, vessel and aircraft traffic at the Amakdedori port, and barge traffic on Iliamna Lake may cause behavioral disturbance to birds in the surrounding areas. Impacts may include direct impact on offspring survival due to brood scattering; change in foraging behavior, and an increase in energetically costly behavior; and a loss of suitable habitat (Kaiser and Fritzell 1984; Keller 1991; Korschgen et al. 1985; Mikola et al. 1994). Waterfowl generally respond to both loud noises and rapid movements, such as boats powered by outboard motors or other threatening visible features (Korschgen and Dahlgren 1992).

As detailed in Chapter 2, Alternatives, the magnitude and extent of daily transportation of concentrate, fuel, reagents, and consumables would be up to 35 round trips per 24-hour day for each leg of the mine and port access road, which includes three loads of fuel per day (PLP 2018-065). The magnitude and extent of disturbance from traffic on the mine and port access roads (based on a 24-hour work day) would be one truck passing in either direction approximately every 21 minutes during operations. There would be additional light vehicle traffic (i.e., vehicles other than large trucks transporting concentrate, fuel, and consumables) along the transportation corridor, which would increase the level of disturbance. This magnitude and extent of vehicular traffic may disturb birds, as discussed below.

Disturbances of nesting birds may cause abandonment of the nest, disruption of the pair bond, reduction in clutch size, increased egg mortality, abandonment of the nesting area, and increased predation of the nest. Disturbances during brood-rearing may cause exhaustion of young and an increase in losses from predation (Korschgen and Dahlgren 1992). Disturbances during critical times of the nesting cycle may eventually cause birds to nest elsewhere, or not to nest at all (Korschgen and Dahlgren 1992). Human disturbance may cause waterfowl to modify food habits, feed only at night, lose weight, or desert the feeding area.

Some species are easily disturbed by the presence of humans, vehicles, and other activities around their nest sites, even if their nesting habitat is not directly impacted. Several species of raptors (e.g., golden eagles) are prone to disturbance around nest sites and may abandon them if disturbed early in the nesting season. Disturbance to golden eagle foraging and roosting areas can stress eagles, leading to reproductive failure or mortality (USFWS 2011c).

Habituation of some bird species to disturbance may occur (Stolen 2003). Waterbird responses to vessel traffic may be dependent on species, biological cycle (e.g., breeding, migrating, stopover, and wintering), and/or vessel attributes (e.g., vessel type, size, and speed). In terms of magnitude and extent of impacts, when vessels are closer to occupied habitat, a flight response would be likely to be greater, especially if the vessel is approaching rapidly.

Some waterbirds in Cook Inlet may be habituated to vessel traffic (especially around existing port and harbor locations); however, vessel traffic at the Amakdedori port may cause disturbance, because the area currently has no port development.

Behavioral disturbances to birds in Cook Inlet could occur during pipeline (and an adjacent fiber-optic cable) installation in Cook Inlet, but the duration of the disturbance would be short-term, occurring only during the pipeline installation period, and would be expected to return to current disturbance levels after installation. Pipeline installation is anticipated to occur during summer months, when breeding birds would be nesting. As detailed in Section 3.23, Wildlife Values, in terms of the extent of impacts, there are no seabird colonies in the analysis area (i.e., within 1 mile of the natural gas pipeline) that would be expected to be disturbed (e.g., by being flushed off the nest) during pipeline installation. However, there are multiple seabird colonies north and south of Amakdedori port, but they are over 6 miles away. There would be a potential for impacts to foraging seabirds that are searching for food during summer months. Only birds resting, foraging, and flying through the area have a potential to be temporarily disturbed during summer-time construction activities. As detailed below, depending on the species, birds would dive, fly, or swim out of the path of approaching vessels, and would be expected to return to their foraging areas after the vessel disturbance has passed. However, behavioral disturbance from vessels could cause additional energy expenditure, less time foraging, and potentially temporary avoidance of foraging areas during summer installation of the natural gas pipeline.

As detailed in Chapter 2, Alternatives, during operations, approximately 27 concentrate vessels and 33 supply barges per year would be needed for transport (an average of one vessel per week). Each concentrate vessel would require 10 trips from the lightering barge between the port site and lightering location to fill the bulk carrier, which would be moored for 4 to 5 days. Vessel traffic could cause birds to swim away, fly, dive, or otherwise avoid approaching vessels. Avoidance behaviors have been documented for multiple avian species, resulting in less time spent foraging, and avoidance of areas; increased energetic expenditure; potential for predation; and other indirect impacts. Although Kittlitz's murrelets (*Brachyramphus brevirostris*) have not conclusively been detected in the analysis area, the similar marbled murrelet (*Brachyramphus marmoratus*) has been documented in the analysis area in Kamishak Bay. During a study in Glacier Bay, Alaska, researchers observed Kittlitz's murrelets while vessels were passing by, and found a 30-fold increase in flight behavior, with large and fast-moving vessels causing the greatest disturbance (Agness et al. 2008). Kittlitz's Murrelet were temporarily displaced from habitat, and birds returned to the same habitat within the same day after the disturbance ceased. Negative effects on the bird's daily energy budget can occur, however, when birds expend energy to fly away (Agness et al. 2008).

Additional studies in Europe have documented the spatial scale of displacement caused by vessels flushing waterbirds (Marine Management Organization 2018). A compilation of studies documented displacement effects ranging from 0.1 mile (for eiders) to up to 1.2 miles for common scoters (*Melanitta nigra)* (Marine Management Organization 2018). One of the studies reviewed (Schwemmer et al. 2011) documented median flushing distances from vessels of 1,325 to 2,638 feet for species of scoter, 961 feet for long-tailed duck, and 682 feet for eiders. Additionally, repeated short-term responses to individual disturbance events may result in longer-term avoidance of areas, and displacement. Seaducks were considered to have high displacement indices in response to transport and traffic activities, and moderate habituation to such activities (Marine Management Organization 2018).

Summary

The magnitude, duration, and extent of impacts would be behavioral disturbance to resident and migratory avian populations during all project phases around the mine site, the immediate vicinity of the ferry terminals, Amakdedori port, along the transportation corridor, and during installation of the natural gas pipeline. In particular, birds would be anticipated to avoid the habitat in close proximity to loud noise disturbances (such as blasting at the mine pit). Avian abundance and distribution may change in the habitat immediately adjacent to project components. The duration of impacts would be for the life of the project, until mining ceases and the habitat is restored. The geographic extent would include the direct footprint of each project component and the surrounding area, depending on noise levels.

Injury and Mortality

Vehicle Collisions

The magnitude and extent of impacts would be that avian mortality from vehicle collisions could occur throughout the mine site and along the transportation corridor. Currently, there are no roads to the mine site, and the project would involve the construction of approximately 74 miles of road through habitat that supports nesting birds; this would create vegetation edge habitats on either side of the road. There would be potential for vehicle collisions for birds flying across the new roads created by the project. In terms of duration of the impact, mortality rates for resident avian species may be expected to decline over time, due to a postulated “learning effect,” whereby resident birds may acclimate to the presence of the road and develop behaviors to avoid collisions (e.g., flying higher when crossing the road to avoid vehicles) (Havlin 1987). However, this is not likely to apply to migratory birds passing through the area that are unfamiliar with the road. Birds have been shown to change flight initiation distances in response to vehicles according to road speed limit (a factor affecting mortality rates on roads) rather than particular car speed, suggesting that birds are able to associate road sections with overall speed limits as a way to assess collision risk (Legagneux and Ducatez 2013). Bird species that spend a considerable amount of time on the ground (e.g., species of grouse and ptarmigan) may be more susceptible to vehicular collisions as opposed to species that are found higher up in the tree canopy (such as species of flycatcher, warblers, and sparrows). Some avian groups tend to fly at a low altitude, close to the ground, and may be more prone to vehicle strikes when flying between brushy areas that are bisected by a road. Additional factors such as vegetation structure and height, proximity of vegetation to the road, terrain, and adjacent habitat areas (such as wetlands and rivers) may all factor into collision risk for avian species.

Clearing of adjacent roadside vegetation and reducing traffic speeds would help reduce the potential for bird collisions (Gunsen et al. 2011). Wildlife safety mitigation measures for the transportation corridor would include vegetation management to increase visibility. Visibility would be improved by reducing roadside vegetation (trimming of shrubs and trees) that may obscure wildlife approaching the road, and reducing its attractiveness. Vehicle speeds would also be reduced along the transportation corridor. The maximum speed limit for the road system would be set at 35 mph. Wildlife present on the road would be given the right-of-way. Traffic would stop, if necessary, to allow the safe passage of wildlife crossing, or walking along, the road (PLP 2019-RFI 122).

Aircraft Collisions

Bird collisions with aircraft have been well documented and appear to be increasing (Dolbeer et al. 2013). Contributing factors are greater populations of large birds near some airports, more air traffic, and higher use of quieter aircraft (e.g., turbofan-powered). Waterfowl, gulls, and raptors were groups with the most numerous and most damaging strikes. Species with high numbers of strikes in Alaska (Dolbeer et al. 2013) include bald eagle, Canada goose (*Branta canadensis*), American golden-plover (*Pluvialis dominica*), bank swallow (*Riparia riparia*), and ducks (*Anas* species and others), which all occurred in the analysis area.

In terms of magnitude and extent, air traffic over Cook Inlet around Amakdedori port may pose a collision risk to bird species (particularly waterbird and seabird species), as well as a safety hazard to the aircraft. The degree of risk would be related to number and timing of the flights with respect to avian habitats (such as over ponds, lakes, and Cook Inlet), time of year, weather conditions, and flight pathways. During project construction, work crews would access sites by helicopter or boat until the port access road to the south ferry terminal is constructed. A permanent airstrip would be built at Amakdedori port to facilitate the construction phase of the port access road. Twin Otter or similar aircraft would make 20 to 40 flights per month (average of 5 to 10 flights per week) during the construction phase to Amakdedori port, before Kokhanok can be accessed by road. Once road access to Kokhanok is established, flights to and from Amakdedori port would occur infrequently for incidental/emergency access only. During this period after road access is established, fewer birds may be potentially affected because interaction opportunities would be relatively infrequent; however, there would be increased potential during periods of inclement weather with reduced visibility and higher winds, especially during periods of avian migration. Flight paths toward the eastern end of the runway would be over the water on final approach (as low as 300 feet for approximately 1 mile, based on a 3-degree angle [Owl Ridge 2018]). This may result in waterbirds and seabirds swimming, diving, scattering, or flying away, which could lead to avian injury and mortality.

Vessel Collisions

Additionally, collisions may occur from vessel traffic on Iliamna Lake and Cook Inlet. The magnitude, duration, and extent of potential effects on avian species that breed, stage, migrate, and winter on Iliamna Lake and at Amakdedori port would be the risk of collision with watercraft. However, in both locations, the watercraft would be traveling slowly, particularly as they reach the shore; therefore, birds are anticipated to be able to move to avoid collision. In some port areas, waterbirds have become accustomed to boats (particularly around the Homer harbor); therefore, waterbirds are anticipated to develop some level of habituation to vessel traffic at Amakdedori port and the ferry terminals.

Powerline and Communications Tower Collisions

Additional sources of avian injury and mortality may come from collisions with powerlines or elevated structures in project components (such as the monopole communications tower at Amakdedori port). In terms of extent, although no powerlines would be situated along the transportation corridor, there may be distribution lines connecting the mine site power plant with other mine-related facilities. The addition of elevated powerlines, particularly near waterbodies, may cause collision hazards for waterfowl as they land and take off. This would be especially important during periods of low or reduced visibility and during periods of avian migration. Birds may also suffer injury and mortality from energized components of the electrical distribution system in the mine site, if not adequately protected. There would be a 100- to 150-foot monopole communications tower at Amakdedori port that would be marked with high-visibility paint bands.

In accordance with FAA and USFWS guidelines, the tower may include flashing red lights at the top if required, in addition to being marked with high-visibility paint bands (FAA 2018b). Lights on structures, particularly steady-state red lights, can result in disorientation and increased collision risk for avian species (Manville 2000). Therefore, the communications tower inside the port facilities at Amakdedori may pose a collision hazard for birds.

Night-Time Lighting

A potential impact to avian species that may result in injury and mortality, but begins with behavioral disturbance, would be disorientation caused by night-time lighting, especially during migration. The magnitude and extent of these impacts would encompass all project components where night-time lighting may occur, including the mine site, ferry terminals, port, lighted navigation buoys, and lightering locations (particularly if the bulk carriers are illuminated at night). Permanent structures mounted to the causeway or dock at the port include illumination and navigation lights. If lights are not adequately shielded down and oriented away from the adjacent water, collisions are possible. These impacts would be long-term, beginning with the construction phase and lasting though the life of the project and into closure.

Some avian species have been documented colliding with a variety of structures during nocturnal migration. This includes species of waterbirds (especially eiders), seabirds, and passerines. Bird mortality typically occurs on cloudy, overcast, or foggy nights with reduced visibility and low cloud ceilings, when birds are flying at lower altitudes (Ove Arup & Partners 2002). Rain or other precipitation can cause refraction and reflection of light by rain droplets, which can disorient birds and cause them to collide with structures. Additional factors such as the moon phase and passage of cold fronts can influence the potential for collision. One potential reason for increased injury and mortality during overcast nights with reduced visibility is that birds become spatially disoriented by bright lights due to cloud cover obscuring their navigational reference points, such as the moon and stars (Greer et al. 2010). Even though birds may not collide with structures, the disorientation from night-time lighting can cause birds to fly in circles around the light source, become exhausted, and drop to the ground. Additionally, mortality may occur from hypothermia, predation of incapacitated birds, and collision with the ground. Night-time lighting can also disrupt breeding activities (for both passerines and seabirds) and increase predation (Greer et al. 2010).

In addition to birds physically colliding with structures due to night-time lighting, predator-prey interactions may be altered. In a 2-year study to determine the potential effects of artificial lighting from Pacific outer continental shelf oil and gas facilities on migrating birds in the Southern California Bight, Johnson et al. (2011) found that red-necked phalaropes (*Phalaropus lobatus*)—one of the predominant marine migrants—became temporarily disoriented from night-time lighting on two oil and gas platforms in the Santa Barbara Channel in Southern California, and were preyed on by peregrine falcons (*Falco peregrinus*). Night-time hunting by peregrine falcons was likely facilitated by platform lighting that assisted with prey detection and disorientation of prey, thereby rendering nocturnal migrants vulnerable to predation. Other avian interactions with oil and gas platforms included opportunistic foraging on insects by migrating passerines; use of platforms for night roosting by migrant birds and resident marine birds (gulls, cormorants, and pelicans); and use of platforms for breeding by peregrine falcons (Johnson et al. 2011). Therefore, although birds can become disoriented and suffer injury and mortality from night-time lighting on facilities in and near nocturnal migratory flyways, some structures also provide resting, roosting, and foraging locations for other species. The study corroborated, as reported in the scientific literature, that the weather and lunar cycle affect the likelihood of birds being attracted and potentially entrapped by night-time lights on offshore structures. This is especially relevant for night-time migrants that depend on celestial clues for navigation, and can become impaired and disoriented when the weather and moonlight conditions are unfavorable for navigation. As applicable to the project, there is a potential for night-time lighting on vessels moored at the lightering locations and lighting from port facilities to cause disorientation and other impacts to night-time migrants.

Increased Predation

In terms of magnitude and extent of effects, birds nesting around the mine site may experience increased predation from common ravens (*Corvus corax*) (and other species) using project infrastructure. The duration of this impact would be long-term, lasting though the life of the mine. A study conducted by Powell and Backensto (2009) on the northern slope of Alaska around the Prudhoe and Kuparuk oil fields documented common ravens nesting on a variety of man-made structures, including processing facilities, drill sites, bridges, radio towers, and inactive drill rigs. The infrastructure permitted common ravens to expand their nesting locations into areas where no nearby natural nesting substrate exists. An analysis of common raven pellets contained a variety of small mammal species, avian remains (eggshell fragments were from geese, ducks, ptarmigan, and other birds), and anthropogenic food items. Therefore, the mine site may provide new structural nesting locations, food, and nesting sources, and increase common raven predation on local small mammal and avian populations.

Care would be taken to minimize access to anthropogenic food sources, and to reduce the chance of subsidizing food resources for wildlife such as bears, red fox, and raven populations at the mine and other sites, including stopped vehicles. Design features should minimize access to anthropogenic food sources. Food and Garbage Management practices that would be implemented are described above.

An additional potential source of predation may come from invasive species. As described in the all-taxa invasive species section of Section 4.26, Vegetation, invasive terrestrial vertebrate species have not been documented from the project area; however, the Norway rat (*Rattus norvegicus*) is a species of high concern due to damaging effect in neighboring ecosystems. Norway rats have high reproductive capacity and are opportunistic feeders capable of large effect on a variety of wildlife populations. Rats may also carry parasites, pathogens, and diseases that can be harmful to other species. In the Aleutian Archipelago, seabird colonies have suffered significant losses due to predation by rats (Buckelew et al. 2011). Most rat infestations in Alaska have resulted from rats escaping from ships while in port (USFWS 2007). Bulk carriers and barges would be coming from locations outside of Alaska and have a potential to inadvertently import Norway rats. Ships that come into contact with seabird colonies on surrounding islands and rocky outcrops in Kamishak Bay (through loss of power, grounding, drifting, or other means) and along the coastline have a potential to introduce a devastatingly effective predator of seabird colonies. Currently, none of the islands or areas around the port site have known rat populations, and ADF&G has developed a plan to keep rats out of Alaska (Fritts 2007). Norway rats are particularly problematic because they can swim hundreds of feet between islands, or between sinking vessels and land. Therefore, rats that could be transported to the port on project vessels have a potential to spread to the port facilities and farther inland on project vehicles and equipment. Despite a lack of seabird colonies in close proximity to the port, any introduction of rats to the port or surrounding area could have negative consequences on the local avian community.

Effects of Roadkill and Mine Site Management Practices

Predatory and scavenging birds (such as common ravens and eagles) that consume roadkill may have difficulty taking off from approaching vehicles, which may result in additional avian collisions. Raptors can consume large amounts of roadkill; and when vehicles approach, the additional weight may decrease their ability to move out of harm's way, potentially resulting in vehicle collisions and mortality.

Birds may be killed by toxins or poisons used at the mine site, especially if rodenticide is used. The WIP would detail roadkill removal and reduction methods to reduce the potential for avian injury and mortality.

As detailed in Chapter 2, Alternatives, a landfill and incinerator would be constructed and operated at the mine site for domestic waste handling. The landfill would be operated in compliance with state and local permit conditions. Domestic refuse would be disposed of in the on-site landfill, or shipped off site to appropriate disposal sites. Wastes suitable for burning, including putrescible wastes, would be incinerated on site. Improper waste management may attract common ravens and mammalian scavengers to the mine site. If waste is not properly managed, it may provide anthropogenic food sources and nesting material for common raven numbers. In terms of magnitude and extent, this may lead to increased predation on local avian and small mammal populations. The WIP would include measures to reduce the attractiveness of the mine site to common ravens and other species, as well as adaptive management measures. These effects from roadkill and mine site management practices would be of long-term duration.

Water Quality

The project would create new areas of standing water that may attract birds, including the various freshwater storage impoundments, the tailings pond, and the pit lake. The magnitude and extent of the impact would be that environmental contamination by contact with water in these locations would be possible. All water management in the project area would be released back into the environment only after it meets water quality criteria, as detailed in Section 4.18, Water and Sediment Quality. Appendix K4.24, Fish Values, describes the potential impacts to wildlife from changes in water quality (in particular, cadmium, copper, mercury, and selenium) at the discharge locations. The pit lake would be deep; contain no shallow water habitats (due to the steep walls); and not support freshwater vegetation that is attractive to many species of waterfowl and shorebirds. Wildlife management around the pit lake would be addressed in the WIP.

Wildlife may be attracted to flooded open-pit mines that have been abandoned, and these mines have caused wildlife mortality, including waterfowl. The flooding results from incursion of groundwater into the open pit forming a "pit lake." Water quality in these pit lakes varies from highly acidic to alkaline. For example, the Berkeley Pit in Butte, Montana is a 1.5-square-mile open pit approximately 1,700 feet in depth, and has caused mortality of waterfowl using it as a migratory stopover. Groundwater has infiltrated the open pit and created a pit lake about 710 feet in depth with a pH of 2.5. Birds landing in these acidic pit lakes can ingest water, causing trauma to their gastrointestinal tracts and leading to mortality. The acidic water also removes natural oils from the birds' feathers, causing them to perish by drowning or hypothermia (USFWS 2020).

In comparison with the acidic water (pH 2.5) of the Berkeley Pit, the project pit lake would be expected to be initially acidic, becoming slightly alkaline (pH 7.6 to 8.2) over time (see Section 4.18, Water and Sediment Quality). Waterfowl that could land on the pit lake would not be exposed to highly acidic water, such as Berkeley Pit, and would not likely be adversely impacted with regard to internal organ toxic exposure or loss of buoyancy/hypothermia.

The predicted water quality values in the pit lake were projected by Lorax (2018), extending from 20 years to 125 years post-closure. Although there would be some exceedances of water quality standards for specific metals during closure, exposure of wildlife—including birds—would be limited and short-term. These values vary across the years and for the various metals that were analyzed. There is a potential that waterbirds would use the pit lake, especially during migration. However, the pit lake would not provide the same ecological communities (e.g., fish, macroinvertebrates, vegetative structure) that nearby suitable waterbodies contain; therefore, waterbirds would be less inclined to use the pit lake for extended periods of time. Waterbirds would likely use it periodically for resting, particularly during migration. Several metal levels would remain elevated above water quality standards post-closure, including aluminum, arsenic, cadmium, copper, iron, mercury, manganese, molybdenum, antimony, lead, selenium, and zinc (Lorax 2018).

Waterbirds can ingest metals from a variety of sources, including directly from drinking water, food, substrate, and vegetation. The pit lake would not be anticipated to provide suitable foraging habitat for waterbirds (due the steep sides, and lack of freshwater vegetation); therefore, the most likely route of exposure would be from drinking water from the pit lake. There would be multiple other nearby sources of water (such as nearby Frying Pan Lake to the south, and Long and Nikabuna lakes to the north) that provide higher-quality cover and foraging habitat that birds may favor.

Summary

The magnitude of injury and mortality impacts on avian species would be anticipated to affect a wide range of taxonomic groups, at various life stages, and across all components of the project. The potential for collisions with vehicles, vessels, aircraft, structures, lights, powerlines, added predation from a potential increase in common ravens (and other predators), and changes in water quality would be expected to result in new sources of avian injury and mortality The duration would be for the life of the project, and the extent would include the footprints of all project components.

Habitat Changes

Temporary and permanent habitat loss would occur as existing vegetation is removed and replaced with buildings, roads, runways, the open pit, and other project facilities and infrastructure. See Section 4.26, Vegetation, for information on direct and indirect impacts to vegetation, which would relate to loss of nesting, foraging, migrating, and staging habitat for species in various vegetation communities. Direct and indirect impacts to vegetation (that would also impact wildlife species), such as the introduction of invasive species (such as Norway rats and Elodea), fugitive dust (extending out to 330 feet), and others are discussed in Section 4.26, Vegetation. Additionally, there is the potential for an altered fire regime, which may lead to additional habitat changes.

The direct loss of habitat from all project components (acreages provided in Table 2-2 of Chapter 2, Alternatives) would impact bird species with home ranges in the disturbance area, as well as those migrating through the area. In terms of extent, loss of habitat during migration may affect bird populations beyond the analysis area, because migrating birds could be forced to use other areas to rest and forage. The magnitude of the effect on migrating birds would be less than the effect on breeding birds, because migrants would use the habitat briefly and would not depend on it to feed young. Waterbirds would be the primary migratory species around the mine site that would be impacted. As detailed in Section 3.23, Wildlife Values, there are several important staging areas to the north of the mine site where large numbers of waterbirds congregate. Large numbers of waterbirds stage during spring at Nikabuna Lakes, Long Lake, and along the Chulitna River, over 11 miles north of the mine site. Development of the project would not be anticipated to impact spring migratory waterbird habitat in these distant areas. However, in the fall, high numbers of waterbirds would be directly adjacent to the mine site. Waterbirds would be anticipated to move to other nearby ponds and lakes not directly in or adjacent to the mine site.

The avian response to habitat fragmentation is species-specific. Some species avoid edge habitat for reasons such as less suitable microclimate or increased predation. Some avian species prefer early successional habitats; habitat availability for these species may increase as a result of fragmentation. Some avian species, particularly raptors, would lose foraging habitat because the vegetation communities that support their prey populations in the mine site would be converted to urban/developed land cover types. In terms of magnitude and extent, this could cause raptor species to seek new foraging locations, thereby potentially placing them in competition with nearby occupied territories. This may lead to fewer individual raptor territories in and adjacent to the mine site, reduced number of young, and decreased raptor abundance in the area. Based on the most recent surveys (detailed in Section 3.23, Wildlife Values), one golden eagle nest was within a 1-mile radius of the mine site, plus additional bald and golden eagle nests were in close proximity to the port access road (several less than 0.5 mile away). According to the Bald and Golden Eagle Protection Act (Eagle Act) (16 United States Code (USC) Sections 668-668c), activities that result in nest-site abandonment constitute take under the Eagle Act because they are cited in the definition of “disturb” (Pagel et al. 2010). Disturb also extends to impacts that decrease eagle productivity by substantially interfering with normal breeding, feeding, or sheltering behavior (72 Federal Register 31132). Therefore, impacts to bald and golden eagles may necessitate the application for an Eagle Take Permit (81 Federal Register 91494).

Fugitive dust emissions would be caused by road construction and vehicle travel on unpaved surfaces. This dust has the potential to collect on vegetation in the vicinity of the dust sources. Windblown dust could affect wetland vegetation well beyond the source, but the effect diminishes with distance and is influenced by prevailing winds and topography. The heaviest dust deposition would be anticipated to occur within 35 feet of the road (Walker and Everett 1987); however, dust has been documented at distances of 330 feet from the most heavily traveled roads in Prudhoe Bay (Walker et al. 1987). Dust deposition impacts wetlands primarily by reducing vegetation productivity and altering species composition. Fugitive dust impacts to vegetation are described in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites; and Section 4.26, Vegetation. Based on these sections, it was determined that fugitive dust has a potential to impact a 330-foot buffer around project components. As detailed in Section 4.26, Vegetation, plant communities that have a high percentage of lichens and mosses would be most impacted. Dwarf shrub lichen communities and partially vegetation land cover types (where lichen is dominant) would be the most impacted by fugitive dust within a 330-foot buffer from project components. The avian community that uses lichen and moss-based vegetation types would be most impacted, such as ground nesters that rely on camouflage for protection, including species of ptarmigan, some shorebirds, and ground-nesting songbirds.

With regard to wildlife, winter dust fall in the corridors along roads in Alaska may cause early snow melt and soil thaw, concentrating waterfowl, passerines, ptarmigan, grouse, and their predators in snow-free areas such as along roadsides. These wildlife may become susceptible to collisions with passing vehicles. Caribou may take advantage of the early snow-free areas for grazing, and grizzly bears, raptors, and other predators may use these areas to hunt ground squirrels and voles (Walker and Everett 1987).

An additional habitat change that has the potential to impact avian species is the spread of invasive plant species. In particular, the spread of invasive aquatic plant species, such as elodea (*Elodea* spp.), have a potential to clog waterways and reduce foraging areas, as well as provide cover for other invasive species. Although no freshwater aquatic invasive species have been documented in the analysis area, elodea forms dense monocultures that displace native flora and alter freshwater habitats by decreasing flow and increasing sedimentation (ACCS 2011d; Nawrocki et al. 2011). Such impacts have been shown to degrade habitat for waterfowl and freshwater fish (Schwoerer 2017). If elodea became established in the project area, it could negatively impact the nesting and foraging areas for waterbirds in the project area by reducing availability to find prey, altering fish habitat, and clogging waterways necessary for diving duck and other waterbirds.

In summary, the magnitude of the impact would be removal of 9,611 acres of habitat occupied by a variety of avian species, including sensitive species that are in decline globally. There would be loss of territories, potential abandonment of previous nesting locations, and interspecific species completion from habitat loss. The duration would be for the life of the project; however, some portions of the project would be restored and eventual revegetation would provide habitat post-mining. The extent of direct impacts would include the footprint of all components, plus additional surrounding habitat that would be indirectly impacted through behavioral avoidance, fugitive dust, potential for invasive plants, altered fire frequency, among others. Impacts would be expected to be noted because they would affect multiple bird species across many habitat types.

4.23.4.2 Terrestrial Wildlife

Behavioral Disturbance

Noise

In terms of magnitude, terrestrial mammals may be affected by blasting and noise from heavy machinery used during construction and operations. See Section 4.19, Noise, for a detailed analysis of the various noise-producing components. In terms of extent of the impact, individuals may move away from the construction areas to avoid loud continuous sounds, periodic percussive sounds, and the presence of people and machinery that would disrupt their normal behaviors. Behavioral responses to disturbance can range from mild “alert” behavior to fleeing, depending on disturbance type, distance, species, season, or other variables. The size of the “avoidance zone” would depend on the type of disturbance, terrain/topography, vegetative cover, as well as species’ behavior, but could result in indirect loss of habitat for each species. Some species, such as moose (*Alces alces*), may habituate (i.e., adapt) to human disturbance; while others, such as gray wolves (*Canis lupus*) and brown bears, may not, and may avoid areas or move away as people and equipment approach. Some facility noise and operations disturbances may allow for habituation. For example, lower-level continuous noise disturbance at the water treatment plant would have lower effects than louder erratic sources of activity, such as blasting, vehicles, or aircraft. The size of the area avoided would vary by species and would fluctuate over time, but would be larger than construction area footprints. Avoidance of project activities could cause increased physical stress, habitat fragmentation, or abandonment, thereby reducing survival and reproductive success for certain species.

Night-Time Lighting

One potential impact from the mine site related to behavioral disturbance would be night-time lighting. Because the mine would operate continuously 24 hours a day, 365 days a year, impacts from artificial night-time lighting into adjacent habitat may disrupt predator-prey interactions and disrupt annual rhythms that are entrained by day length (Longcore and Rich 2016). The nearby topography can cause artificial lighting to be exacerbated by reflecting off nearby hillsides (especially when covered in snow). Some prey species are nocturnal and forage in open areas at night. However, artificial light that extends into adjacent habitat may affect predator-prey interactions, particularly during long winter nights in tundra habitats (Longcore and Rich 2016).

Wildlife Attraction to Waste

Attraction, habituation, food-conditioning, and predator population augmentation are well-understood impacts of industrial development in Alaska. Minimizing attractants and eliminating food rewards include using wildlife-proof storage of food, garbage, and hazardous substances, incineration of wastes, proper disposal of unburned wastes, and enforcing bans on littering and feeding wildlife.

Management of waste requires proper handling of food and non-food materials to reduce impact to local wildlife populations. Handling food waste correctly would limit the attraction of animals (e.g., foxes, gulls, ravens, and bears) to the project area. Procedures include appropriately designated disposal receptacles, storage, cleanliness, and odor limitation throughout the area, including vehicles. Non-food materials (e.g., plastic, rubber, motor oil, fuel, and chemical such as antifreeze) can be attractive to some wildlife species if these materials are not handled properly. Potentially harmful materials would be stored in secure containers or inside buildings/sheds, and would be properly disposed of away from the project area.

As detailed previously and elaborated on in Chapter 2, Alternatives, a landfill and incinerator would be constructed at the mine site for domestic waste handling. This may cause a behavioral shift in some species by attracting them to the landfill. Some species, such as bears and red foxes (*Vulpes vulpes*) that become habituated to food resources may become a nuisance and safety hazard. Although the landfill would be operated according to permit conditions (if issued), the WIP would detail additional measures, should food-conditioned wildlife become a problem.

Behavioral Avoidance

Behavioral avoidance may function as a barrier to movement for some species (particularly small species with reduced home ranges and dispersal distances), or for particular sex and age classes within species. Physical features of the mine and port facilities, access roads, ferry terminals, steep cut banks, holding ponds, material yards, or retaining walls may prevent or limit animal movements through the area. For species with large home ranges, or species that travel seasonally between winter and summer ranges, such as caribou, moose, brown and black bears (*Ursus americanus*), and gray wolves, a barrier to movement could fragment and decrease the size of preferred habitat.

Behavioral changes to wildlife such as movement away from the physical disturbance of pipeline stringing during construction could occur. These impacts would likely be temporary.

During construction, excavated and open pipeline ditches could also disrupt wildlife movement, and pose injury and entrapment hazards for wildlife. Construction activities in the area of the open ditches would generally tend to frighten larger wildlife away, causing temporary displacement, although some injury could occur. Smaller species would be able to traverse or climb out of open ditches. Traffic on the access road during the operations phase would be subject to speed restrictions; but in terms of duration, would last for the life of the project and potentially longer. As detailed in Chapter 2, Alternatives, roads would remain as long as needed for long-term post-closure water treatment and monitoring. The specific fate of the access roads post–long-term closure is undetermined. Because the access roads would be constructed in an area with no previously established roads, this would result in a new visual and auditory source of disturbance. The level of truck traffic would be one truck passing approximately every 21 minutes. There would be additional light vehicle traffic (i.e., vehicles other than large trucks transporting concentrate, fuel, and consumables) along the transportation corridor, which would increase the number of daily vehicle trips.

In terms of extent and duration of impacts, project activities may disturb terrestrial mammals throughout construction, operations, and project closure, with the disturbance zone expanding as the mine is developed to its maximum size. During the closure phase, the mine site would be subject to periodic monitoring activities involving small numbers of workers and vehicles for relatively brief periods of time. Post-closure, the potential disturbance of animals from periodic monitoring activities would be minimal and at regular intervals during long-term management of the mine site.

In addition to inhibiting movement patterns, high levels of disturbance could have effects that range from physiological reactions to stress, potential for injury and mortality from exposure to predators (including interspecific species competition), and from sub-optimal habitats, injury, and mortality for denning mammals and small mammals in subnivean (under snow) spaces during winter construction, and reduced survivability and/or reproductive success in unfamiliar territories. Some species are particularly sensitive at certain times of year (e.g., caribou calving in spring, bear and wolf denning in winter, and moose rutting in fall). Ground-based activities would be the primary concern for most species, but airplane and helicopter traffic could also adversely impact certain species, such as caribou, which are known to react strongly to low-flying aircraft by fleeing.

If animals abandon their familiar territories or alter their movement patterns, they may enter the territories of other animals that aggressively defend their area, with the potential for injury or mortality. They may also be more susceptible to predation through lack of experience with local cover and escape terrain. The magnitude of the effect would be that disturbance may also lead to mortality due to young separation or abandonment, or if the animal is injured trying to flee.

The Amakdedori port and both ferry terminals on Iliamna Lake would be sources of long-term disturbance due to vessel traffic, loading and unloading activities, and the presence of workers, night-time lighting, equipment, and vehicles. The disturbance zone around these facilities would likely be much smaller than the area around the mine site due to a lack of blasting and a reduced footprint.

Caribou

Various studies have been conducted on caribou behavior associated with development such as roads, oil drilling, pipelines, and mines. In Alaska, several studies on caribou have been conducted on the North Slope around Prudhoe Bay to document impacts from roads, oil drilling operations, oil pipelines, and other infrastructure. One study (Shideler 1986) found that maternal caribou groups avoided the Trans Alaska Pipeline corridor (including the Dalton Highway) during every season except fall, while bull caribou did not appear to avoid the corridor. Maternal groups almost completely avoided the Prudhoe Bay oil field during summer. In terms of magnitude, Shideler found that traffic levels averaging 15 vehicles per hour caused significant declines in crossing success of caribou during the mosquito season; traffic levels averaging six vehicles per hour have not impacted crossing success of a road or pipeline complex. Multiple factors affect the ability of caribou to successfully cross a road, including time of year, effects of mosquitoes and other insect harassment, and group size. The anticipated level of truck traffic would be one truck passing in either direction approximately every 21 minutes. There would be additional light vehicle traffic (i.e., vehicles other than large trucks transporting concentrate, fuel, and consumables) along the transportation corridor, which would increase the number of daily vehicle trips. Therefore, the proposed truck traffic (at approximately three trucks per hour), combined with a similar number of light vehicles, would correlate to six vehicles passing every hour. According to Shideler (1986), this level of traffic is unlikely to impact caribou road-crossing success. The actual number of vehicles and time between vehicle passes may result in different reactions by caribou compared to those found by Shideler.

Johnson et al. (2019) assessed caribou use of habitat near energy development on the North Slope for the Central Arctic Herd. This herd has been exposed to oil development on its summer range for over 40 years, and findings in Johnson et al. (2019) suggest that caribou habituation to industrial development in the Arctic is likely weak or absent. Based on a review of 2015-2017 location data for GPS-collared female caribou, they reduced their use of habitat within 3.1 miles of development during the calving period; within 1.2 miles during the post-calving period; and within 0.6 mile during the mosquito harassment period. Female caribou exhibited avoidance responses to infrastructure during all time periods, with the effects waning across the summer. This study confirms that despite long-term presence of infrastructure, caribou exhibit behavioral avoidance, especially during important seasonal habitat occupation.

A study in the Canadian Arctic estimated the zone of influence (i.e., area of reduced caribou occupancy based on a change in behavior, habitat selection, and distribution relative to disturbance) surrounding two open pit mines in a caribou herd's summer range (Boulanger et al. 2012). During operation of the mines, an 8.7-mile zone of influence based on aerial surveys and a 6.8-mile zone based on satellite-collar locations were detected. The study found that caribou were approximately four times more likely to choose habitats greater than 8.7 miles from the mine complex (Boulanger et al. 2012). Caribou responded to industrial development at greater distances, possibly related to fine dust deposition from mine activities in areas of open tundra habitats. Therefore, in terms of the extent of impacts, in addition to avoiding the mine site facilities, caribou may avoid a buffer around the mine site.

A fourth study assessed the human disturbance effects and cumulative habitat loss on two migratory caribou herds in northern Canada (Plante et al. 2018). Caribou avoidance of human disturbances at a large spatial scale were examined, including avoidance of mines, powerlines, roads, and human settlements, along with the barrier effect of roads and their influence on caribou movement rates. The study found that caribou avoided disturbances over large spatial scales, and they avoided all disturbance types except powerlines. Roads were avoided by caribou, which impacted their movements by limiting their access to certain areas or increasing their movement rates. Road avoidance may be exacerbated in areas and at times when caribou are hunted. Caribou avoided mining exploration sites by a few miles around drill or trench sites, but by as much as 13 miles during the winter. The cumulative habitat loss for the two herds by avoiding disturbance areas was estimated at 30 percent of their winter range, and disturbance precluded access to 37 percent of high-quality caribou winter habitat in some years (Plante et al. 2018), effectively limiting the amount of habitat for the two herds. The study demonstrated that a single road could preclude or hinder movements, and caribou avoided long-established infrastructure.

Based on data presented in Section 3.23, Wildlife Values, caribou are less common along the transportation and natural gas pipeline corridor compared with the mine site. Caribou move between calving grounds (May to June), insect relief areas (June to July), and seasonal foraging areas (fall and winter months); however, none of these movements would be through the transportation and natural gas pipeline corridors. They tend to occur farther west (toward the mine site); 29 years of telemetry data that were analyzed found few instances of caribou in the area covered by the transportation and natural gas pipeline corridors. Therefore, caribou are more likely to be impacted by activities at the mine site than the transportation corridor.

In summary, the magnitude and extent of the impact would be caribou avoidance around the mine site and transportation corridor due to behavioral disturbance. The approximate acreages of avoidance areas are provided in the habitat changes section below. The duration would be long-term, and last for the life of the project, including during post-closure due to the need for maintenance of the water treatment facilities. The duration of avoidance may last longer depending on the ultimate fate of the transportation corridor and other project roads. The current plan is to leave roads open for use by local residents, which would extend the duration of avoidance into the long term. The extent of impacts may stretch beyond the mine site and transportation corridor, including additional avoidance of areas due to increased noise, presence of humans and equipment, and other sources of disturbance. Impacts would be likely to occur, because there is currently little anthropogenic activity in the area compared to the size of the project.

Moose

Moose seasonally migrate between higher elevations in the summer and lower elevations in the winter; bull moose move extensively during the fall rut (in September and October) as they search for cows. These movements may be affected by activities at the mine site, which may cause abandonment of foraging and rutting areas and alteration of movement routes. However, moose densities are low in the mine site due to a lack of suitable habitat (see Section 3.23, Wildlife Values, for specific moose densities).

Moose are known to occur more commonly in the transportation corridor (due to higher-quality habitat), and may be adversely affected for the life of the project. Laurian et al. (2008) found that moose avoid roads by up to 1,640 feet, which can fragment their available habitat. Shanley and Pyare (2011) studied the effect of roads on moose distribution in Yakatat, Alaska, and found that even dispersed vehicular activity on rural road networks significantly affects moose distribution. This activity could also substantially affect the amount of available habitat by moose avoiding areas near roads, particularly if roads would be near preferred habitat. In particular, male moose were negatively impacted at least 1,640 feet from rural roads; for female moose, the road-effect zone extended greater than 3,281 feet (Shanley and Pyare 2011). Therefore, the extent of road avoidance by moose may extend up to 0.6 mile on either side of the road. The level of avoidance may vary depending on time of day, time of year, and adjacency to nearby foraging, rutting areas, or movement corridors. Possible reasons for the road effect may be related to actual vehicle noise, as well as perceived risk from hunting (Stankowich 2008). Stankowich (2008) found that ungulates in rural landscapes with low levels of disturbance are less likely to habituate, and therefore show stronger effects from disturbance.

In summary, the magnitude of impacts on moose would be avoidance of areas in and around the project due to behavioral disturbance. The duration would extend for the life of the project, and the extent would include the direct footprint of all project components plus an additional avoidance buffer. The extent of avoidance may vary around the project components, especially along the access roads, depending on the time of year and location of biological resources (such as summer foraging, wintering, and rutting areas).

Bear

Brown and black bears may experience a range of potential impacts from the project. This includes loss of habitat due to land conversion, altered feeding, denning, and travel routes, increased mortality (from vehicular collisions, defense of life and property, and interspecific competition from avoidance of preferred feeding areas), and behavioral changes based on avoidance of humans. Because brown bears are common around all components of the project (see Section 3.23, Wildlife Values, for specific bear densities), and black bears only occur at a low density in the area primarily north and east of Iliamna Lake, this impact section focuses primarily on impacts to brown bears from behavioral disturbance. The limitations of baseline bear data outlined in Section 3.23, Wildlife Values, were considered in the analysis herein.

Based on surveys conducted for the project and wildlife agency surveys in the region, brown bear densities are high along the port access road and around the proposed port location at Amakdedori. The proposed infrastructure associated with the project would traverse through an area where currently no established roads exist. Roads can affect wildlife populations through barriers to movement, increased vehicle collisions and road kills, and diminished habitat effectiveness (Flynn et al. 2012). A summary of research on the adverse effects of roads on brown bears includes avoidance of roads at distance from 0.3 mile to 1.9 miles, with most road crossings occurring during decreased periods of traffic and at night (Flynn et al. 2012). Flynn et al. (2012) conducted a pre-construction study of brown bear spatial use, habitat selection, and population ecology along a proposed Juneau road corridor access improvement project; they found that bears extensively used habitats along stream edges and impacts to movement corridors could be reduced simply by widening proposed bridges to encompass more of the stream edge habitat.

A recent study in British Colombia and Alberta, Canada assessed the impacts of resource roads on brown bears and found that motorized access into brown bear habitats can have measurable negative consequences at the individual and population level through habitat use, home range selection, movements, population fragmentation, survival, and reproductive success (Proctor et al. 2018). Researchers found that management of motorized access to roads, where roads are fully closed or restricted to the motorized public, but remain accessible to short-term industry use, was effective mitigation for areas where brown bear conservation and recovery are a priority. Their research also found that industrial use of roads may not be as detrimental to brown bears as recreational use of roads that are open to the public. Therefore, the long-term management of the transportation corridor and roads associated with the mine would be important.

In another study, brown bears have been shown to avoid roads regardless of traffic volume (McLellan and Shackleton 1988), and may avoid mine facilities. McLellan and Shackleton found that most bears used habitat within 328 feet of roads less than expected, resulting in additional habitat loss. They found that roads and adjacent areas were used more at night and were avoided during the day. Additionally, yearlings and females with cubs used habitats near roads more than other bears, likely because roads were avoided by adult male bears. However, some brown bears at a coal mine in Alberta, Canada, have appeared to adapt to disturbance from the mine (Cristescu et al. 2016). Based on the study, female brown bears with cubs appeared most adaptable to mining disturbance (their home ranges overlapped with areas of active mining), while male brown bears appeared to leave the area during active mining. This study concluded that active mining influenced the incidence of encounters between male bears and females with cubs, which may increase the likelihood of cubs' survival while active mining would be taking place. Once mining stopped and the area was restored, male bears appeared to return to the area, and females indicated some flight response (Cristescu et al. 2016).

In Denali National Park, a study was conducted between 1996 and 1997 that compared brown bear, caribou, and moose densities in proximity to the gravel road in the park with backcountry areas (Yost and Wright 2001). Overall, brown bear and caribou distributions indicated no pattern of traffic avoidance, while moose distribution suggested possible traffic avoidance (confounded by preferred forage farther from the road). The road in Denali National Park is primarily a controlled access road with National Park Service-operated buses comprising a majority of vehicles on the controlled access portion of the road. The port and mine access roads would also be controlled access roads during construction and operations of the project. However, post-closure, use of the roads is undetermined.

Roads can also cause functional habitat loss if bears avoid them due to proximity to nearby resources (preferred foraging areas such as salmon streams, and denning locations). Although roads can cause habitat avoidance, alter movement patterns, and become ecological traps, many of the negative effects of roads are related to human use of roads, and not the roads themselves (Northrup et al. 2012). In a study in Alberta, Canada, Northrup et al. (2012) found that traffic patterns caused a clear behavioral shift in brown bears, with increased use of areas near roads and movement across roads during the night, when traffic was low. Typically, brown bears in areas of low human population are most active during the day, with no daily pattern of road use (Boyce et al. 2010); Northup et al. (2012) found that vehicular activity shifted these patterns. Bears selected areas near roads traveled by fewer than 20 vehicles per day, and were more likely to cross these roads, avoiding roads receiving modest traffic (i.e., 20 to 100 vehicles per day). They strongly avoided high-use roads (i.e., more than 100 vehicles per day) at all times. As detailed previously, the magnitude of truck traffic on the transportation corridor roads would be expected to be approximately one truck passing in either direction every 21 minutes (including at night) during operations, and therefore, bears may avoid crossing the mine access road, especially during daytime hours. In addition to concentrate, supply, and fuel truck traffic, there would be an additional number of lighter vehicle traffic such as support vehicles.

An additional impact of the port access road and port facilities is behavioral avoidance of the area during denning. This would likely be most intense during construction of the port access road, including vegetation clearing, grading, grubbing, blasting, and other construction activities related to landscape modification to create the port access road. Once construction is complete, actual disturbance to denning bears would be reduced mainly to noise, ground vibration, and fugitive dust from passing vehicles. Based on a literature review conducted by Linnell et al. (2000), North American bear species select den sites from 0.6 mile to 1.2 miles from human activities (roads, habitation, industrial activities, etc.). They found that activity closer than 0.6 mile caused a variety of responses, including den abandonment, especially if the disturbance occurred early in the denning period. Linnell et al. (2000) found that den abandonment for bears with cubs of the year led to increased cub mortality, and female brown bears showed a greater degree of den-area fidelity compared with males. A bear study in the Talkeetna Mountains found that bears tend to den in the same general area in different years (Miller 1990). The study also found that dens were located on the periphery of home ranges used during summer and fall, and that some male bears moved long distances (up to 46.6 miles) to den on the same hillsides used previously. This indicates strong selective pressure on bears to return to good denning areas where wind currents assure the den entrance is well-sealed with snow, and where soil and frost characteristics prevent dug dens from collapse during winter (Miller 1990). Therefore, bears that den along the port access road may have a harder time relocating to a new area, and suffer the consequences of being behaviorally excluded from preferred denning areas in close proximity to the road.

Bear denning ecology has been studied by Schoen and Beier (1990) for several years at the Greens Creek Mine on Admiralty Island in Southeast Alaska. To assess the effects of the mine site development on denning bears, they selected six female bears that had denned within 2.5 miles of the mine site in upper Greens Creek. It was assumed that these bears were most influenced by mine site activities, including intensive helicopter traffic. During the first year of observation, these bears denned on average 2.1 miles away from the mine site. The following year, they denned significantly farther from the mine site, with a mean distance of 7.3 miles (Schoen and Beier 1990). When compared with bears that denned outside of the area of mine influence, the mean distance among den sites in subsequent years was significantly greater for the six bears that initially denned closest to the mine. Therefore, bears that had initially denned close to the mine location withdrew their denning locations to areas farther away from the mine. Although the habitat conditions on Admiralty Island (upland old-growth rain forest with alpine tundra) are different than those along the port access road (dwarf shrub vegetation, open/closed forest, and open tall shrub), it is possible that the construction and operations of the port access road and mine site may cause brown bears to locate denning areas farther away from areas of disturbance.

Apart from bears moving dens farther away from the Greens Creek Mine, Schoen and Beier (1990) found that it did not appear that home ranges and seasonal distribution of most adult brown bears were substantially influenced in the short-term by development activities. The established home ranges of most bears continued to include areas where intensive road construction was occurring. However, bears shifted their activity away from construction activity (by using other salmon streams in their home ranges that were not influenced by construction activities), and then moved in closer to the road once construction activity was reduced (Schoen and Beier 1990). This is likely due to bears having established home ranges with abundance of spawning salmon and sufficient forest cover that kept them out of sight of humans. One potential effect of shifting feeding areas depending on their proximity to construction activities is the potential for reduced fitness for individual bears that are displaced from familiar feeding areas close to human activities.

To further assess the effects that road construction had on bear distribution at the Greens Creek Mine, the number and location of summer day beds was recorded before and after road construction. Before road construction along lower Zinc Creek, Schoen and Beier (1990) recorded 57 day beds within a 1-mile strip. Following construction, they counted 17 day beds in the same stretch, suggesting that bears avoided the streamside area adjacent to road development. When all movement data were taken into account, Schoen and Beier determined that although bears remained in their traditional home ranges (that were identified prior to start of construction activities), they shifted their movements away from active development areas. It is important to note that Schoen and Beier's study looked at the short-term effects of development activities, and the long-term effects of development on the local brown bear population cannot be concluded based solely on these initial findings. Subsequent years of data collection via telemetry flights during the summers of 1990 and 1991 appear to support the claim that bears remain in their home ranges, but shift activity patterns away from active development (Titus and Beier 1992).

To further understand the potential implications of roads acting as potential barriers to movement, one study on the Kenai Peninsula analyzed radiotelemetry data to determine the spatial and temporal distribution of brown bear crossings of the Sterling and Seward highways (Graves et al. 2006). The study found that bears were more likely to cross the highway during night-time than daytime; and when bears crossed the highway, they moved more rapidly and acutely, compared to before or after crossing. Bears may change the period they are active to cross at times with lower traffic and greater cover provided by darkness. Additional factors such as traffic volume, road configuration, and highway mortality can exacerbate population-level effects (Graves et al. 2006).

A study in British Columbia that assessed bear density, food sources, and use patterns in relation to logging road densities found that the density of brown bears was more related to bear avoidance of areas close to open roads and the risk of human-caused mortality, rather than a difference in habitat (between their two study locations) and high-calorie food sources (Ciarniello et al. 2007). They detected avoidance of areas near primary logging roads due to a high volume of logging truck traffic. They also identified roads as potential "sink" or ecological trap areas, where bears are attracted closer to roads (often due to close proximity to food resources), and then experience human-caused mortality. For brown bears to remain viable outside of protected areas, it is important to maintain landscapes that are secure from the risk of human-caused bear mortality (Ciarniello et al. 2007). While project roads would not be at a comparable density to logging roads, the long-term management of the port access road is an important factor for understanding potential long-term impacts on bears in the local area.

Additionally, aircraft disturbance at Amakdedori port during construction of the port access road would likely cause bears to move away from the area. Because bears were detected fishing in Amakdedori Creek, they may be disturbed by construction and operation of the port, and vacate the area. The WIP would detail specific parameters to prevent disturbance to bears. The general limitations of the provided baseline data regarding bear study areas, abundance, distribution, and activity are recognized. Additional bear den surveys may be required prior to construction as a mitigation measure.

In a Lake Clark National Park brown bear study, location data (collected between October 1, 2014 and November 8, 2017) from 46 brown bears collared in Lake Clark National Park and Preserve illustrate that bears move widely across the landscape, including using areas in the mine site and along the north shore of Iliamna Lake (including the mine access road) (NPS 2019). Therefore, impacts to brown bears from the mine site would directly impact brown bears whose home ranges overlap with Lake Clark National Park and Preserve.In summary, the magnitude of impacts would include avoidance of the mine site, the transportation corridor, the ferry terminals, and port, with avoidance distances differing between bear ages, genders, and life history stages. Because there are no established roads in the mine site, along the transportation corridor, and at Amakdedori port, the access roads, mine, port, and ferry terminals represent novel sources of disturbance to the landscape. In particular, the port access road may alter use of habitats and localized movements of bears around the road. The duration would last for the life of the project, and longer depending on how the roads are managed post-closure. The extent of impacts would encompass all project components, but be greatest along the port access road and around the port. Some age and gender groups of bears may avoid the mine site, specifically during operations (such as adult male bears), and others may be less affected or become habituated to mine site disturbance. Vehicular traffic along the transportation corridor (in particular, the port access road) would be anticipated to alter movement patterns, because there are currently no roads in the majority of the transportation corridor. Some bears may avoid resting, denning, and foraging within the transportation corridor, or shift their movement patterns depending on traffic volume. Because the area has a high density of brown bears (see Section 3.23, Wildlife Values), some individuals would experience disturbance. The level of disturbance, displacement of feeding, denning, and other important life stage habitats would likely impact bears of varying age and gender differently. Boars, sows with cubs, and juvenile bears may respond differently, and behavioral avoidance of areas around the port access road may lead to increased interspecific competition. If the mine were permitted and constructed, many of these behavioral disturbance impacts would be expected to occur.

Gray Wolf

Gray wolves travel widely in pursuit of prey, using a variety of habitat types; however, gray wolves strongly avoid roadways and other areas with high levels of human activity (Person 2001; USFWS 2000), and may have a large avoidance zone around the mine site and access roads. Wolf behavior in the transportation corridor may be affected; either by avoiding the roadways, or potentially using them for travel (especially during the winter when roads are plowed/maintained). Overall, the magnitude of impacts would encompass wolf territories that overlap with the mine site and other project components. There are currently no mines in the area, and the disturbance from the project may cause wolves to avoid the area or alter their movement patterns. They may change denning locations or forage in new areas away from the project, especially if the mine causes caribou and moose distributions to change. The duration would last for the life of the project, and the extent would encompass all project components, and potentially longer, if it affects prey populations. Impacts would be expected to occur because wolves have shown avoidance of roadways and areas with high levels of human activity (Person 2001; USFWS 2000).

Small Terrestrial Vertebrates

Some small mammals present in the direct footprint of project components at the beginning of construction are anticipated to vacate the area due to presence of humans and ground-disturbing equipment. Other species may be attracted to project components due to newly created shelter and feeding opportunities. Some individual small mammals and wood frogs (*Lithobates sylvaticus*) may be more susceptible to disturbance during the process of mine site development. Although wood frogs were detected in many of the wetlands and waterbodies in the mine site, they are likely to also occur along the transportation corridor, around ferry terminals, and the port. Any habitat avoidance during construction and operations would be additive to the direct habitat loss at the project components.

The magnitude and extent of impacts would be that some small terrestrial vertebrates would avoid the transportation and natural gas pipeline corridors and Amakdedori port due to loss of habitat, and resulting edge impacts (e.g., increased predation along edge habitats and habitat changes). In summary, the magnitude of impacts would include behavioral avoidance of the project because many smaller terrestrial mammals may avoid areas during construction; but some species, such as red foxes, may eventually become accustomed to the presence of the mine. The duration would last for the life of the project, and extent would include the entire project footprint.

Injury and Mortality

Species may experience injury and mortality from a variety of sources such as habitat avoidance and food/territory competition, vehicular collisions, lethal removal due to defense of life and property, and increased access to areas for legal hunting. The potential for an increase in access for hunting from the transportation corridor is discussed in detail in Section 4.5, Recreation; and Section 4.9, Subsistence. The WIP would outline measures to reduce impacts to wildlife species, including proper trash disposal, containment of wildlife attractants, defining speed limits on roads, and prohibition of hunting, among others.

The main source of injury and mortality directly related to the project would be the potential for wildlife strikes along the transportation corridor. In terms of extent, injury and mortality would have a low potential to occur at the mine site and Amakdedori port due to the low speeds vehicles would likely be traveling. In terms of magnitude, injury and mortality on project roads would be greatest during construction and operations, because the access roads would be built through previously undeveloped habitats. The extent of impacts would encompass 78 miles of gravel road that would be constructed between the Amakdedori port and the mine site. As previously detailed, during operations, daily truck traffic would equate to one truck every 21 minutes. A regulated speed limit on the gravel transportation corridor roads would be maintained for dust suppression and safety. There would be additional light vehicle traffic (i.e., vehicles other than large trucks transporting concentrate, fuel, and consumables) along the transportation corridor, increasing the number of daily vehicle trips. Use of salt or other applicants on the road surface for safety is currently undetermined. Therefore, the magnitude and extent of impact of wildlife being attracted to the access roads due to salt—and increased potential for injury and mortality —are unknown. The WIP would outline ways to reduce the potential for wildlife mortality along the road; however, varying weather and seasonal conditions would likely cause periods of increased mortality for some species (such as increased moose mortality during winter months, and reduced bear mortality during hibernation). The duration of these impacts would be long-term, lasting through the life of the project.

Clearing of adjacent roadside vegetation and reducing traffic speeds would help reduce the potential for collisions with terrestrial wildlife (Gunsen et al. 2011). Wildlife safety mitigation measures for the transportation corridor would include vegetation management to increase visibility. Visibility would be improved by reducing roadside vegetation (trimming of shrubs and trees) that may obscure wildlife approaching the road, and reducing its attractiveness. Vehicle speeds would also be reduced along the transportation corridor. The maximum speed limit for the road system would be set at 35 mph. Wildlife present on the road would be given the right-of-way. Traffic would stop, if necessary, to allow the safe passage of wildlife crossing, or walking along, the road. (PLP 2019-122).

Caribou

Caribou distribution around project components is detailed in Section 3.23, Wildlife Values. Caribou would not be anticipated to occur in large numbers in the vicinity of the mine site during construction and operations (due to behavioral avoidance); would be anticipated to occur as scattered individuals around Amakdedori port; and would be anticipated to occur uncommonly along the transportation and natural gas pipeline corridors. Caribou would be expected to move away from areas of human activity during operations, especially during blasting. As detailed in Boulanger et al. (2012), in terms of extent, caribou would be expected to avoid a large area of habitat around the mine site due to behavioral disturbance; therefore, caribou would not be anticipated to occur within range of injury or mortality during any blasting. The primary potential for injury or mortality would be through vehicle collision while crossing roads in the mine site and along the transportation corridor. A regulated speed limit at the mine site and a 35 mph speed limit along the transportation corridor, along with measures to be specified in the WIP, would reduce the potential for injury or mortality. Additionally, the WIP would outline vehicle restrictions for when caribou are adjacent to roadways to prevent injury and mortality. There would also be a potential for increased hunting pressure from increased accessibility to areas, especially along the transportation corridor.

In summary, the magnitude and extent of impacts would be the potential loss of individual caribou from mortality on the access roads and increased/altered hunting pressure. The duration would last for the life of the project, and the extent would mainly be limited to the mine and port access roads.

Moose

Moose are known to occur in the analysis area, and are at risk of vehicular collisions during construction and operations; and to a lesser extent, after closure, depending on the final determination of the access roads. Moose-vehicle collisions are well documented, especially during long nights and short, dimly lit winter days. Collisions vary depending on snow conditions and road conditions. In terms of magnitude, the majority of collisions occur during the winter months, when accumulating snow forces moose into lowland areas, often around roads where travel is easier and food sources are more exposed (ADF&G 2019b). Moose sometimes feed near roads (often depending on shoulder vegetation management), and rest or travel along cleared roads during heavy snow conditions. They may cross roads when vehicles are present, and be startled, running from one side to the other. This may cause cows to be temporarily separated from their calves, and increases their risk of injury or mortality through vehicle collisions when the animals try to reunite. Although project vehicles would be restricted to a 35 mph speed limit, the potential for injury and mortality exists during all three project phases, especially at night or during other periods of poor visibility, and in winter when animals may use access roads to escape deep snow. Snow berms along the road would be maintained with breaks to allow moose to safely exit the roadways.

The mine site contains low densities of moose due to less suitable habitat, compared to the habitat of the transportation and natural gas pipeline corridors. Because most vehicles and equipment would be traveling at low speeds in the mine site, moose density is low, and the open, low-growing vegetation permits greater visibility, moose would not be expected to be struck in the mine site footprint.

Although there are low moose densities across the analysis area, moose tend be concentrated in riverine areas where preferred forage occurs. The 74 miles of road that compose the transportation corridor cross many riverine areas where moose may occur; therefore, there is the potential for moose to be struck by project vehicles. This risk would be greatest around dawn and dusk, when moose are typically more active; during winter; and during periods of low visibility.

The magnitude of impacts would be that few individual moose could experience injury and mortality, especially because moose density is low in the analysis area, and the extent is primarily along the transportation corridor. The duration would last for the life of the project and possibly longer, depending on the ultimate fate and management of roads post-closure. There would be a likelihood of occurrence, because moose are killed on roads, particularly in winter and during periods of reduced visibility.

Bear

Across the species' range, one factor that has caused reduction in brown bear abundance has been the availability of human access into brown bear habitat by roads built for resource extraction (Boulanger and Stenhouse 2014). One study in Alberta, Canada by Boulanger and Stenhouse (2014) attempted to estimate the direct demographic impact of roads on survival rates, reproductive rates, and other demographic parameters for brown bears. They found that sex and age class survival was related to road density, with sub-adult bears being most vulnerable to road-based mortality. Additionally, females with young of the year and/or yearling cubs had lower survival rates compared to females with 2-year-old or no cubs (Boulanger and Stenhouse 2014).

As resource extraction activities enter an area, road construction can provide entry for hunters and other users (McLellan 1989). The port access road would be in an area with high brown bear densities, and occurs directly north of Katmai National Park and Preserve and McNeil River State Game Refuge and Sanctuary. In terms of magnitude and extent, these areas have the highest documented concentration of wild brown bears in the world, and include popular bear-viewing locations (ADF&G 2018b). According to ADF&G, no one has ever been injured by a bear at McNeil River, and no bears have been killed by visitors who felt threatened since the permit program to access the sanctuary was initiated (ADF&G 2018b). Amakdedori port and the port access road would be approximately 13 miles north of McNeil River Falls.

Brown bears are common in the area along the port access road and Amakdedori port, especially along coastal plains in the early summer, and then along salmon-spawning streams later in the summer and fall. This was documented in 2018 Environmental Baseline Data (EBD) studies along the port access road, with bears along the coast in the spring and early summer, and along salmon streams later in the summer. Therefore, bears move around in relation to seasonally available food resources. Bears would be expected to cross the port access road as part of their regular movement patterns, but may show initial caution, or avoidance. Because the road would be a novel item in the landscape, bears may be wary of crossing it initially. As detailed above under Behavioral Disturbance, brown bears in particular would likely avoid the transportation corridor during periods of high vehicular traffic. The magnitude of impacts to brown bears include the potential for an undetermined number to experience injury or mortality along the transportation corridor across the life of the project. Roads may serve as ecological traps for brown bears. Female brown bears with cubs-of-the-year tend to be more attracted to roads due to higher forage availability (often early in the season/springtime), and to avoid potentially infanticidal adult males (Northrup et al. 2012, as cited in Penteriani et al. 2018). The potential for bears to be impacted along project roads would likely fluctuate in relation to age and gender of bears, the location of seasonal resources, movement corridors, time of day, and season. Bears that are forced to den farther away from the transportation corridor due to behavioral avoidance have a potential for injury or mortality through interspecific competition for optimal denning locations. There would also be a potential for bear mortality due to defense of life and property. Bears that become habituated and frequent the mine site, ferry terminals, Amakdedori port, or other project locations, may become a safety risk. Some of these bears may experience hazing and other negative human interactions, and then travel to areas such as Katmai National Park and Preserve and McNeil River State Game Refuge and Sanctuary. Bears that are negatively habituated to the project, or have become food conditioned, may become a danger to the public at bear-viewing areas. Human food–conditioned bears can become a problem, and dangerous to personal property and human safety (Gunther and Wyman 2008). Most bears conditioned to human foods eventually become aggressive in their efforts to obtain human foods, which may result in damage to property, injury to humans, and ultimately destruction of the bear (Gunther and Wyman 2008). In contrast to food conditioning, human habituation in wildlife, defined as the waning of an animal's flight response (loss of avoidance or escape response) following repeated exposure to inconsequential stimuli, is not necessarily detrimental to bears or humans. The success of McNeil River State Game Refuge and Sanctuary has hinged on bears becoming habituated to humans acting in a predictable manner, often in close quarters. Although the port access road may cause some injury and mortality to brown bears, especially during the initial years during construction and operations, some brown bears have shown the potential to become habituated to regular, consistent, and predictable human behaviors. Habituation can benefit some bears (especially younger bears and females with cubs) by allowing them access to high-quality food resources adjacent to roads that would otherwise be underused (Gunther et al. 2018). Three forms of habituation can occur in Alaska: bear-to-bear, bear-to-human, and human-to-bear (Smith et al. 2005). Bear density is an important factor influencing a bear's overt reaction distance; where bear density increases, the overt reaction distance decreases, as does the likelihood of bear-human interactions. Bear-to-bear habituation is responsible for shaping bear aggregations and for creating the relatively safe environment for bear viewing at locations with high bear densities (Smith et al. 2005). Bears' social flexibility enables them to habituate to one another in areas of rich forage resources. Because bears that use McNeil State Game Refuge that may be bear-to-bear habituated and bear-to-human habituated may use areas along the port access road and around the port, it is crucial that human activity at the port and along the port access road remain predictable and benign.

Many of the general measures, and those specific to brown bears outlined previously above, are designed to reduce the potential for negative bear and human interactions. Specifically, these include the creation and implementation of a detailed bear interaction plan as part of the WIP. Methods to decrease potential negative interactions include use of bear-proof containers and trash receptacles used for food and garbage. Mandatory training would be required for mine workers on ethical behavior around brown bear populations (e.g., strict use of bear-safe trash cans; strict prohibition of bear feeding and harassing). Implementation of a WIP may reduce the potential for conflict between wildlife and humans through a variety of measures, such as enforcing a 35 mph speed limit on project roads. There would be also a potential for increased hunting pressure from increased accessibility to areas, especially along the transportation corridor. The project would have a no hunting, fishing, or gathering policy for non-local employees to minimize competition for local resources. However, the port access road would remain open for use by local residents.

In summary, the magnitude of injury and mortality impacts would be loss of individual bears along the access roads and during defense of life and property, or from other negative human interactions. The duration would last for the life of the project, and potentially longer, depending on the long-term management of the access roads. The extent would include all project components, but could extend into adjacent areas if negatively habituated bears move into public bear-viewing areas. There would be a likelihood of occurrence because bears may be injured or killed along the transportation corridor, and there would be a potential for food-conditioned bears to become a safety hazard.

Gray Wolf

Similar to other large mammal species discussed above, the greatest risk to gray wolves from the project would be the potential for vehicular collisions and the potential for increased hunting pressure. In terms of magnitude of potential effects, surveys did not document large numbers of wolves in the area; therefore, regulated speed limits on the access roads and guidance provided in the WIP would reduce the potential for injury and mortality to gray wolves. The magnitude of impacts may include the rare instance of injury or mortality for individual wolves, especially because wolves are uncommon in the analysis area. The duration would last for the life of the project, and extent would include the entire project footprint.

Small Terrestrial Vertebrates

Small mammal species have the potential for injury and mortality from a variety of sources, and impacts are often species-specific. Blasting and removal of rock and vegetation during construction and operations of the mine (including clearing and vegetation removal) may cause injury and mortality, especially to small mammals and wood frogs that have limited ability to move away or avoid heavy machinery. In terms of extent, some species (such as Arctic ground squirrels [*Spermophilus parryii*] and snowshoe hares [*Lepus americanus*]) may experience injury and mortality due to collisions with project vehicles, especially along the transportation and natural gas pipeline corridors. In terms of magnitude, there would be frequent use of the mine and port access roads by vehicles, especially while mine equipment and construction materials would be delivered to the Amakdedori port and transported on the road. Some species, such as Arctic ground squirrels, may experience an increase in roadkill mortality due to their use of dirt roads for burrowing. The risk of injury and mortality from collisions with vehicles would be higher for young-of-the-year wildlife, and during limited visibility such as during the winter, twilight hours, and during inclement weather. When roads are icy, increased slowing and stopping distances, coupled with decreased visibility, may lead to increased mortality. Additionally, small mammals may experience increased predation from predatory species using the newly created edge habitat. Because the transportation corridor would bisect habitat that currently lacks an established road, small terrestrial vertebrates would experience edge effects such as increased predation and increased mortality due to lack of cover while foraging and transiting throughout adjacent habitat. Wood frogs would likely experience impacts as the mine site is dewatered and wetlands are filled to construct the project. Wood frogs that are not able to vacate the area during construction would likely experience injury and mortality.

In summary, the magnitude and extent of impacts may include mortality of individual small mammals along the 78 miles of new roads. Although the amount of mortality is difficult to quantify, roadkill would likely increase seasonally when small mammal abundance is greatest (in late summer when novice young-of-the-year are present) and during peaks in wildlife population cycles. The duration would last for the life of the project, and the extent would generally include the transportation corridor, and to a lesser extent the mine site. In the mine site, vehicles would move slower, and there is less available adjacent habitat in the mine site; therefore, the potential for vehicle collisions would be reduced. There is a high likelihood of injury and mortality to small terrestrial vertebrates in the vicinity of the transportation corridor in relationship to their seasonal abundance, edge effects, and behavior of foraging along roadsides.

Habitat Changes

There would be permanent and long-term removal of vegetation in the mine site during construction and operations of the mine, which currently provides habitat for a variety of wildlife species. Project component acreages are provided in Chapter 2, Alternatives, Table 2-2, and highlighted in this section. In terms of magnitude and extent, terrestrial wildlife species that use project components would experience a direct loss of 9,611 acres of breeding, foraging, wintering, and dispersing habitat during construction and operations. Some of the large mammal species such as caribou, moose, bears, and gray wolves occupy the habitat in the mine site at varying densities and at different times of the year. In terms of the duration of effects, a large portion of this habitat would be revegetated once the project would be completed, and the species may return over time as the vegetation and habitat mature to conditions suitable for each species. The open pit lake and other project components that would not be reclaimed and restored would result in a permanent loss of habitat for all terrestrial species.

The Amakdedori port facilities would result in a loss of vegetation that supports a variety of wildlife species. The port facilities would be removed during closure, except for those required to support shallow draft tug and barge access to the dock for the transfer of bulk supplies. Disturbed areas would be recontoured, graded, ripped, and scarified. Topsoil and growth media would be placed as needed, and surfaces would be seeded for revegetation.

Construction of the transportation and natural gas pipeline corridors would include the removal and conversion of vegetation to gravel roads, ferry terminals, and material sites. This habitat removal would be additive to that at the mine site and Amakdedori port; post-closure, the roads would remain in place as long as needed for long-term post-closure water treatment and monitoring.

With regard to terrestrial wildlife, winter dust fall in the corridors along roads in Alaska may cause early snow melt and soil thaw. This may concentrate waterfowl, ptarmigan, and their predators in snow-free areas along the roadside, making these wildlife susceptible to collision with passing vehicles. Caribou may take advantage of the early snow-free areas for grazing; and grizzly bears, raptors, and other predators may use these areas to hunt ground squirrels and voles (Walker and Everett 1987).

Changes in vegetation communities are discussed in Section 4.26, Vegetation. In terms of extent and duration, these changes would affect the availability and quality of habitat for terrestrial wildlife in the analysis area, during both construction and operations, and potentially post-closure. Although all affected habitat would not be directly lost (apart from habitat converted to open water, such as the pit lake), it may be become less suitable, and may cause displacement of individuals to more suitable habitat.

Caribou

Caribou are highly mobile and their range changes with density of animals, snow pack, and forage availability. The main calving areas in the region have changed dramatically in the last 5 years, and historical data show how the range of the Mulchatna herd has changed over time. Currently, the herd is at severely depressed numbers of approximately 13,500 individuals.

As described previously in Section 3.23, Wildlife Values, the mine site is in the range of the Mulchatna caribou herd. The habitat in the mine site is seasonally used by caribou, mainly during the post-calving summer period. Traditional ecological knowledge (TEK) of the Mulchatna caribou herd identified areas of caribou concentration, which has shifted over time from the eastern portion of the range (1960-1979) to the west during the 1990s (Van Lanen et al. 2018). During the mid-1990s, when the Mulchatna herd had reached its peak population, the herd expanded its range north and west. At the same time, the herd shifted away from the analysis area. Although unknown at this time, the Mulchatna caribou herd may shift back toward its traditional calving areas at some point in the future, which would be closer to the mine site. In addition to removal of habitat, per Boulanger et al. 2012, caribou avoided habitat in a radius of 6.8 to 8.7 miles around an active mine in Alberta, Canada. This area of avoidance is considered habitat that may not be used due to behavioral disturbance. In terms of extent of potential impacts, with a conservative approach, an 8.7-mile buffer around the mine site corresponds to a total avoidance area of approximately 291,313 acres (roughly 1 percent of their current range based on limited radio-collared data).

Additional habitat along the transportation corridor may be avoided due to fugitive dust and impacts to lichen communities along the road. As detailed in Section 4.26, Vegetation, dust-induced changes in plant community composition would likely vary by vegetation type, and could occur out to 330 feet from the edge of the transportation corridor. Lichen- and *Sphagnum*-dominated communities would be the most sensitive to dust deposition (Farmer 1993). Lichens are extremely slow-growing, and take decades to over a century to recover from disturbance (Joly et al. 2010). The sensitivity of lichen-rich communities to dust deposition and disturbance in general is important for caribou, which have been shown to derive much of their winter diet from reindeer lichens (Joly et al. 2010). Because large migratory herds of caribou seek out lichen-rich areas during the winter, once range areas are depleted, they may shift their range to find new areas with high lichen abundance while former range areas recover. Although the recovery period for depleted winter ranges can take up to decades, the recovery period can be hampered by climate change, which favors increased wildfire activity and shrub and deciduous forest expansion (Joly et al. 2010). Therefore, caribou avoidance around the mine site and around other project components, coupled with potential impacts from fugitive dust, may cause caribou to use other areas in their range.

As detailed previously under the behavioral disturbance section, Johnson et al. (2019) found that female caribou reduced their use of habitat within 3.1 miles of development during the calving period; within 1.2 miles during the post-calving period; and within 0.6 mile during the mosquito harassment period. Therefore, if the transportation corridor, including the ferry terminals and terrestrial portion of the port, are buffered by a 3.1-, 1.2- and 0.6-mile radius, the level of additional habitat avoidance would be around 272,589 acres, 111,634 acres, and 57,997 acres, respectively. In summary, the magnitude of potential habitat loss (including both direct and indirect) could reach 291,313 acres, depending on the extent of habitat avoidance. This represents around 1 percent of their current occupied range based on the limited radio-collared data. The additional acreage of avoidance around the transportation corridor, ferry terminals, and port could reach up to 272,589 acres, especially during the calving period. If impacts are assessed during the calving period, the combined acreage of avoidance around the mine site, transportation corridor, ferry terminals, and port, in addition to the direct habitat loss from project components, could total over 563,902 acres of habitat that would be effectively removed from use for the Mulchatna caribou herd. The duration would last for the life of the project, and potentially longer, depending on the level of human activity during post-closure long-term management and from use of the access roads by local residents. The extent of impacts would include all project components. The direct loss of habitat and additional habitat avoidance would be certain to occur if the project is permitted and constructed.

Moose

As detailed in Section 3.23, Wildlife Values, moose density is low in the area around the mine site (i.e., 0.07 moose per square mile) (ABR 2011a). Moose density in the transportation and natural gas pipeline corridors is slightly higher, at an estimated 0.13 moose per square mile (for areas around Iliamna Lake). The magnitude of impacts would be loss of 9,611 acres of habitat that has a low density of moose. The duration would last for the life of the project, and longer in some areas that would not be fully restored. The extent would represent the direct footprint of all mine components, plus a buffer area that is avoided due to disturbance. The impacts would be certain to occur if the project is permitted and constructed because the habitat would be removed, and moose are known to use the area.

Bear

In terms of magnitude and extent of impacts, the direct loss of approximately 9,611 acres of habitat from construction and operations of the project (including the mine site, Amakdedori port, ferry terminals, and transportation and natural gas pipeline corridors) would be expected to displace bears that use the habitat for foraging, denning, and as part of their home range. There would be additional habitat around mine components that would be indirectly removed by avoidance due to behavioral disturbance. Avoidance areas may include salmon spawning streams (and other locations of seasonal food resources), preferred denning habitat (such as near Amakdedori port), and movement corridors. Habitat fragmentation may also cause bears to avoid some areas that contain important life history attributes (such as preventing access to feeding areas). Bears that experience habitat loss (either directly or indirectly) would be anticipated to use the surrounding habitat, although they may encounter increased competition with other bears. Brown bears are distributed throughout the landscape and are seasonally concentrated around resources such as high-quality vegetation sources (sedges, grasses, berry sources) and salmon-spawning streams. In particular, brown bears may avoid locations or alter foraging patterns where the transportation corridor crosses anadromous streams. Habitat loss may also result if some bears are hesitant to cross mine access roads, particularly the port access road. The port access road may inhibit movement patterns, and cause bears to seek out other locations for foraging and denning. As mentioned above under Behavioral Disturbance, brown bears have been shown to avoid habitat within a variety of distances from roads. McLellan and Shackleton (1988) report an avoidance radial buffer of 328 feet from roads, while Flynn et al. (2012) report avoidance of roads ranging from radial distances of 0.3 mile to 1.9 miles, with most road crossings occurring during decreased periods of traffic and at night.

Based on a literature review conducted by Linnell et al. (2000), North American bear species generally select den sites from 0.6 mile to 1.2 miles from human activities (roads, habitation, industrial activities, etc.). Linnell et al. found that activity closer than 0.6 mile caused a variety of responses, including den abandonment, especially if the disturbance occurred early in the denning period. Based on a study conducted at the Greens Creek Mine on Admiralty Island in Southeast Alaska, Schoen and Beier (1990) found that brown bears denned farther from the mine site, with a mean distance of 7.3 miles once construction began. Although the project is not directly comparable to the Greens Creek Mine in terms of bear habitat, mining techniques, etc., the Green Creek Mine still provides a robust example of a well-studied mine and its impacts on the local brown bear population. Therefore, using a 7.3-mile distance as a radial buffer around the mine site, bears may avoid denning in a large area around the mine site.

Specific to black bears, the analysis area is generally considered low-quality, because surveys document few bears (Becker 2010), mainly concentrated to the north and east of Iliamna Lake, and the loss of habitat would be anticipated to have little effect on black bears.

In summary, the magnitude of direct habitat loss would be 9,611 acres plus additional indirect habitat loss through avoidance. The indirect habitat loss through avoidance and habitat fragmentation may include loss of foraging and denning locations, altered movement corridors, and increased interspecific competition. The duration would last for the life of the project and longer, especially because the access roads would remain open for long-term water quality management, and local resident use would be permitted. The extent would include all of the mine components, and in particular, the port access road. Given the high density of brown bears in the area, impacts would be expected to occur if the project is permitted and constructed. Although the impacts to the brown bear population in the area from direct and indirect loss of habitat and subsequent interspecific competition are difficult to accurately quantify, there could be noticeable impacts.

Gray Wolf

Several individual gray wolves were detected dispersed across the analysis area over multiple years, but no packs of wolves or dens were detected in the mine site (ABR 2011a). Two gray wolves were detected in summer 2018 around Amakdedori port. The magnitude of habitat loss would be 9,611 acres of direct impacts plus additional habitat that would be avoided. The duration would last for the life of the project, and the extent would include all of the mine components. Impacts would be expected to occur if the project is permitted and constructed, because wolves have been detected in the area, and would experience direct displacement of foraging areas and indirect avoidance of areas due to behavioral disturbance.

Small Terrestrial Vertebrates

As detailed in Section 3.23, Wildlife Values, multiple smaller mammalian species such as coyotes (*Canis latrans*), red foxes, river otters (*Lontra canadensis*), wolverines (*Gulo gulo*), beavers (*Castor canadensis*), and other species were found throughout the analysis area. There are additional mammal species that are not considered “furbearers,” and are known to occur in the analysis area. These include North American porcupine (*Erethizon dorsatum*), hoary marmot (*Marmota caligata*), Arctic ground squirrel, snowshoe hare, tundra hare (*Lepus othus*), collared pika (*Ochotona collaris*), and various species of mice, lemmings, shrews, voles, and wood frogs. These species would experience a direct loss of habitat during construction and operations of the project. Some of the habitat would be restored or reclaimed and likely repopulated by these species from adjacent unaffected areas, but the pit lake and infrastructure necessary for long-term pit lake water management would remain a permanent loss of habitat. In summary, the magnitude of habitat loss would be 9,611 acres, because the home ranges of small mammals would be directly removed. The duration would last for the life of the project, and longer for permanent impacts such as the pit lake. The extent would encompass all project components; impacts would be expected to occur if the project is permitted and constructed.

4.23.4.3 Marine Mammals

Potential impacts specific to construction, operations, and post-closure activities of the mine site, transportation corridor across Iliamna Lake, Amakdedori port, and the natural gas pipeline corridor across Cook Inlet are described in the following sections. The project has the potential to directly and indirectly impact marine mammals through behavioral disturbance and habitat changes, as detailed in the following sections. Injury and mortality of marine mammals have a low potential to occur because vessels would be traveling at slow speeds across Iliamna Lake, and less than 10 knots when transiting between the port and lightering locations in Kamishak Bay.

A detailed analysis for potential impacts to threatened and endangered marine mammal species is provided in Section 4.25 and Appendix K4.25, Threatened and Endangered Species. This includes underwater noise impacts from construction of the port using various designs, and noise related to installation (from vessels and various dredge technologies) of the natural gas pipeline and adjacent fiber-optic cable.The same noise levels and potential impacts have a potential to occur to non-listed marine mammal species such as gray, minke, and killer whales, Dall’s and harbor porpoise, and harbor seal in the analysis area. There is also a low potential for California sea lions to be encountered, particularly in shipping lanes in the southern parts of Alaska. In particular, impacts from underwater noise from the construction of the port are not reiterated here. The caisson dock construction would have lower noise levels compared to pile-driving or sheet pile associated with solid fill or pile-supported docks. The same Level A and Level B hazard radii would apply, and marine mammal monitoring by Protected Species Observers (PSO) would be implemented (as detailed in the NMFS biological assessment in Appendix H). Therefore, the discussion of potential impacts to marine mammals below is less focused on impacts to marine mammals in Cook Inlet, and includes information on potential impacts to the population of harbor seals in Iliamna Lake.

Impacts from the construction and operations of the mine site would not be expected for marine mammals due to their absence in the mine site footprint. Project sources of noise, which may disturb marine mammals in project component areas, include vessels used during installation of the natural gas pipeline across Iliamna Lake and Cook Inlet; construction noise associated with the construction of the Amakdedori port, ice breaking to conduct barging operations across Iliamna Lake; and aircraft used during construction and occasionally during operations at Amakdedori port.

Project components most likely to impact marine mammals would be the marine and freshwater portions of the transportation corridor, which would involve near- and offshore vessel activity across Iliamna Lake and Cook Inlet, the construction of the Amakdedori port and natural gas pipeline and adjacent fiber-optic cable. In this section, species-specific potential impacts are discussed by project component, if information is available. In terms of likelihood, these impacts would be expected to occur if the project is permitted and constructed. Potential impacts from oil or another substance spill are discussed in Section 4.27, Spill Risk.

Behavioral Disturbance

Underwater and Airborne Noise

The effects of underwater and airborne sound from industrial activities on marine mammals may include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, temporary or permanent hearing impairment, or non-auditory physical effects (Richardson et al. 1995a; Southall et al. 2019). More information on marine mammal underwater and airborne hearing capabilities and general effects from noise on marine mammals is presented in Appendix K4.25, Threatened and Endangered Species. Potential impacts to federally listed marine mammals would be the same for non-federally listed species. Whether a specific noise source would affect a marine mammal depends on several factors, including the distance between the animal and the sound source, the sound intensity, background noise levels, the noise frequency, the noise duration, and whether the noise is pulsed or continuous.

Anticipated sources of noise include vessels used during installation of the natural gas pipeline in Iliamna Lake and Cook Inlet; anchor handling operations associated with natural gas pipeline construction; construction noise associated with the Amakdedori port and ferry terminals on Iliamna Lake; vessels used in the transportation corridor across Iliamna Lake, which includes the need to break ice during mining operations; and aircraft during construction and operations at Amakdedori port.

The caisson dock under Alternative 1a would result in the lowest magnitude of noise impacts to marine mammals, because no sheet- or pile-driving would be necessary. Therefore, underwater noise impacts would be greatly reduced when compared with the earthen causeway dock and pile-supported dock variants described in the alternatives.

Vessel and aircraft noise generally does not exceed thresholds that may result in injury. A summary of noise sources for each activity related to the project is presented in Appendix K4.25, Threatened and Endangered Species.

The magnitude of impacts from underwater and airborne noise on marine mammals would vary depending on the noise source and may affect marine mammals if they are present during construction and operations. For construction of the port, caisson installation would require leveling of the seabed prior to caisson placement. As detailed in Section 4.25, Threatened and

Endangered Species (and applied to all marine mammals), all in-water use of heavy equipment for manipulating the substrate, including fill placement, would require a monitoring zone radius extending out to 984 feet (300 meters) from the sound source to avoid exceeding the NMFS level B marine mammal disturbance threshold of 120 decibels (dB). The ensonified area that would receive noise levels above the level B threshold (120 dB) from installation of the natural gas pipeline (and fiber-optic cable) would extend out 1.7 miles on either side of the pipeline centerline. This buffer would encompass the noise generated by both vessels and dredging equipment. Placement of the mooring buoys at the lightering locations would result in an ensonified area with a radius buffer of 1.7 miles, based on noise levels from tugboats operating bow thrusters. The noise levels generated by bulk carriers in established shipping lanes in Cook Inlet, the Gulf of Alaska, and beyond would extend 1.4 miles on either side of the vessels. The shipping lanes are approximately 4.6 miles wide; and when buffered by 1.4 miles on either side, equate to a shipping lane width of 7.4 miles. All other impacts to marine mammals in Cook Inlet, the Gulf of Alaska, and beyond are detailed in Section 4.25, Threatened and Endangered Species.

Underwater noise from ice-breaking operations in Iliamna Lake could displace harbor seals from overwintering sites. In particular, the ice-breaking ferry would generate loud noises near the Eagle Bay ferry terminal during ice-breaking. Although no studies have been conducted on the noise levels generated by ice-breaking ferries in Iliamna Lake, several studies have been conducted on other marine mammals, and impacts from ice-breaking vessels. In one study, Erbe and Farmer (2000) looked at the zones of impact around ice-breakers affecting beluga whales in the Beaufort Sea. Researchers found that the ice-breaker *Henry Larsen* generated two types of noise (bubbler system and propeller cavitation noise) that were audible to beluga whales from 21.7 to 48.5 miles away, depending on the specific location. They found that the zone of behavioral disturbance was slightly less, and masking of beluga communication signals was predicted to occur within a 8.7- to 44-mile range. It was determined that temporary hearing damage could occur if a beluga whale remained for at least 20 minutes within 0.6 mile to 2.5 miles of the ice-breaker (Erbe and Farmer 2000). Although beluga whales are not necessarily appropriate for comparison with harbor seals (that spend time hauling out of the water and are therefore less prone to impacts from underwater noise while above water), the impacts from underwater noise during ice-breaking activities can cover vast distances. Reactions of pinnipeds to ice-breaking activities appear to be less dramatic, with ringed and bearded seals on pack ice diving into the water within 0.6 mile of a vessel (77 FR 49922). The area where ice-breaking activities would occur is a known winter location for harbor seals, because they haul out under the ice on the shore in this area of the lake. Noise modeling would be conducted prior to submittal of an MMPA permit request, at which time the Applicant would determine the area of ensonification, duration, and density of harbor seals in affected portions of Iliamna Lake to better understand potential impacts from underwater noise on the species. During periods when Iliamna Lake is covered in ice, harbor seals access dry platforms for hauling-out and air spaces for breathing by exploiting air pockets that develop along shorelines when the water levels drop (Burns et al. 2016). If ice-breaking were to occur through these areas, the noise impacts on harbor seals that are under the ice hauled out on land may be difficult to determine, because the seal would not be visible. Noise propagation under the ice, but above the water level during ice-breaking, could cover a large area.

The extent to which project noise would be audible depends on source levels, frequency, ambient noise levels, the propagation characteristics of the environment, and sensitivity of the receptor (Richardson et al. 1995a). The magnitude of the impact from underwater noise from construction, operations, and reclamation activities of the transportation corridor through Iliamna Lake, Amakdedori port, and the natural gas pipeline corridor across Cook Inlet would affect marine mammals in the nearby vicinity. In particular, ice-breaking activities in Iliamna Lake could generate loud noises that disturb harbor seals in Iliamna Lake. However, implementation of industry-standard mitigation measures required through Endangered Species Act (ESA) and

MMPA consultation would reduce impacts. The duration of time that marine mammals may be exposed to underwater sound would be relatively short-term (for example, while a vessel passes by or during ice-breaking activities), but last for the life of the project. In particular, impacts would occur during pipeline installation, port and lightering location construction activities, and from vessel traffic during mine operations, including ice-breaking activities in Iliamna Lake. Exposure to disturbance would be expected when seasonal distribution and habitat selection overlap in time and space with in-water project activities.

Physical Presence (Vessel and Aircraft)

Impacts from physical presence can occur either from increased vessel traffic or newly erected human-made structures. Sources of physical presence include vessels used during installation of the natural gas pipeline in Iliamna Lake and across Cook Inlet; in-water construction associated with the development of Amakdedori port and the ferry terminals; lightering locations; vessels used throughout the transportation corridor (across Iliamna Lake and Cook Inlet); and aircraft and vessels during construction and operations.

The physical presence of low-flying aircraft, including helicopters, can disturb marine mammals, particularly individuals resting on the sea surface (reviewed in BOEM 2012) or hauled-out on land (Greig and Allen 2015; Kucey 2005; Suryan and Harvey 1999). Observations made from low-altitude aerial surveys report that the behavioral responses of marine mammals are highly variable, ranging from no observable reaction to diving or rapid changes in swimming speed or direction (Smultea et al. 2008). One response of marine mammals hauled-out on land to low-flying aircraft is to rapidly seek refuge in nearby water.

Reactions of marine mammals to vessels while in the water often include changes in activity (from resting or feeding to active avoidance), changes in surfacing-respiration-dive cycles, and changes in speed and direction of movement (NMFS 2013a).

Minke whales (*Balaenoptera acutorostrata*) have been observed to avoid boats when approached, and approach boats when they are stationary (Richardson et al. 1995a). Minke whales are thought to react similarly to other baleen whales, namely the humpback (*Megaptera novaeangliae*) and fin (*Balaenoptera physalus*) whales, discussed in Section 4.25, Threatened and Endangered Species. Harbor porpoises (*Phocoena phocoena*) often rest at the surface, and their reaction to boats can be strong within 1,300 feet (Polacheck and Thorpe 1990) out to 10.9 miles (Palka 1993). Harbor porpoises have often been seen changing direction in the presence of vessel traffic (Richardson et al. 1995a). Avoidance has been documented up to 1 mile away from an approaching vessel, but the avoidance response is strengthened in closer proximity to vessels (Palka 1993).

The distances at which harbor seals in the marine environment were disturbed and the level of disturbance (e.g., detection, alarm, and harassment) varied by region, type of vessel, and vessel speed. No information is known about reactions to disturbance of seals inhabiting freshwater; however, in the case of the seals that inhabit Iliamna Lake, they are the same species as marine harbor seals, and without literature specific to their reactions, the best available information to use in lieu of detailed studies is those of harbor seals as a whole species. The presence and movements of ships in the vicinity of seals can cause disturbance to harbor seals' normal behaviors (Jansen et al. 2010), and could potentially cause seals to abandon their preferred breeding habitats in areas with high traffic (Reeves 1998). Depending on circumstance, seals may not respond at all to vessel traffic, or may respond by deflection from the noise source, avoidance behavior, short-term vigilance behavior, or short-term masking behavior (NMFS 2015). Harbor seals hauled-out on mudflats have been documented returning to the water in response to nearing boat traffic (Richardson et al. 1995a). Harbor seals in the marine environment are known for vessel tolerance (Richardson et al. 1995a). However, vessels that approach haul-outs slowly may also elicit alert reactions without flushing from the haul-out; small boats with slow, constant speed elicit the least noticeable reactions (Richardson et al. 1995a). In Alaska specifically, harbor seals are documented to tolerate fishing vessels with no discernable reactions, and habituation is common (Johnson et al. 1989). Overall, vessel noise does not seem to strongly affect pinnipeds that are in the water (Richardson et al. 1995a).

Reactions of freshwater seals—such as those that inhabit Iliamna Lake—to vessel presence is unknown. There is a high level of use of Iliamna Lake by recreational and subsistence watercraft in the open water season. The impacts of a large ice-breaking ferry during winter would have disturbance impacts to seals, especially if seals are using air pockets under the ice that are then disrupted during ice-breaking activities. Additionally, noise associated with ice-breaking may cause seals to leave the area. Operations of the ferry across Iliamna Lake under Alternative 1a would be in the middle of the lake, and although seals are generally not observed in high density in the middle of the lake, there are several islands where they haul out, forage, and pups have been sighted that the ferry would travel past. In terms of geographical extent, as discussed under Underwater and Airborne Noise, above, harbor seals inhabiting Iliamna Lake are most commonly observed on the northeastern side of the lake, east of an imaginary line between Kokhanok and Newhalen, and therefore east of the natural gas pipeline and transportation corridor. Also, the transportation corridor lies to the west of the imaginary line between Kokhanok and Newhalen. Although seals that inhabit Iliamna Lake are largely found in the northeastern portion, there is a potential for adverse interactions with vessels during construction of the natural gas pipeline and operation of the ferry. The extent that physical presence would occur would be expected to only affect the area in the immediate vicinity of the project activity.

The magnitude of impacts from physical presence of vessels and equipment on marine mammals during all project phases would vary depending on the season, and sensitivity of marine mammals to disturbance. The physical presence of project vessels, equipment, and human operators are likely to cause behavioral avoidance of areas in the immediate vicinity of Amakdedori port and the lightering locations. The duration of impacts from vessels would last for the life of the project. The extent would be localized in Kamishak Bay. If any responses of marine mammals associated with aircraft were to occur, they would likely be of short duration. An incremental addition of vessels associated with the project may negatively affect marine mammals, as discussed above. In terms of extent, the construction of the natural gas pipeline would disturb marine mammals occurring in the immediate area. The duration that marine mammals would be exposed to vessel presence during construction would be short-term (during one summer [June through August]), occurring during pipeline installation and construction activities. Continued vessel presence throughout the life of the project (through operation of the mine until closure) would result in a long-term increase in physical presence from vessels accessing the port site and operations of the ferry across Iliamna Lake. Vessels associated with activities would have a transitory presence in any specific location and would be traveling slowly, allowing marine mammals to leave or avoid the area. The magnitude of impacts would be limited to brief behavioral responses such as reducing surface time, diving, swimming away, and leaving haul-out sites, in the case of harbor seals and Steller sea lions (discussed in Section 4.25, Threatened and Endangered Species), which could negatively impact marine mammals. Pinnipeds physiologically require a certain amount of time hauled out to meet their resting needs (Brasseur et al. 1996); if they are forced to leave haul-out locations from physical presence of vessels associated with the project, they could be expending energy that could have negative affects on other life history aspects. Likewise, harbor seals in particular can experience chronic stress if vessel traffic or other anthropogenic disturbances causes the animals to flush into the water (Cates and Acevedo-Gutierrez 2017), particularly during pupping in cold locations where they endure thermal stress (Jansen et al. 2010).

The magnitude of impacts from the physical presence of aircraft at Amakdedori port on marine mammals may occur during construction of the port access road, and include displacement from haulout and feeding locations. Aircraft landing at Amakdedori would likely cause marine mammals underneath the aircraft approach and take-off locations to swim away, dive, or otherwise vacate the area during aircraft operations. The duration that marine mammals may be exposed to aircraft presence would be temporary, because aircraft support would be expected to be intermittent and of short duration (2 years); only during construction of the port access road. Important harbor seal haul-out areas occur in Kamishak and Kachemak bays and along the coast of the Kodiak Archipelago and the Alaska Peninsula. Chinitna Bay, Clearwater and Chinitna creeks, Tuxedni Bay, Kamishak Bay, Oil Bay, Pomeroy and Iniskin Islands, and Augustine Island are also important spring-summer breeding and molting areas and known haulout sites (seals have a need to haul out in late June and July (pupping) and August (molting). The extent of impacts would primarily include the area around Amakdedori port, and any other locations where aircraft, including helicopters, may occur. Potential exposure to aircraft is expected to be of short duration and limited to landing and taking off of aircraft. These critical stages of flight are the noisiest, and are also when the aircraft are flying the lowest, well below the suggested 1,500 feet above ground level suggested by regulatory agencies to negate the physical presence reactions of marine mammals. Aircraft-related noise and visual disturbance are expected to have a negative effect on marine mammals limited to behavioral responses (such as diving, swimming away, reducing surfacing time). If marine mammals are forced to leave haul-out locations or flush in the water as a result of aircraft associated with the project, they could be expending unnecessary energy that could have negative effects on other life history aspects.

One potential impact from the physical presence of the port and lightering locations is the potential for marine mammal movement to be influenced by bright lights. Several studies summarized in Greer et al. (2010) describe how some pinniped species in certain areas have learned to use artificial lighting from bridges and vessels to forage on prey species at night. Additional studies looked at the risk to marine mammals from lighting from offshore development around Australia, and found no evidence that artificial lighting negatively affected migration, feeding, or breeding behaviors in cetaceans, largely because cetaceans used acoustic rather than visual cues to monitor their environment. Although there are currently no forms of artificial light around Amakdedori, the port facilities are not in any known marine mammal migration corridors. A lighting plan would be developed for the port to reduce the construction and operational impacts from lights that might impact marine birds, which could reduce potential impacts from lighting on marine mammals as well.

Injury and Mortality

Vessel Collision

Marine mammal species are vulnerable to collisions with moving vessels (Pace 2011). There would be increased vessel traffic in Cook Inlet, as well as through Iliamna Lake, as a result of the project components, and therefore a greater possibility of vessel strike impacts to marine mammals. Of the marine mammals that occur in lower Cook Inlet, only one ship strike of a gray whale (*Eschrichtius robustus*) was reported in Alaska between 1999 and 2003 by the California Stranding Network (Allen and Angliss 2012). Specifically, in Cook Inlet, no collisions of gray whales with vessels have been reported. The majority of the gray whale population migrates south of the mouth of lower Cook Inlet in the Gulf of Alaska. There have been three reports of whale-vessel collisions in Cook Inlet between 1978 and 2011 (one humpback, one unidentified whale, and one beluga whale) (Neilson et al. 2012), but none have been reported in lower Cook Inlet. In rare instances, killer whales (*Orcinus orca*) have been injured or killed by collisions with passing ships and powerboats, primarily from being struck by the propeller blades (Carretta et al. 2004).

An increase in vessel traffic across Iliamna Lake may increase the likelihood of vessel interactions with the Iliamna Lake seal. Given this population of harbor seals is around 400 animals, the loss of animals to vessel strike may have adverse effects on the success of the population. Therefore, the magnitude of impacts from injury and mortality would be that a few individuals could be affected; however, the potential for vessel encounters would be reduced, given the slow speeds that vessels would be traveling when they transit between the port and lightering locations (less than 10 knots). The duration that marine mammals may be exposed to vessel collisions along the natural gas pipeline corridor would be short-term, during pipeline installation and construction activities. The duration of impacts in Iliamna Lake and at Amakdedori port would last for the life of the project. The extent would encompass the footprint of project activities in Cook Inlet and Iliamna Lake.

Habitat Changes

In terms of magnitude, the development of the north ferry terminal in Eagle Bay and the south ferry terminal in Iliamna Lake have a potential to cause both direct habitat loss and indirect loss through avoidance of known year-round feeding locations to less suitable areas for Iliamna Lake seals. Furthermore, the small islands around the Eagle Bay ferry terminal are used by Iliamna Lake seals for foraging, and for summer and winter hauling-out. The area between Eagle Bay and the south ferry terminal contains several early spring pressure cracks and seal haulout sites, as well as some winter pressure cracks and haulout sites. The south ferry terminal is a known seal feeding site, and seal pups have been observed along the shore near the mouth of the Gibraltar River. The habitat changes would be most impactful on Iliamna Lake seals during the winter months, when the ice-breaking ferry has the potential to disrupt their winter haul-out site under the ice around the Eagle Bay ferry terminal. There would be a small amount of acreage lost in comparison to total available habitat in Iliamna Lake, due to the construction of the ferry terminals. There is a potential for ice-breaking activities to negatively impact harbor seals during the winter months by either creating new, open leads for seals to inhabit—thereby increasing the likelihood of a vessel interaction—or by direct loss of air habitat (e.g., sea ice). Therefore, the area around both ferry terminals and the ferry route is used by Iliamna Lake seals for different reasons throughout the year.

For harbor seals in Kamishak Bay, onshore support facilities might displace harbor seals from hauling out or foraging near the Amakdedori port. In Cook Inlet, harbor seals tend to haul out near areas with available prey, and avoid areas with high anthropogenic disturbance (Montgomery et al. 2007). They select sides with rock substrate that are near deep water. Specific to the project, harbor seals were hauled out in Iliamna and Iniskin bays, around Augustine Island, around Nordyke Island, on rocky intertidal reefs that are exposed at low tide in Kamishak Bay, and several areas in southern Kamishak Bay, especially around Douglas River Shoals (Montgomery et al. 2007). Although there were no haul-out locations specifically at the proposed port location, the presence of the port at Amakdedori Port and associated human disturbance has a potential to cause avoidance of haulout locations in Kamishak Bay that may be transited past by project vessels. These impacts would occur in the vicinity of the facilities (including vessel routes) and extend for the life of the project. The magnitude of direct impacts to harbor seals (and other marine mammals foraging in the area) would be 10.7 acres of loss of benthic marine habitat from construction of Amakdedori port.

The extent of habitat alteration in the summer would only be expected to affect the immediate area around the north and south ferry terminals in Iliamna Lake and Amakdedori port during construction. The extent of habitat alteration in the winter may affect the immediate area where the ferry would transverse, including an additional area immediately adjacent to the vessel track where broken ice may occur. Potential effects from seafloor habitat disturbance would be expected to limit the foraging quality of the disturbed area during construction. Potential effects from ice disturbance would persist throughout the life of the project in the winter months, when the ferry is actively breaking ice to traverse Iliamna Lake.

During installation of the natural gas pipeline, marine mammals that forage during the summer in Cook Inlet and those that occur year-round may be temporarily displaced from feeding areas and experience increased turbidity in waters adjacent to active trenching/dredging for pipeline installation. Although the exact method of natural gas pipeline installation is currently not determined, there would be disturbance to the seafloor while the pipeline is trenched into place. The duration that marine mammals may be exposed to habitat alteration in the form of increased turbidity from construction in marine and freshwater environments would be temporary, because construction activities would be of short duration. The duration that marine mammals may be exposed to direct habitat loss from development of Amakdedori port and the north and south ferry terminal in Iliamna Lake would be permanent. Impacts would likely be due to loss of foraging habitat.

Potential Impacts on Food Sources—Habitat alteration, turbidity, and discharge from routine activities may impact marine mammal prey species. In terms of magnitude and extent, turbidity may affect the prey species' distribution and diversity, as well as the ability of marine mammals to locate prey in the immediate area of the project activity. The effects of habitat alteration would not be expected to impact gray or minke whales, because gray whales are not expected to feed in the shallow waters offshore from the port, and minke whales are not found in great concentrations in Cook Inlet (see Section 3.23, Wildlife Values, for more information on species occurrence in the analysis area).

During installation of the natural gas pipeline, increased turbidity from trenching/dredging for pipeline installation may impact marine mammal prey in several ways. The trenching/dredging technology may crush benthic and epibenthic invertebrates from the physical components of the dredge, benthic organisms may be dislodged, and the suspended sediment may settle out and clog the gills or feeding structures of sessile invertebrates (82 FR 22099). Material that is removed during trenching/dredging would temporarily increase turbidity (which would be rapidly dissipated by strong tidal currents) and cause avoidance by mobile fauna. Planktonic species would not be able to avoid increased turbidity in the water column, and may experience increased abrasion and potential mortality. If jetting technology is used as the pipeline installation method, it may result in increased suspension of sediments, which may be carried long distances in the strong tidal currents of Cook Inlet. The effects would be limited in extent (but range farther away from the source depending on the method of pipeline installation); the duration would be short-term and temporary; and turbidity would rapidly return to background levels following active dredging.

The magnitude of impacts to killer whales from habitat alteration would include reduced prey availability from increased turbidity over the short-term, during pipeline construction. The extent would be limited to the natural gas pipeline corridor through Cook Inlet. Habitat alteration from installation of the natural gas pipeline is not anticipated to have adverse effects on populations of fish and shellfish prey for marine mammals.

Potential impacts of noise on food sources are discussed in detail in Appendix K4.25, Threatened and Endangered Species. Because Iliamna Lake seals are principally dependent on lake resources, especially in early life, responses of this population to environmental change are likely to differ from those of the marine harbor seal populations (Brennan et al. 2019), and further information is necessary to understand such impacts. Harbor seals endemic to Iliamna Lake have been subject to large shifts in sockeye salmon returns in Bristol Bay, and therefore, tributaries of

Bristol Bay. The stability of the Iliamna Lake harbor seal population may in part be due to the seal's ability to integrate across lake and marine resources (Brennan et al. 2019). It is not known whether these seals migrate between the lake and ocean, nor is it known to what extent seals rely on trophic resources predicted from in Iliamna Lake versus the ocean (Brennan et al. 2019). Stomach content from seal harvested in Iliamna Lake contained no evidence of marine prey items (Burns et al. 2016).

4.23.5 Alternative 1

Impacts to wildlife from construction, operations, and closure of the mine site under Alternative 1 are similar to those discussed previously under Alternative 1a and are generally not reiterated here. The only major differences between Alternative 1 and Alternative 1a are the mine access road that parallels Upper Talarik Creek, a short Iliamna spur road, north ferry terminal, and ferry and natural gas pipeline route across Iliamna Lake. There are no new terrestrial wildlife species in the area of Alternative 1, and there are no new impacts for terrestrial wildlife. For Alternative 1, the ferry route crossing Iliamna Lake would be farther west from the locations of Iliamna Lake seals, so there would be a lower impact to these seals. Also, the port for Alternative 1 includes the earthen fill causeway and sheet pile dock variants. These types of dock construction would increase the noise impacts on wildlife (specifically marine mammals) over Alternative 1a, which is a caisson dock that requires no sheet pile or pile-driving).

Impacts that may occur to wildlife species along Alternative 1 transportation and natural gas pipeline corridors are discussed below. These impacts would be expected to occur if Alternative 1 is permitted and constructed.

<u>Birds</u>

Impacts to birds that occur along the transportation and natural gas pipeline corridor would be similar to Alternative 1a and are not repeated herein. In terms of magnitude, impacts would include a loss of foraging and nesting habitat as a result of construction, increased potential for injury and mortality along the road, behavioral disturbance due to increased noise, and other edge effects associated with a road.

Behavioral Disturbance

For terrestrial avian species, impacts from the transportation corridor may result in temporary avoidance during construction.

The magnitude of impacts for marine birds along the natural gas pipeline corridor caused by behavioral disturbance may result in birds avoiding foraging areas while project-related vessels transit through. For waterbird and seabird species, the project vessels would have to pass through these areas throughout the year. This may increase time and energy spent avoiding vessels, although vessels would be traveling slowly. The duration of impacts would last for the life of the project, and extent would include all project components.

Injury and Mortality

There would be potential for avian mortality along the transportation corridor while flying between patches of habitat bisected by the road. There may be increased predation from predatory species along the road due to increased visibility and clear flight path along the road edge.

The Amakdedori port area is used throughout the year by waterbirds and seabirds. Therefore, the magnitude and extent of impacts would be that injury and mortality to birds along the transportation corridor and around the port would be expected to occur. The duration would be for the life of the project. However, overall impacts to birds from vehicle or vessel collisions would be minimized because of restricted vehicle and vessels speeds.

Habitat Changes

Loss of habitat from construction of the transportation and natural gas pipeline corridors would occur primarily in forested habitat types. There would be suitable habitat adjacent to the transportation corridor that species may disperse to; however, loss of some individual territories and preferred habitat may occur. Loss of habitat would occur at a narrow strip along the transportation corridor with suitable adjacent habitat.

At Amakdedori port, there would be a loss of nearshore benthic foraging habitat through construction of the port. The magnitude and extent of impacts would include loss of 9,600 acres, which encompasses all mine components.

The duration would last for the life of the project. Specifically, habitat changes at the Amakdedori port would include loss and avoidance of marine habitat for waterbird and seabird species, while the mine site and transportation corridor would involve direct loss of breeding habitat. If Alternative 1 is permitted and constructed, impacts from loss and avoidance of habitat would be expected to occur for a range of avian species, including raptors, waterbirds, seabirds, landbirds, and shorebirds.

Terrestrial Wildlife

The magnitude, duration, extent, and likelihood of impacts to terrestrial wildlife from the mine site under Alternative 1 would be similar to those for Alternative 1a, and are not repeated here.

In terms of magnitude and extent, impacts to moose, brown and black bears, gray wolves, and other terrestrial wildlife would be primarily related to behavioral disturbance (through increased noise, vehicular traffic, and human interaction), injury and mortality, and loss of habitat (both directly through vegetation removal, and avoidance of areas near the transportation and natural gas pipeline corridors).

The magnitude, duration, and likelihood of impacts to small mammal species and wood frogs would be similar to those detailed under Alternative 1a. Impacts would be primarily related to loss of habitat, increased potential for injury and mortality along the access road, and increased edge effects.

Behavioral Disturbance

Wildlife would be anticipated to avoid the transportation and natural gas pipeline corridors as a result of vehicular traffic in areas that currently have no established roads. Moose have been known to avoid roads by up to 1,000 feet, and bears would be anticipated to alter feeding patterns in salmon-spawning streams adjacent to the transportation and natural gas pipeline corridors. Traffic would be anticipated to temporarily disturb wildlife while vehicles are passing. The magnitude of the visual, noise, and fugitive dust disturbance from passing vehicles would be minimized in forested areas due to buffering effects of tall, dense vegetation. The extent of behavioral disturbance to wildlife would be an impact on individuals along the transportation corridor. Some species may avoid the transportation corridor, especially where it overlaps with favored foraging areas, such as along salmon streams.

The duration of behavioral disturbance impacts would extend for the life of the project (and longer depending on the ultimate fate of the access roads and their use in long-term management of the pit lake and by local residents), and the extent would include all project components. It would be likely that behavioral impacts would occur to some species and individuals, especially those that would not be accustomed to vehicular traffic.

Injury and Mortality

A regulated speed limit of 35 mph and other measures in the WIP would be designed to minimize wildlife injury and mortality.

The extent of potential for injury and mortality would be along the mine and port access roads to the mine site. Moose, bears, wolves, and smaller terrestrial wildlife that cross the road have a potential to collide with truck traffic. In terms of magnitude, the potential would be greatest at dawn and dusk, night-time, during the winter, and during periods of reduced visibility. Additionally, there would be a potential for increased mortality due to increased access for hunting. The magnitude of impacts would correspond to the number of wildlife injured or killed by the project, especially along the transportation corridor. The duration would last for the life of the project, and extent would include the entire project footprint. If Alternative 1 is chosen, permitted, and constructed, impacts would be expected to occur, especially with wildlife being killed along project roads, although such injury and mortality may occur infrequently.

Habitat Changes

In terms of magnitude, construction and operations of the transportation and natural gas pipeline corridors would result in loss of wildlife habitat detailed in Chapter 2, Alternatives (see Table 2-2). Habitat removal would result in edge effects, such as wildlife traveling along the road in winter (especially if the road would be plowed), dust accumulation on surrounding vegetation, changes in plant phenology due to earlier spring melt in vegetation along the road prism, and other vegetation changes that directly affect foraging habitat for wildlife species. The magnitude is the loss of 9,600 acres of habitat, and extent encompasses all project components. The duration would last for the life of the project, and the extent would include all of the project components. If Alternative 1 is selected, permitted, and constructed, impacts from loss and avoidance of habitat would be expected for a range of terrestrial species such as moose, bears, wolves, and smaller terrestrial wildlife.

Marine Mammals

The analysis area for Alternative 1 is the same as Alternative 1a. There are no new geographical areas in the marine environment of Cook Inlet under Alternative 1 beyond those detailed above for Alternative 1a. Aside from the more western ferry and pipeline routes across Iliamna Lake, the only significant difference between Alternative 1a and Alternative 1 with a potential to impact marine mammals are two different dock designs or variants at Amakdedori. The on-land portion of the port on the beach and bluff at Amakdedori would be the same regardless of the variant. The two in-water variants of the port are:

- earthen causeway and wharf (sheet pile dock structure)
- Pile-Supported Dock Variant

Details for the two dock variants are included in Chapter 2, Alternatives. Each of these would result in different impacts to the marine environment, including the amount of disturbance to the benthic marine environment and the amount of noise generated during construction. The earthen causeway and wharf would have the greatest level of disturbance to the benthic marine environment (largest in-water footprint), followed by the pile-supported dock. Both the earthen causeway and pile-supported dock would generate differing levels of sheet/pile-driving associated with underwater noise. Once construction of the port is complete, port operations would be the same regardless of dock construction design. There would be no change in the level of vessel or aircraft traffic, which was previously analyzed under Alternative 1a. There would be no change in the installation of the natural gas pipeline, and it would follow the same route detailed above for Alternative 1a. The main source of disturbance to marine mammals would be noise from sheet pile or pile-driving in dock construction, and habitat loss.

Behavioral Disturbance

Behavioral disturbance to marine mammals from airborne noise and physical presence is the same as Alternative 1a, and is not repeated here. However, the earthen causeway and wharf or pile-supported dock variants would have a greater level of disturbance on marine mammals than the caisson dock in Alternative 1a. The ferry crossing and pipeline route across Iliamna Lake would be farther west from the locations of Iliamna Lake seals, so a lower impact to Iliamna Lake seals would be expected.

Injury and Mortality

Impacts from injury and mortality from vessel collisions and entanglement are the same as Alternative 1a, and are not repeated here.

Habitat Changes

Other than a reduction in the acreage of benthic marine habitat lost in the footprint of Amakdedori port, potential impacts on food sources from habitat changes are the same as Alternative 1a, and are not repeated here.

4.23.5.1 Variants Impact Analysis

Summer-Only Ferry Operations Variant

Under the Summer-Only Ferry Operations Variant, trucks would only operate when the ferry(ies) would be running (during the open water season), which would double the number of round-trip truck trips to 70 per day on each side of the ferry terminals during the summer (PLP 2018-RFI 065). Truck traffic would occur 24 hours a day, and the number of truck trips on the access road would be one truck passing in either direction approximately every 10 minutes during the summer. There would be additional light vehicle traffic (i.e., vehicles other than large trucks transporting concentrate, fuel, and consumables) along the transportation corridor that would add additional daily vehicle trips. Impacts to wildlife would vary by species; but overall, the magnitude of the primary impact from an increase in summer truck traffic on the access roads would be an increase in potential for injury or mortality from collisions, especially for those species that hibernate and migrate. Because increased truck traffic would occur generally when species are out of hibernation and migratory species are breeding, collision potential would be elevated. Wildlife species would have an increased potential for both behavioral avoidance of the access roads (due to higher truck passage rates and increased noise levels), and potential for collisions, especially for young-of-the-year wildlife that are not accustomed to the road. The increase in truck traffic may increase species avoidance of foraging and breeding areas. However, this variant may also reduce injury and mortality for some species. Because the truck traffic would be eliminated during winter months, there would be a potential reduction in collisions for species that do not hibernate, such as moose. A reduction in winter-time truck traffic would also decrease the potential for moose (and other wildlife) collisions, due to improved visibility for truck drivers during summer.

Specific to marine mammals, under this variant, ice breaking would not occur; therefore, no effect on overwintering seals in Iliamna Lake would occur. There would be no change in the lightering of concentrate from Amakdedori port; therefore, there would be no change in impacts to marine mammals in Cook Inlet under this variant.

The magnitude of impacts would be 9,661 acres of habitat removal plus avoidance of surrounding habitat due to behavioral disturbance, an increased potential for injury and mortality for some species, and a decreased potential for others. The duration of impacts would last for the life of the project, but only occur during the open water season when the ferry would be operational. The impacts to wildlife would vary depending on the species and time of year. An increase in summer truck traffic would increase the potential for wildlife mortality along the access roads for some species, but decrease the potential during winter due to elimination of truck traffic. The extent of impacts would be primarily limited to the access roads, and it would be expected that some wildlife would experience mortality. These impacts would be expected to occur if this variant is chosen and the project is permitted and built.

Kokhanok East Ferry Terminal Variant

Under this variant, the extent of impacts to wildlife would vary slightly because the south ferry terminal would be shifted north around Kokhanok. In terms of magnitude, this would reduce impacts to wildlife species (such as brown bears) around Gibraltar Lake and along Gibraltar Creek because the port access road would lead north to Kokhanok and avoid Gibraltar Lake. This variant would increase the number of bald eagle nests that may experience impacts, because there are two bald eagle nests less than 1 mile from the port access road along the shore of Iliamna Lake near Kokhanok. This variant would bring ferry operations closer to areas where the harbor seals that inhabit Iliamna Lake are more regularly observed. There would be no new impacts to species at the mine site, mine access road, north ferry terminal, Amakdedori port, or in Cook Inlet. The magnitude of impacts would result in a loss of 9,635 acres. The duration would last for the life of the project, and longer, depending on final disposition of the road to Kokhanok; and the extent would be limited to the Kokhanok east ferry terminal and access road. If this variant is chosen and the project is permitted and built, it would be expected that impacts to wildlife around Kokhanok would occur.

Pile-Supported Dock Variant

Under this variant, the footprint of Amakdedori port would be reduced to 0.07 acre of impacts to the benthic marine environment. In terms of magnitude, this would decrease the acreage of habitat loss for marine wildlife. During construction, noise levels may be higher during pile-driving activities, as opposed to construction of an earthen causeway and wharf. There would be reduced impediment to marine wildlife that move along the western edge of Cook Inlet, because some species would pass through the piles instead of having to navigate around the earthen causeway and wharf. All other impacts to wildlife species would remain the same, except for a slight reduction in overall acreage of the project (9,589 acres). The magnitude of impacts would be a reduction in benthic marine habitat loss; the duration would last for the life of the project until the port would be removed; and the extent would encompass the marine portion of the port. If this variant is selected, and the project is permitted and built, it would be expected that a reduction in impacts would occur.

4.23.6 Alternative 2—North Road and Ferry with Downstream Dams

Impacts to wildlife from construction, operations, and closure of the mine site under Alternative 2 are similar to those discussed previously under Alternative 1a and Alternative 1. Under Alternative 2, the mine site footprint would result in slightly more habitat loss for wildlife species. However, the primary difference with Alternative 2 is the geographical shift of the transportation and natural gas pipeline corridors to the north at the eastern end of Iliamna Lake, and the Diamond Point port in Iliamna Bay. This shift north includes more forested areas along the northern side of Iliamna Lake, and a sheltered, rocky, coastal marine environment where Diamond Point port would be. Additionally, there would be no airstrip at the port, because the Pedro Bay airstrip that would be used during construction is farther inland. Impacts that may occur to wildlife species along Alternative 2 transportation and natural gas pipeline corridors and at Diamond Point port are discussed below. These impacts would be expected to occur if Alternative 2 is permitted and constructed.

4.23.6.1 Birds

Impacts to birds that occur along the transportation and natural gas pipeline corridor would be similar to Alternative 1a, but different in geographic extent, due to the location along the northern shore of Iliamna Lake. In terms of magnitude, impacts would include a loss of foraging and nesting habitat as a result of construction; increased potential for injury and mortality along the road; behavioral disturbance due to increased noise; and other edge effects associated with a road. Also in terms of magnitude, the avian community that would be impacted by Alternative 2 includes more species that occur in forested habitats, which are common along the transportation and natural gas pipeline corridor. Additionally, the Diamond Point port would be in an area that provides important migratory bird stop-over habitat (especially for shorebirds), important summering and wintering habitat for a variety of waterbirds, and an important nesting area for several species of seabirds. Many of the islands and rocky islets at the mouths of Iliamna and Iniskin bays that project vessels would transit past are in the Alaska Maritime National Wildlife Refuge.

Behavioral Disturbance

As discussed in Section 3.23, Wildlife Values, there are several golden eagle nests along the Williamsport-Pile Bay Road, one peregrine falcon nest at Diamond Point, a bald eagle nest adjacent to the Diamond Point barge dock cut-and-fill area, one bald eagle nest adjacent to the road at the Eagle Bay ferry terminal, and bald and golden eagle nests in the valley between Ursus Cove and Cottonwood Bay. Construction of the transportation corridor to Diamond Point, and construction of the port would likely cause disturbance through increased noise (particularly where blasting would be needed to construct the road), and increased human presence. In terms of magnitude, the greatest source of disturbance would occur during road construction, because there is currently no road to Diamond Point or to Eagle Bay. Disturbance to any golden eagle or bald eagle nest would require coordination with the USFWS, and possibly an Eagle Take Permit (81 Federal Register 91494). Additional avian species may experience behavioral avoidance of the habitat immediately adjacent to the mine access road (from the Eagle Bay ferry terminal to the mine site) in an area where no road currently exists. This may cause avoidance of the road edge habitat due to vehicular traffic.

Impacts to avian species may also occur through noise and physical presence of vessels at Diamond Point port and near the mouths of Iliamna and Iniskin bays, where multiple seabird species (e.g., gulls, cormorants, puffins, oystercatchers) nest on adjacent cliffs, rock outcrops, and small islands, and forage in the surrounding waters. Although the exact number of vessels using Iliamna Bay is not currently known; during summer months, approximately 50 fishing boats are transferred on the Williamsport-Pile Bay Road annually, and approximately 22 barge loads of fuel and cargo were transported on the road in 2009 (Kevin Waring and Associates 2011c). Therefore, there is currently a low level of vessel activity in Iliamna Bay, primarily during summer months. In terms of magnitude, the project would result in approximately 10 lightering trips to fill each bulk carrier, which would be moored for 4 to 5 days at the lightering location. Annual vessel traffic at the port would consist of up to 27 concentrate vessels and 33 supply barges. This equals at least two lightering trips per day to fill each concentrate vessel while it would be moored in Iniskin Bay, or west of Augustine Island at the alternate lightering location. This increase in vessel traffic would likely cause disturbance to birds molting, wintering, feeding, resting, and migrating through Iliamna and Iniskin bays. In particular, the protected waters of Iliamna and Iniskin bays provide sheltered feeding and wintering habitat for a variety of waterbirds (especially scoter species). There are multiple seabird colonies around the mouths of Iliamna and Iniskin bays; and in terms of extent, vessels passing by White Gull Island (at the mouth of Iliamna Bay) would likely be less than 0.25 mile from the island, depending on the specific route taken. Many of these islands are protected as part of the Alaska Maritime National Wildlife Refuge. Vessel traffic may cause species to swim away, fly, dive, or otherwise avoid approaching vessels. Although Kittlitz's murrelets have not conclusively been detected in Iliamna and Iniskin bays, the similar marbled murrelet has been documented throughout both bays (ABR 2011d). Agness et al. (2008) observed a 30-fold increase in flight behavior for Kittlitz's murrelets, with large and fast-moving vessels causing the greatest disturbance. Negative effects on the bird's daily energy budget occur when birds expend energy to fly away from disturbances.

In summary, the magnitude of impacts caused by behavioral disturbance may result in birds avoiding foraging in areas while project-related vessels would be transiting through. For waterbird and seabird species, the project vessels would have to pass through areas of high avian density throughout the year. This may increase time and energy spent avoiding vessels, although vessels would be traveling slowly. For terrestrial avian species, impacts from the transportation corridor may result in temporary avoidance during construction (especially near eagle nests). Because there is an existing road near the Diamond Point port (the Williamsport-Pile Bay Road), some of the eagles in the surrounding area are likely accustomed to occasional road traffic, especially during the summer. The duration of impacts would last for the life of the project, and extent would include all project components, but especially the Diamond Point port and surrounding waters.

Injury and Mortality

There would be potential for avian mortality along the transportation corridor while flying between patches of habitat bisected by the road. Because the transportation corridor along the north shore of Iliamna Lake includes large portions of forested habitats, the avian species that may be impacted include warblers, thrushes, waxwings, sparrows, finches, kinglets, flycatchers, woodpeckers, and other birds that use those habitat types. There may be increased predation from predatory species along the road due to increased visibility and clear flight path along the road edge.

There would be increased potential for bird collisions during inclement weather in Iliamna and Iniskin bays, especially if lights are used on the lightering vessels and bulk carriers. As detailed in Section 4.25, Threatened and Endangered Species, some waterbird species such as eiders have a potential to collide with stationary objects, especially if illuminated by lights at night during inclement weather. Therefore, there would be potential for vessels moored at the lightering location to pose a collision hazard to birds in Iniskin Bay. The lightering location would be near the mouth of Iniskin Bay, and the local topography creates narrow passage at the mouth where there would be increased potential for avian collisions. As detailed in Section 3.23, Wildlife Values, both bays are used throughout the year by large numbers of waterbirds and nesting seabirds. Therefore, the magnitude and extent of impacts would be that injury and mortality to birds along the transportation corridor and around the Diamond Point port would be expected to occur. The duration would be for the life of the project. However, overall impacts to birds from vessel collisions would be reduced because vessels would be traveling at slow speeds (less than 10 knots).

Habitat Changes

Loss of habitat from construction of the transportation and natural gas pipeline corridors would occur primarily in forested habitat types to the north of Iliamna Lake. There would be suitable habitat adjacent to the transportation corridor that species may disperse to; however, loss of some individual territories and preferred habitat may occur. Loss of habitat would occur at a narrow strip along the transportation corridor with suitable adjacent habitat. At Diamond Point port, there would be a loss of nearshore benthic foraging habitat through construction and periodic dredging of the port. The magnitude and extent of impacts would include loss of 9,763 acres, which encompasses all mine components. The duration would last for the life of the project. Specifically, habitat changes at the Diamond Point port would include loss and avoidance of marine habitat for waterbird and seabird species, while the mine site and transportation corridor would involve direct loss of breeding habitat. If Alternative 2 is permitted and constructed, impacts from loss and avoidance of habitat would be expected to occur for a range of avian species, including raptors, waterbirds, seabirds, landbirds, and shorebirds.

4.23.6.2 Terrestrial Wildlife

The magnitude, duration, extent, and likelihood of impacts to terrestrial wildlife from the mine site under Alternative 2 would be similar to those for Alternative 1a. The primary difference would be the impact to wildlife from the transportation and natural gas pipeline corridors along the northern part of Iliamna Lake. This area is forested compared to the mine site, and therefore has a lower abundance and distribution of caribou, and a higher population of moose and black bears. Overall, the abundance of caribou from Newhalen east to Cook Inlet along the transportation and natural gas pipeline corridors is low (due to a lack of suitable caribou habitat); therefore, impacts to caribou would not be expected from construction and operations of the transportation and natural gas pipeline corridor and Diamond Point port. In terms of magnitude and extent, impacts to moose, brown and black bears, gray wolves, and other terrestrial wildlife would be primarily related to behavioral disturbance (through increased noise, vehicular traffic, and human interaction), injury and mortality, and loss of habitat (both directly through vegetation removal, and avoidance of areas near the transportation and natural gas pipeline corridors).

The magnitude, duration, and likelihood of impacts to small mammal species and wood frogs would be similar to those detailed under Alternative 1a. Impacts would be primarily related to loss of habitat, increased potential for injury and mortality along the access road, and increased edge effects. The extent of these impacts would be expected to be localized to the area around the access road, and impact species with home ranges that overlap the road, as well as impacting dispersing individuals (e.g., juveniles seeking new territories, or wildlife in search of mates).

Behavioral Disturbance

Wildlife would be anticipated to avoid the transportation and natural gas pipeline corridors as a result of vehicular traffic in an area that currently has no established roads (apart from the existing Williamsport-Pile Bay Road). Moose have been known to avoid roads by up to 1,000 feet, and bears would be anticipated to alter feeding patterns in salmon-spawning streams adjacent to the transportation and natural gas pipeline corridors. Traffic volumes, at 35 round-trip truck trips per 24-hour day (one vehicle every 21 minutes) would be anticipated to temporarily disturb wildlife while vehicles are passing. There would be additional light vehicle traffic (i.e., vehicles other than large trucks transporting concentrate, fuel, and consumables) along the transportation corridor that would add daily vehicle trips. The magnitude of the visual and noise disturbance from passing vehicles would be reduced due to the forest habitat that most of the transportation corridor passes through. The extent of behavioral disturbance to wildlife would be an impact on individuals along the transportation corridor. Some species may avoid the transportation corridor, especially where it overlaps with favored foraging areas, such as along salmon streams. Bear may also opt to den farther from the transportation corridor. As detailed in Section 3.23, Wildlife Values, wildlife cameras were placed along seven anadromous streams along the north shore of Iliamna Lake, from Roadhouse Mountain to the Pile River (ABR 2015a). Bear use reflected salmon run timing, with the highest activity from late July to early August. Small, shallow streams with high numbers of spawning salmon were the preferred foraging areas. The highest level of activity occurred during early morning and late evening, but bears spent little time fishing in the portions of the river in the camera's viewshed, according to the time-lapse photography (ABR 2015a). Conversely, this finding may not fully represent the extent of bear use at these locations throughout the year, but provides a snapshot of activity levels during one summer. The duration of behavioral disturbance impacts would extend for the life of the project, and the extent would include all project components. It would be likely that behavioral impacts would occur to some species and individuals, especially those that would not be accustomed to vehicular traffic apart from occasional use of the Williamsport-Pile Bay Road.

Because black bears are more common along the north shore of Iliamna Lake, they have the greatest potential to be impacted through construction and operations of the mine access road and port access road for Alternative 2. One bear study in the North Cascades of Washington looked at the effect of roads (including level of vehicle traffic) on potential habitat effectiveness (probability of black bears using landscape features) for female black bears (Gaines et al. 2005). The study found that roads consistently had a negative influence on black bear resource selection functions across seasons. During all seasons, roads reduced the habitat effectiveness across study areas, with potential habitat value changes ranging from 1.7 to 16.9 percent. Therefore, the presence of roads makes the surrounding habitat less likely to be used by black bears, but this can vary depending on the season and level of vehicle traffic. It was found that female black bears in one study area (Snoqualmie Study Area, composed of moist western Cascade forests) were negatively associated with areas within 1,644 to 3,281 feet, and 3,284 to 6,562 feet of roads that received moderate (roads with 1 to 10 vehicles per hour) levels of vehicular traffic (Gaines et al. 2005). Under Alternative 2, traffic levels would fall within the moderate level (approximately 3 trucks per hour with additional light vehicle traffic) of vehicle traffic (as defined by Gaines et al. 2005), and therefore, black bears are expected to exhibit some avoidance of the road corridor, but the full extent of avoidance is difficult to accurately predict.

The magnitude of impacts from behavioral disturbance would be loss of habitat by avoidance from construction and operations noise, fugitive dust, and the presence of human activity, among other factors. The avoidance distance would vary by species and time of year; but for some species, such as caribou and brown bears, the level of avoidance can extend for several miles, especially during post-calving for caribou and the denning season for brown bears. The duration of behavioral avoidance is likely to last for the life of the project, but would decrease as habitat is reclaimed and human activities in the area decrease during the post-closure phase. The extent would encompass all project components; and if Alternative 2 is chosen, permitted, and constructed, impacts would be expected to occur, especially around the mine site, with levels of disturbance varying between species.

Injury and Mortality

Because the transportation and natural gas pipeline corridors roughly parallel the north shore of Iliamna Lake, wildlife that follow the various creek and stream drainages that flow towards Iliamna Lake would be expected to intersect the access road. Although fish passage structures would permit some wildlife to pass underneath the road along anadromous streams, other wildlife may be forced to cross over the road while moving to and from Iliamna Lake. A regulated speed limit and WIP would be designed to minimize wildlife injury and mortality. Increased moose densities along several of the creek and river drainages that flow into Iliamna Lake, along with increased black bear density, may result in greater wildlife injury and mortality for these species compared to Alternative 1a. The extent of potential for injury and mortality would be along the mine access road from the Eagle Bay ferry terminal to the mine site, and along the portion that overlaps with the Williamsport-Pile Bay Road. Moose, bears, wolves, and smaller terrestrial wildlife that cross the road have a potential to collide with truck traffic, which would entail a truck passing by approximately every 21 minutes. There would be additional light vehicle traffic (i.e., vehicles other than large trucks transporting concentrate, fuel, and consumables) along the transportation corridor, including use by local residents, which would add daily vehicle trips. In terms of magnitude, the potential would be greatest at dawn and dusk, night-time, during the winter, and during periods of reduced visibility. Additionally, there would be a potential for increased mortality due to increased access for hunting. The area around the Iliamna River has a greater concentration of moose than other portions of the transportation corridor, and increased hunting pressure in some of the drainages sloping into Iliamna Lake may occur. The magnitude of impacts would correspond to an unknown number of wildlife injured or killed along the transportation corridor. The duration would last for the life of the project, and extent would include the entire project footprint. If Alternative 2 is chosen, permitted, and constructed, impacts would be expected to occur, especially along project roads, with levels of injury and mortality varying between species. Generally, smaller-bodied terrestrial wildlife with smaller home ranges and high overall abundance (such as arctic ground squirrels and snowshoe hares) are more likely to suffer injury and mortality along the road compared with larger wildlife with vast home ranges that are less common on the landscape (such as bears, moose, caribou, and gray wolves).

Habitat Changes

In terms of magnitude, construction and operations of the transportation and natural gas pipeline corridors would result in loss of wildlife habitat detailed in Chapter 2, Alternatives (Table 2-2). Habitat removal would result in edge effects, such as wildlife traveling along the road in winter (especially if the road would be plowed), dust accumulation on surrounding vegetation, changes in plant phenology due to earlier spring melt in vegetation along the road prism, and other vegetation changes that directly affect foraging habitat for wildlife species. The magnitude is the loss of 9,763 acres of habitat, and extent encompasses all project components. Additional habitat would be lost by wildlife avoidance. For caribou, which are known to avoid locations of human disturbance such as roads and other development, the range of avoidance would depend on the time of year. Caribou show the greatest avoidance of human disturbance during the calving period, up to several miles away from project activities. Caribou would experience habitat loss through avoidance around the transportation corridor, ferry terminals, and port. This would be in addition to habitat avoidance around the mine site and from direct loss of habitat from project components.

Bears exhibit similar areas of avoidance. Based on a literature review conducted by Linnell et al. (2000), North American bear species generally select den sites from 0.6 mile to 1.2 miles from human activities (e.g., roads, habitation, industrial activities). They found that activity closer than 0.6 mile caused a variety of responses, including den abandonment, especially if the disturbance occurred early in the denning period. Based on Schoen and Beier (1990), where brown bears denned significantly farther from the mine site with a mean distance of 7.3 miles once construction began, bears may avoid denning in a large area around the mine site. Therefore, given habitat that may be avoided around the mine site and other project components, brown bears may experience a large amount of habitat avoidance.

The duration would last for the life of the project, and the extent would include all of the project components. If Alternative 2 is selected, permitted, and constructed, impacts from loss and avoidance of habitat would be expected for a range of terrestrial species such as moose, bears, wolves, and smaller terrestrial wildlife.

4.23.6.3 Marine Mammals

A discussion of the affected environment for marine mammals is presented in Section 3.23, Wildlife Values. Impacts to marine mammals from construction of the Diamond Point port and natural gas pipeline corridor would be the same as those listed under Alternative 1a for Amakdedori port, but shifted north into Iliamna Bay. Impacts would be similar to those presented above for Alternative 1a. One of the main differences for marine mammals with Alternative 2 would be that vessel access to Diamond Point port would require regular dredging, and subsequent noise and water turbidity in the marine habitat. In terms of magnitude and duration, this would result in short-term modification of marine benthic habitat resulting from an increase in turbidity and decreased water quality during dredging activities. Increased turbidity may potentially have impacts on marine mammal prey.

The Alternative 2 ferry route would transit through the northeastern portion of Iliamna Lake, where most of the harbor seal haul-outs and highest seal concentrations occur (Burns et al. 2016). Many of the islands that are in the eastern part of Iliamna Lake are part of a 12,700-acre conservation easement that was created by the Bristol Bay Heritage Land Trust (Troll 2019). The islands in the northeastern part of Iliamna Lake are critically important for all life stages of the Iliamna Lake seals. Although the ferry route would not physically impact any of the islands, it would transit through waters that are used year-round by the seals for foraging and transiting. In several cases, the ferry would come in proximity to known haul-out locations, and has a potential to impact overwintering locations. Sensitive life stages of the Iliamna Lake seals are discussed in Section 3.23, Wildlife Values, along with a map of known haulout locations. Burns et al. 2016 detail many of the important resources in the eastern part of Iliamna Lake that are used by the seals. The Alternative 2 ferry route would travel approximately 0.5 mile offshore from several of the islands used by the seals. Potential impacts include year-round disturbance from vessel traffic (including disruption of feeding, pupping, and haul-out locations, especially during winter from the ice-breaking ferry), potential for injury and mortality, and potential disturbance to prey resources.

In terms of magnitude of impacts, the Alternative 2 ferry route has a potential to increase adverse behavioral interactions with vessels and harbor seals that inhabit the lake. This longer route may also cause a potential heightened rate of vessel strikes with Iliamna Lake seals. An increase in vessel traffic across Iliamna Lake, especially through the northeastern portion of the lake, may increase the likelihood of vessel interactions with the Iliamna Lake seal. Given this population of harbor seals is around 400 animals, the loss of animals to vessel strike may have adverse effects on the success of the population. The Eagle and Pile Bay ferry terminals would intersect concentrated harbor seal haul-out locations (see figures in Section 3.23, Wildlife Values). The northeastern portion of Iliamna Lake is where seals pup, molt, forage, and overwinter (Burns et al. 2016). In summary, the magnitude of impacts to marine mammals in Cook Inlet would include habitat disturbance during dredging activities at Diamond Point port and behavioral disturbance from the physical presence and noise created by the ferry transiting past harbor seal haul-out locations in Iliamna Lake. The duration of impacts would last for the life of the project. The extent would be limited to Diamond Point port in Cook Inlet and the northeastern side of Iliamna Lake, where seal haul-outs are located and the highest concentrations of seals are found. If Alternative 2 is selected, there is a likelihood of impacts to marine wildlife, particularly harbor seals inhabiting Iliamna Lake.

4.23.6.4 Variant Impacts Analysis

Summer-Only Ferry Operations Variant

Under the Summer-Only Ferry Operations Variant, trucks would only operate when the ferry(ies) would be running (during the open water season), which would double the number of round-trip truck trips to 70 per 24-hour day on each side of the ferry terminals during the summer (PLP 2018-065). The number of truck trips on the access roads would be one truck passing in either direction every 10 minutes during the summer. There would be additional light vehicle traffic (i.e., vehicles other than large trucks transporting concentrate, fuel, and consumables) along the transportation corridor, which would add daily vehicle trips.

The increase in vessel traffic during seasons when seals are seen in high concentrations throughout Iliamna Lake (Burns et al. 2016) may increase the likelihood of vessel interactions with Iliamna Lake seals. Given this congregation of harbor seals is around 400 animals, the loss of animals to vessel strike may have adverse effects on the success of the population.

Impacts to wildlife would vary by species; but overall, in terms of magnitude, the primary impact from an increase in summer truck traffic on the access roads would be an increase in potential for injury or mortality from collision, especially to those species that hibernate and migrate. Because higher truck traffic would occur generally when species are out of hibernation, and migratory species are breeding, collision potential would be elevated. Wildlife species would have an increased potential for both behavioral avoidance of the access roads (due to higher traffic volumes, increased noise, and increased levels of fugitive dust), and potential for collisions, especially for young-of-the-year wildlife that would not be accustomed to the road. The increase in truck traffic may increase species avoidance of foraging and breeding areas. However, this variant may also reduce injury and mortality for some species. Because the truck traffic would be eliminated during winter months, there would be a potential reduction in collisions for species that do not hibernate, such as moose. A reduction in winter-time truck traffic would decrease the potential for moose (and other wildlife) collisions, due to improved visibility for truck drivers during summer.

Specific to marine mammals, under this variant, ice-breaking would not occur, thereby eliminating negative effects of vessel traffic on overwintering seals in Iliamna Lake.

The magnitude of impacts would be 9,819 acres of habitat removal plus avoidance of surrounding habitat due to behavioral disturbance, an increased potential for injury and mortality for some species, and a decreased potential for others. The duration of impacts would last for the life of the project, but occur only during the open water season when the ferry(ies) would be operational. The extent of impacts would be primarily limited to the access roads; and if this variant is chosen and the project is permitted and constructed, it is expected that some wildlife would experience mortality.

Newhalen River North Crossing Variant

Under Alternative 2 there would be a bridge over the Newhalen River upstream of the south crossing location by approximately 0.74 mile. All impacts to wildlife species would be similar, apart from potential impacts to nesting bald eagles. No suitable golden eagle nesting habitat is present in the area around the Newhalen River bridge crossings, because the habitat is primarily riparian, with large spruce and cottonwood trees. As detailed in Section 3.23, Wildlife Values, the latest nesting raptor surveys were conducted in July 2019, and the closest nest (determined to be active based on surveys) was approximately 1.4 miles upstream of the bridge location. There is a material site adjacent to the northern bridge abutment that is approximately 1 mile from the closest active bald eagle nest. If construction of the bridge occurs during the bald eagle nesting season (generally February through August), there is a potential for visual and noise disturbance from construction activities, depending on noise levels (especially if blasting is conducted at the material site). Prior to construction, additional permitting would likely be necessary with the USFWS to determine potential impacts to all bald and golden eagle nests in project areas. This would include additional nest surveys prior to any construction activities to determine the location of active nests, and potential avoidance and minimization measures (including avoidance buffers as detailed in Richardson and Miller 1997). Although bald eagles nest in close proximity to human activity at various locations throughout Alaska, USFWS would be consulted to determine measures necessary to ensure the nest is not disturbed during bridge construction. Once bridge construction is complete, operations are unlikely to disturb nesting eagles, because regular vehicle traffic would create less noise and would result in predictable vehicle movement. Overall, the magnitude of impacts would be low, because the only currently known active nest is 1.4 miles away from the bridge, and measures would be required by USFWS to prevent disturbance if construction occurs during the nesting season. The extent would encompass the immediate vicinity of the bridge and material site, and although the duration of noise impacts would be brief—only during construction—additional noise impacts may occur longer, depending on use of the material site. Vehicle traffic along the mine access road would last for the life of the project and potentially longer, depending on use of the road post-closure.

<u>Pile-Supported Dock Variant</u>

Under this variant, the total combined area of the pilings would result in less than 0.1 acre of impacts to the benthic marine environment. In terms of magnitude of impacts, this variant would decrease the acreage of habitat loss for marine wildlife. Dredging could still occur; therefore, 58 acres of the benthic marine environment would be dredged on a periodic basis. Also in terms of magnitude and extent, during construction, noise levels may be higher during pile-driving activities, as opposed to construction of an earthen causeway and wharf. In terms of extent of impacts, there would be reduced impediment to marine wildlife foraging around the port, because some species would pass between the piles instead of having to navigate around the earthen causeway and wharf. All other impacts to wildlife species would remain the same. The magnitude of impacts would be 9,753 acres of habitat loss, which includes a reduction in benthic marine habitat loss. The duration would last for the life of the project until the port is removed, and the extent would encompass the marine portion of the port. If this variant is permitted and constructed, a reduction in impacts compared to an earthen causeway port would be expected to occur.

4.23.7 Alternative 3—North Road Only

The magnitude, duration, extent, and potential for direct and indirect impacts from the mine site to wildlife species from Alternative 3 would be similar to Alternative 1a. The main differences would be no ferry in Iliamna Lake (and no ferry terminals) under Alternative 3, and the length of the road associated with the transportation corridor would be 83 miles. In terms of magnitude, this all-road option for the transportation corridor would increase the amount of permanent habitat loss and increase the potential for vehicular collisions with terrestrial wildlife, including birds. Up to 35 round trips per day for trucks transporting concentrate, fuel, and consumables would equate to a truck passing in either direction approximately every 21 minutes during a 24-hour period. There would be additional light-vehicle traffic (i.e., vehicles other than large trucks transporting concentrate, fuel, and consumables) along the transportation corridor, which would add daily vehicle trips. Impacts to birds and terrestrial wildlife from behavioral disturbance and injury and mortality from this level of truck traffic would be similar to that previously described for Alternative 1a. The main difference would be that the transportation corridor for Alternative 3 traverses more forested vegetation communities (compared with the other alternatives) along the northern side of Iliamna Lake. In terms of extent of impacts, forested habitat along the access road would buffer some of the noise and fugitive dust generated by truck traffic, so that the distance where behavioral impacts to birds and other wildlife may occur would be less. Additionally, forested habitat along the road provides a visual buffer and adjacent cover for wildlife to use. Forest habitats also tend to trap fugitive dust from spreading farther away from the road, compared with more open habitats (which are present in greater abundance along the transportation corridors for the other alternatives).

In terms of habitat avoidance by species, caribou may avoid the transportation corridor and port by up to 3.1 miles during the calving period. Brown bears may avoid denning around the mine site, up to 7.3 miles away. They may also avoid denning around the transportation corridor and port by up to 1.2 miles.

Alternative 3 would have no ferry in Iliamna Lake; therefore, there would be no impacts to harbor seals in Iliamna Lake from the project. All other impacts to marine mammals would be similar to Alternative 2, but the Diamond Point port would be farther in Iliamna Bay under Alternative 3. There is no pile-supported dock variant under Alternative 3, and no earthen causeway and sheet pile dock. There would be a caisson dock, similar to the one described under Alternative 1a. The caisson dock would include a maintenance dredging channel that would be periodically dredged to maintain the necessary depth.

Although the full details of the port are described in Chapter 2, Alternatives, some key elements that impact wildlife include the use of an elevated, fully enclosed conveyor system to load concentrate from the port onto the lightering barges for eventual transfer to the bulk carriers moored in Iniskin Bay. There would be only one proposed lightering location in a deepwater trench on the western side of Iniskin Bay near the mouth of the bay. There would be no secondary lightering location on the western side of Augustine Island. Therefore, the risk of entanglement with cables would be less under Alternative 3. The only port design is a caisson dock design, which reduces underwater noise from sheet or pile-driving, but would necessitate dredging. The dock would be constructed in a dredged area, with a large navigation channel for vessels to approach the dock at all tidal stages, and a turning basin. This channel and turning basin would require maintenance dredging approximately every 5 years to maintain the necessary depths. This dredging would likely be conducted with a barge-mounted cutterhead suction dredge approximately every 5 years, with the dredged material stored onshore. There would be no airstrip at the Diamond Point port; instead, the existing airstrip at Pedro Bay would be used. This would remove potential overflight noise and visual disturbance impacts to marine mammals and other wildlife around the port. There would be a monopole communications tower ranging from 100 to 150 feet, with high-visibility bands and flashing red lights, in compliance with FAA and USFWS guidance. The access road to the port would be shorter compared with Alternative 2, and therefore have reduced impacts to the marine intertidal zone.

In summary, the magnitude of impacts from Alternative 3 would be a loss of 10,130 acres of habitat for a variety of wildlife species. There are no impacts to wildlife species that are unique to Alternative 3, with impacts similar to those discussed previously for Alternative 1a and Alternative 2. The duration of impacts would extend for the life of the project and longer, depending on the post-construction use of the transportation corridor. The extent would include the footprint of all project components, especially the transportation corridor. If Alternative 3 is permitted and constructed, these impacts would be expected to occur.

4.23.7.1 Variant Impacts Analysis

Concentrate Pipeline Variant

Anticipated wildlife impacts include habitat loss from the concentrate pipeline pump house (1 acre in the mine site), booster station (0.7 acre), and an increase in the transportation and natural gas pipeline corridor width by 3 feet to accommodate the concentrate pipeline and optional return water pipeline. The concentrate pipeline (and the optional return water pipeline) would be co-located in a single trench with the natural gas pipeline at the toe of the road corridor embankment. The magnitude of impacts under this variant would be 10,132 acres. Impacts to wildlife would be reduced, because the number of truck trips necessary to transport concentrate to Diamond Point port would be reduced to 18 truck trips per day (15 truck trips would transport molybdenum, and the other trips would transport consumables). This would equate to a truck passing in either direction every 40 minutes. There would be additional light vehicle traffic (i.e., vehicles other than large trucks transporting concentrate, fuel, and consumables) along the transportation corridor, which would add daily vehicle trips. The Concentrate Pipeline Variant would lower impacts by reducing the potential for injury and mortality, fugitive dust, and noise. Because the lightering barges would be loaded directly with concentrate (instead of using International Organization for Standardization containers as proposed for the other alternatives), fewer lightering trips would be needed to fill each bulk carrier. Approximately 5 to 6 lightering trips would be necessary to load each bulk carrier, as opposed to 10 trips for the other alternatives. A reduction in these impacts may cause wildlife to have less behavioral avoidance of the transportation corridor. The duration of impacts would extend for the life of the project and vary in the post-closure phase, depending on the level of vehicle traffic from local residents and traffic related to post-closure and reclamation activities. The extent would encompass the transportation and natural gas pipeline corridor; and if Alternative 3 with this variant was selected, permitted, and constructed, impacts would be expected to occur, but overall, would be lower compared with the other alternatives.

4.23.8 Cumulative Effects

Impacts to wildlife would include behavioral disturbance (from noise or presence of humans, vehicles, and equipment, and structures among others); injury and mortality from vehicular collisions, exposure to contamination or defense of life and property; or habit changes from loss, fragmentation, fugitive dust, spills, changes in water quality, or introduction or spread of invasive species. See additional discussion and impact analysis in Section 4.18, Water and Sediment Quality; Section 4.20, Air Quality; Section 4.22, Wetlands (fugitive dust); Section 4.25, Threatened and Endangered Species; Section 4.26, Vegetation (fugitive dust); and Section 4.27, Spill Risk (spills).

The cumulative effects analysis area for wildlife encompasses the footprint of the project, including alternatives and variants, the expanded mine footprint (including road, pipeline and port facilities), and any other reasonably foreseeable future actions (RFFAs) in the vicinity of the project that would result in potential synergistic and interactive effects where direct and indirect impacts to wildlife can be expected from project construction, operations, and closure. In this area, a nexus may exist between the project and other past, present, and RFFAs that could contribute to a cumulative effect on wildlife. Section 4.1, Introduction to Environmental Consequences, details the comprehensive set of past, present, and RFFAs considered for evaluation as applicable.

The cumulative effects of mineral exploration and development have been studied in the Northwest Territories of Canada, where recent mineral discoveries have led to unprecedented levels of exploration and development (Johnson et al. 2005). Specifically, the impacts of mines and other major developments, exploration activities, and outfitter camps were assessed for their impacts to barren-ground caribou, gray wolves, brown bears, and wolverines. Researchers attempted to quantify the reduction in habitat effectiveness as a function of disturbance based on wildlife locations (from satellite and radio collars) collected during previous studies. Their results varied between species and time of year, with caribou during the post-calving season exhibiting the greatest avoidance of major development areas, which resulted in a 37 percent reduction in area of high-quality habitat, and an 84 percent increase in low-quality habitats. Both brown bears and wolves demonstrated the strongest negative response to disturbance, and a corresponding reduction in habitat effectiveness. Wolverines exhibited the lowest reduction in high-quality habitats. Research observed a decreased use of habitats within 1,640 feet to 3.1 miles from disturbance, with avoidance distances highest for major development (Johnson et al. 2005). This research is especially important for caribou, because it highlights how avoidance of major developments during the post-calving period can lead to a substantial reduction in high-quality habitat. Because the Mulchatna caribou herd is currently at severely depressed levels, and the mine site and surrounding areas are in post-calving habitat, there is a potential for cumulative impacts to a large area of seasonally important habitat.

Past, present, and RFFAs in the cumulative impact study area have the potential to contribute cumulatively to impacts on wildlife. Section 4.1, Introduction to Environmental Consequences, details the past, present, and RFFAs considered for evaluation in Figure 4.1-1. Several of these RFFAs are considered to have no potential for cumulatively impacting wildlife resources in the analysis area, such as those outside the analysis area. Some of the RFFAs include tourism, recreation, fishing, and hunting, among others. Although these ongoing activities do not necessarily result in habitat loss for wildlife species, they can result in impacts to species in the analysis area (such as regulated hunting), and therefore are cumulative. For example, access roads put in for the project have a potential to provide increased access for regulated activities, such as legal hunting by local residents, because the roads would remain open for local residential use.

4.23.8.1 Past and Present Actions

Past and present actions that have or are currently affecting wildlife in the analysis area include infrastructure development, marine vessel traffic, oil/gas and mineral exploration, residential activities, sport and subsistence hunting and sport subsistence, and commercial fishing. Most of the analysis area is undisturbed by human activity, with only a few small villages and roads. There are currently no major development projects under way. These activities have had, and are having, minimal, site-specific impacts on wildlife. In addition, many of these impacts are temporary and seasonal, based on the nature of disturbance.

4.23.8.2 Reasonably Foreseeable Future Actions

RFFAs in the cumulative effects analysis area were evaluated for impacts to both terrestrial wildlife and birds, and to impacts to marine mammals. Impacts to marine mammals would be similar to those detailed in Section 4.25, Threatened and Endangered Species, for impacts to threatened and endangered marine mammal species.

RFFAs included in this analysis are those that contribute to the cumulative loss of habitat for terrestrial wildlife, such as direct habitat loss, or avoidance of areas that are noisy or have increased human presence. Habitat loss for raptors, waterbirds, landbirds, and shorebirds would contribute to the global decline of many avian species. In particular, many species of shorebirds and songbirds are experiencing global declines; and loss of important breeding habitat, confounded by impacts of climate change, would contribute to species' declines. The cumulative impact to birds from current climate change trends could potentially favor some species (such as shrub-breeding songbirds), but potentially lead to a decrease in other species due to habitat conversion, potential for increased fire frequency, and altered forage fish populations in Cook Inlet.

Loss of habitat and habitat fragmentation for wide-ranging species, such as caribou, may occur through the creation and expansion of new roads into calving areas and other critical life stage areas. New active mining projects in the range of the Mulchatna caribou herd may cause the herd to shift locations at critical times or seek out new foraging areas, thereby reducing overall fitness. New roads, gas lines, and other infrastructure features have the potential to cause habitat fragmentation and avoidance of preferred habitat areas, including migratory pathways. Moose would be at risk of vehicular collisions while crossing new roads, and may avoid areas of high-quality forage habitat in close proximity to roads. Additional development may alter predator-prey relationships through increased levels of certain predators, such as red foxes. Bears may change their foraging and denning areas and have increased mortality from new roads, and mortality from defense of life and property.

The following RFFAs identified in Section 4.1, Introduction to Environmental Consequences, were carried forward in this analysis based on their potential to impact terrestrial wildlife in the analysis area: Pebble Project expansion scenario; mining exploration activities for Pebble South/PEB, Big Chunk South, Big Chunk North, Fog Lake, Groundhog, Shotgun and Johnson Tract mineral prospects; Alaska Liquefied Natural Gas, Drift River Oil Pipeline, Cook Inlet Lease Sales and exploration, onshore hydrocarbon exploration; Lake and Peninsula Borough transportation, infrastructure and energy projects; Kaskanak Road Project and other road improvements; and the continued development of the Diamond Point Rock Quarry.

Potential impacts on marine mammals from RFFAs primarily include noise and behavioral disturbance, displacement from habitat alteration, altered prey resources, and bottom sediment disturbance. The potential future actions included in this analysis are based on the spatial and temporal overlap of activities on marine mammals. Some potential future actions would increase exposure to marine mammals (e.g., underwater noise, vessel traffic).

Noise, behavioral disturbance from physical presence, and vessel and aircraft traffic associated with routine operations could affect marine mammals. Noise generated during construction and operations may temporarily disturb some marine mammals, causing them to leave or avoid the area. Noise from operations of the port, lightering locations, and project vessels would last for the life of the project, and longer during post-closure. Potential effects of underwater noise on marine mammals are detailed in Appendix K4.25, Threatened and Endangered Species, and loud underwater noises can cause temporary or permanent hearing loss, mask other sounds, and cause disturbance in other ways (Southall et al. 2019). All projects with a potential to disturb marine mammals would have to comply with the MMPA (and ESA if there are ESA-listed species that might be impacted), during which time the approximate number of marine mammals that may be impacted would be determined in consultation with the USFWS and NMFS.

Those individuals or groups of marine mammals that could be disturbed by the project may experience high vessel activity during summer from recreation, commercial fisheries, barging, and other forms of commercial and scientific vessel traffic. Because of this frequent vessel activity in Cook Inlet, some marine mammals in the area may be at least partially habituated to vessel presence and noise, and impacts from vessel traffic from the project would add incremental effects to marine mammals.

The following present and RFFAs were carried forward in this analysis based on their potential to impact marine mammals in Cook Inlet: Pebble Project expansion scenario; Johnson Tract mineral exploration, Cook Inlet Oil and Gas Lease Sales, Alaska Stand Alone Pipeline Project/Alaska Liquefied Natural Gas (one or the other, project would be developed based on funding), Driver River Oil Pipeline Transportation Project, Lake and Peninsula Borough and other regional Renewable Energy Initiatives, Commercial, Sport and Subsistence Fishing, Subsistence Activities, Scientific Surveys and Research, and the continued development of the Diamond Point Rock Quarry.

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

The RFFA contribution to cumulative effects on wildlife are summarized by alternative in Table 4.23-4.

Table 4.23-4 Contribution to Cumulative Effects on Wildlife

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Pebble Project expansion scenario	**Mine Site:** The mine site footprint would have a larger open pit and new facilities to store tailings, waste rock, and manage water, which would contribute to cumulative effects related to habitat loss, disturbance, and potential injury/mortality. At the mine site, 31,892 acres (almost 50 square miles) of habitat would be directly lost, plus additional habitat around the mine site would be avoided, with the avoidance buffer varying by species. Some species are particularly sensitive during critical life stages, such as caribou during calving and the post-calving season and bears while denning. These species in particular would likely avoid a large area around the mine site, effectively reducing the overall amount of available habitat, and potentially interrupting migration or movement corridors. **Other Facilities:** A north access road, and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment, and extended to a new deepwater port site at Iniskin Bay. Pipeline construction would have potentially limited impacts on soils from trenching activities. The construction and operation of concentrate and diesel pipelines from the mine site to Iniskin Bay would result in the loss of an additional 1,022 acres of habitat. The pipeline would follow the route of the north access road proposed under Alternative 3. The new pipeline would require construction of an adjacent access road, to be constructed in a previously undisturbed area. The construction and operation of this additional linear feature would increase the project footprint compared to Alternative 2 and Alternative 3. This would increase the likelihood of habitat fragmentation effects, because road density can adversely	**Mine Site:** Impacts would be similar to Alternative 1a, with a permanent footprint of 32,418 acres. **Other Facilities:** Impacts would be similar to Alternative 1a, except that the portion of the access road from the north ferry terminal to the existing Iliamna area road system would already be constructed. The north access road would be extended east from the Eagle Bay ferry terminal to the Pile Bay terminus of the Williamsport-Pile Bay Road. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. **Magnitude:** The duration and extent of cumulative impacts to wildlife would be similar to duration and extent of Alternative 1a, although affecting a smaller number of acres. **Duration/Extent:** The duration and extent of cumulative impacts to wildlife would be similar to the duration and extent of	**Mine Site:** Impacts would be similar to Alternative 1a, with a permanent footprint of 31,528 acres. **Other Facilities:** The north access road would be extended east from the Eagle Bay ferry terminal to Iniskin Bay. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. The construction and operation of concentrate and diesel pipelines from the mine site to Iniskin Bay would result in the loss of an additional habitat. The loss of habitat at the Iniskin Bay port would be the same as for Alternative 1a. Under Alternative 2, the additional compressor station would be 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	**Mine Site:** Impacts would be similar to Alternative 1a, with a permanent footprint of 31,541 acres. **Other Facilities:** Overall expansion would use the existing north access road; concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay. Loss of wildlife habitat would be less than Alternative 1a, Alternative 1, or Alternative 2. Because the natural gas pipeline and most of the road would already exist under Alternative 3, the amount of additional disturbance to terrestrial wildlife resulting from the Pebble Project expansion scenario would be less than the same scenario under Alternative 1a, Alternative 1, or Alternative 2. Marine mammals in the vicinity of the Diamond Point port and Iniskin Bay port would be affected by the increased vessel traffic at these locations. Effects would be compounded by

Table 4.23-4 Contribution to Cumulative Effects on Wildlife

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	affect wildlife distribution (Shanley and Pyare 2011; Fahrig and Rytwinski 2009). Habitat loss and fragmentation over an additional 78-year period is likely to have a permanent impact on terrestrial wildlife species around the mine. The concentrate and diesel pipeline would reduce the amount of truck traffic on the access roads to approximately 21 truck trips per day, plus additional light vehicles, which would add daily vehicle trips. The construction and operation of a deepwater port in Iniskin Bay would affect wildlife habitat by direct loss of 30 acres of nearshore habitat and disturbance of marine-associated species, and a wide variety of birds (waterbirds, seabirds, and shorebirds). Iniskin Bay has a large seasonal concentration of brown bears at the end of the bay, which would be directly impacted. Marine mammals may be affected by the construction noise and vessel traffic in the vicinity of the Iniskin Bay port. The Amakdedori port would be constructed and operate concurrently with the Iniskin Bay port. The additional compressor station at Amakdedori port is not expected to affect terrestrial wildlife. **Magnitude:** Pebble Project expansion scenario project footprint would directly impact approximately 31,892 acres, compared to 32,418 acres under Alternative 1 (see Table 4.1-2 for detailed acreage breakdown). There would be a substantial amount of additional habitat indirectly impacted through avoidance that would vary by species. Caribou would likely experience the greatest amount of cumulative habitat loss because they tend to avoid areas of disturbance. Bears would likely den farther away from disturbance, effectively	Alternative 1a, although affecting a smaller number of acres. **Contribution:** The contribution to cumulative effects would be slightly less than Alternative 1a, but more than Alternative 2 and Alternative 3.	under Alternative 2, the amount of habitat loss necessary for mine expansion would be lower under Alternative 2 compared to Alternative 1. In addition, there would be one linear feature during mine operations, rather than two; therefore, the magnitude of habitat fragmentation impacts under Alternative 2 would be lower than Alternative 1. **Magnitude:** Overall expansion would affect fewer acres than Alternative 1 (31,528 acres compared to 32,418 acres) given that a portion of the north road and all of the gas pipeline would already be constructed. The magnitude of cumulative impacts from this alternative would be lower than Alternative 1a and Alternative 1, but higher than Alternative 3. **Duration/Extent:** The duration and extent of cumulative impacts to soil would be similar to duration and extent of Alternative 1a, although affecting a smaller amount of acreage. The geographic extent of impacts would be localized. The	the close proximity of the two ports. **Magnitude:** Overall expansion would affect less acreage than Alternative 1a (31,541 acres compared to 31,892 acres), Alternative 1 (31,541 acres compared to 32,418 acres) or Alternative 2 (31,541 acres compared to 31,528 acres), given that the north road and gas pipeline would already be constructed. The magnitude of cumulative impacts from this alternative would be lower than either Alternative 1a, Alternative 1, or Alternative 2. The duration of impacts would increase to 78 years, extending recurring impacts. **Duration/Extent:** The duration and extent of cumulative impacts to soil would be similar to duration and extent of Alternative 1 and Alternative 2, although affecting a smaller number of acres and smaller geographic area. The geographic extent of impacts would be localized. **Contribution:** The contribution to cumulative impacts would be similar to Alternative 1 and

Table 4.23-4 Contribution to Cumulative Effects on Wildlife

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	reducing the overall amount of available denning habitat. Species would shift areas that they currently use away from development, thereby placing them in competition with conspecifics, potentially resulting in decreased wildlife abundance. **Duration/Extent:** The Pebble Project expansion scenario would increase the magnitude, duration, extent, and likelihood of impacts. The longer duration of mining activities would also increase the likelihood of injury or mortality to wildlife, and cause longer habitat avoidance of nearby areas. **Contribution:** Mine expansion contributes to cumulative effects of habitat for terrestrial wildlife, such as direct habitat loss, or avoidance of areas that are noisy or have increased human presence. The potential for injury and mortality to wildlife also increases over a longer duration and larger geographic area. The additive stress of climate change, in conjunction with the expansion scenario, may cause additional habitat loss for some species. The cumulative loss of occupied habitat for many species under the expansion scenario could lead to local population declines or shifts in use areas.		additional compressor station at the Diamond Point port is not expected to affect wildlife. **Contribution:** The contribution to cumulative impacts would be similar to Alternative 1, although affecting a smaller number of acres over a smaller geographic area.	Alternative 2, although affecting a smaller number of acres over a smaller geographic area.
Other Mineral Exploration Projects	**Magnitude:** Some RFFAs associated with mineral exploration activities (e.g., Pebble South, Big Chunk North, Big Chunk South, Fog Lake, and Groundhog) could have wildlife impacts—primarily, disturbance from aircraft and drilling (noise and vibrations)—and localized effects on water quality in watersheds common to the project (e.g., drill pads, camps); however, the exploration activities would be seasonally sporadic, temporary, and localized. Any impacts to wildlife populations from development based on the results of mineral exploration activities	Impacts would be similar to Alternative 1a.	Impacts would be similar to Alternative 1a.	Impacts would be similar to Alternative 1a.

Table 4.23-4 Contribution to Cumulative Effects on Wildlife

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	would be analyzed separately during the environmental review process, and are not included herein. **Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. Table 4.1-1, Section 4.1, Introduction to Environmental Consequences, identifies seven mineral prospects in the analysis area where exploratory drilling is anticipated (four of which are in relatively close proximity to the Pebble Project). **Contribution:** Although exploration activities are considered to have minimal cumulative impacts to wildlife, there could be potential for greater impacts from disturbance and temporary habitat loss from future development.			
Oil and Gas Exploration and Development	**Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration; and in limited cases, exploratory drilling. Seismic exploration would involve temporary overland activities, with permit conditions that avoid or minimize soil disturbance. Should it occur, exploratory drilling would involve the construction of temporary pads and support facilities, which would result in habitat fragmentation. Cook Inlet RFFAs, including Alaska Stand Alone Project, Alaska Liquified Natural Gas, and Cook Inlet lease sales, would increase shipping traffic, and result in temporary disturbance to waterbirds, seabirds, shorebirds, and marine mammals. Loss of marine habitat associated with new ports and drill rigs would be minimal in the context of Cook Inlet.	Impacts would be similar to Alternative 1a.	Impacts would be similar to Alternative 1a.	Impacts would be similar to Alternative 1a.

Table 4.23-4 Contribution to Cumulative Effects on Wildlife

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Duration/Extent: Seismic exploration and exploratory drilling are typically single-season temporary activities. The 2013 Bristol Bay Amended Plan shows 13 oil and gas wells drilled on the western Alaska Peninsula, and a cluster of three wells near Iniskin Bay. It is possible that additional seismic testing and exploratory drilling could occur in the analysis area, but based on historic activity, it is not expected to be intensive. Temporary effects from sedimentation during construction are likely, but expected to be minimal. Potential impacts to marine mammals from shipping activities would be intermittent over the long-term. **Contribution:** Onshore oil and gas exploration activities would be required to minimize surface disturbance, and would occur in the analysis area, but distant from the project. The project would have minimal contribution to cumulative effects.			
Road Improvement and Community Development Projects	**Magnitude:** Road improvement projects would take place in the vicinity of communities, and have impacts through grading, filling, and potential increased erosion. Communities in the immediate vicinity of project facilities, such as Iliamna, Newhalen, and Kokhanok, would have the greatest contribution to cumulative effects with regard to potential wildlife injury/mortality, disturbance/avoidance, and habitat fragmentation. The Williamsport-Pile Bay Road improvements project would involve additional habitat loss from roadway widening, which may cause temporary disturbance during construction, and increase the risk of wildlife/vehicle collisions if traffic increases.	Impacts would be similar to Alternative 1a.	The footprint of the Diamond Point rock quarry in Alternative 1 coincides with the Diamond Point port footprint in Alternative 2 and Alternative 3. Cumulative impacts would be limited to a potential increase in localized marine mammal impacts from commonly shared project footprints with the quarry site.	Impacts would be similar to Alternative 2; less than Alternative 1.

Table 4.23-4 Contribution to Cumulative Effects on Wildlife

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	The annual Williamsport channel dredging project maintains a 150-foot by 500-foot channel and turning basin by annually dredging 2,250 cubic yards at the approach to the barge ramp. This causes minor annual impacts to Iliamna Bay. Additionally, the Kaskanak Road project, if constructed, could lead to additional wildlife mortality along the Kvichak River drainage, as well as habitat loss and fragmentation. Some limited road upgrades could also occur in the vicinity of the natural gas pipeline starting point near Stariski Creek, or in support of mineral exploration previously discussed. Expansion of the Diamond Point Rock Quarry has potential to increase wildlife disturbance in analysis area. The estimated area that would be affected is approximately 140 acres (ADNR 2014a). **Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. Potential wildlife injury/ mortality, disturbance/avoidance, and habitat fragmentation associated with road construction would be long-term. Geographic extent would be limited to the vicinity of communities and Diamond Point. **Contribution:** Road construction would be required to minimize surface disturbance, and would occur in the analysis area but removed from the project. Any new roads would also contribute to increased hunting pressure on local wildlife populations. The road projects would have minimal contribution to cumulative effects.			

Table 4.23-4 Contribution to Cumulative Effects on Wildlife

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Summary of Project contribution to Cumulative Effects	Overall, Alternative 1a would contribute to cumulative effects on wildlife populations in the region. This primarily includes both the direct loss (almost 50 square miles) and indirect loss through avoidance of habitat surrounding areas of development. The cumulative loss of habitat may result in local declines for species in the area.	Impacts would be similar to Alternative 1a, although slightly more acres of wildlife habitat would be impacted by the Pebble Project expansion scenario.	Impacts would be similar to Alternative 1a, although fewer acres of wildlife habitat would be impacted by the Pebble Project expansion scenario.	Impacts would be similar to Alternative 2, although slightly more acres of wildlife habitat would be impacted by the Pebble Project expansion scenario.

Note:

RFFAs = Reasonably Foreseeable Future Actions

4.24 FISH VALUES

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

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

Primary Impacts in or Near the Mine Site:

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

4.24.1 EIS Analysis Area

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

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

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

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

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

4.24.2 Methodology for the Analysis of Impacts to Fish Values

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

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

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

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

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

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

4.24.3 Summary of Key Issues

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

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

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

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

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

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

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

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

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

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

Notes:

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

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

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

Mitigation

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

4.24.4 No Action Alternative

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

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

4.24.5 Alternative 1a

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

4.24.5.1 Mine Site

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

Direct Loss of Aquatic Habitat

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

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

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

North Fork Koktuli

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

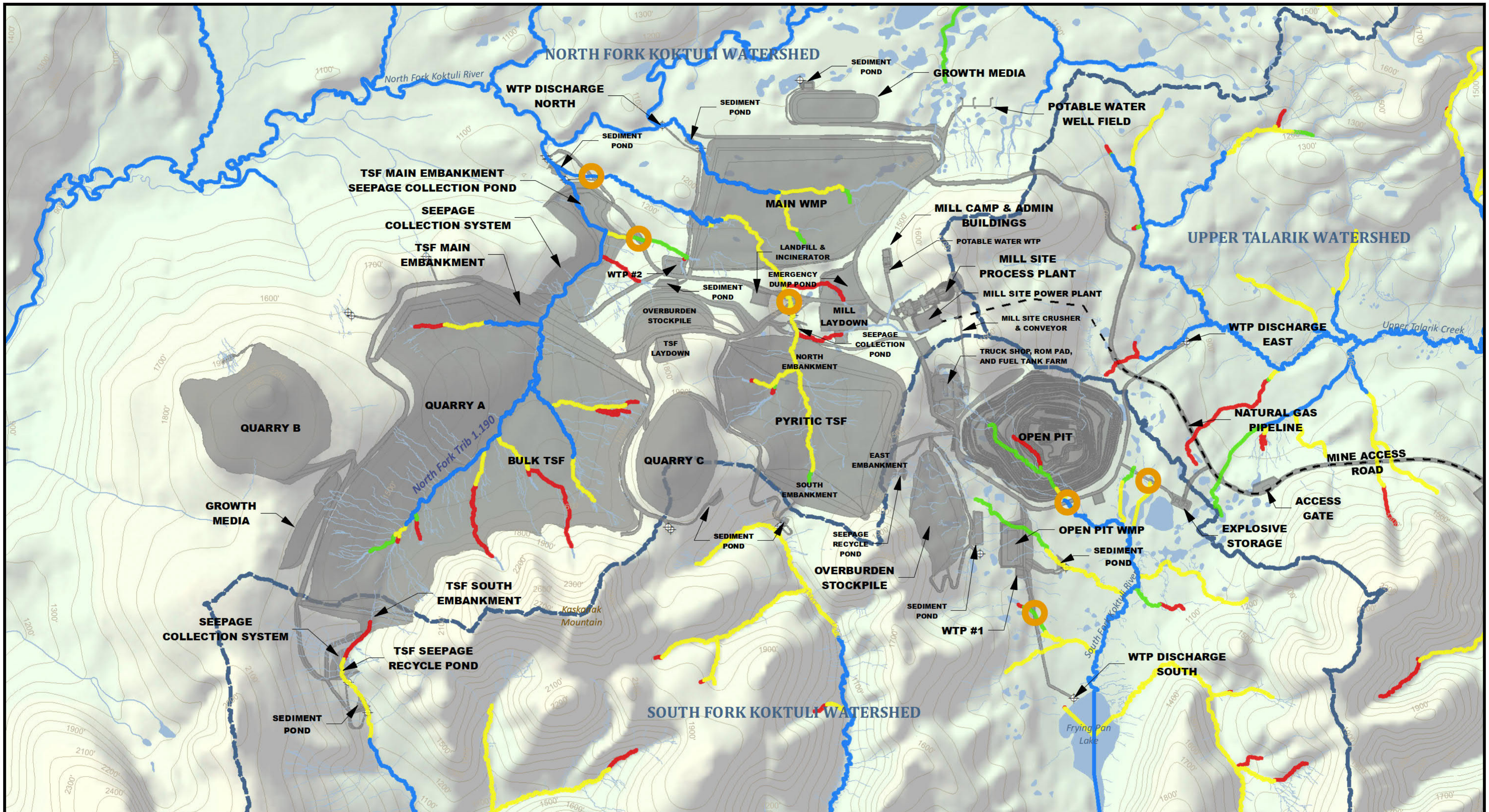
Except for coho salmon, Pacific salmon spawning has not been documented in Tributary NK 1.190 and sub-tributaries (see Table 3.24-4B), although resident fish species rear and presumably spawn in these tributaries. The substrate and physical characteristics of the tributary indicate it is not ideal spawning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

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

South Fork Koktuli

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

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



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

US Army Corps of Engineers®

Fish Distribution

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

Alternative 1a

- Monitoring Wells
- Natural Gas Pipeline
- Mine Site Footprint

Other Features

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

MINE SITE AREA FISH DISTRIBUTION

PEBBLE PROJECT EIS

FIGURE 4.24-1

Upper Talarik Creek

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

Riverine Wetlands

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

Fish Displacement, Injury, and Mortality

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

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

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

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

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

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

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

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

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

Changes in Habitat Suitability

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

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

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

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

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

Impacts to Spawning and Rearing Habitat

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

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

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

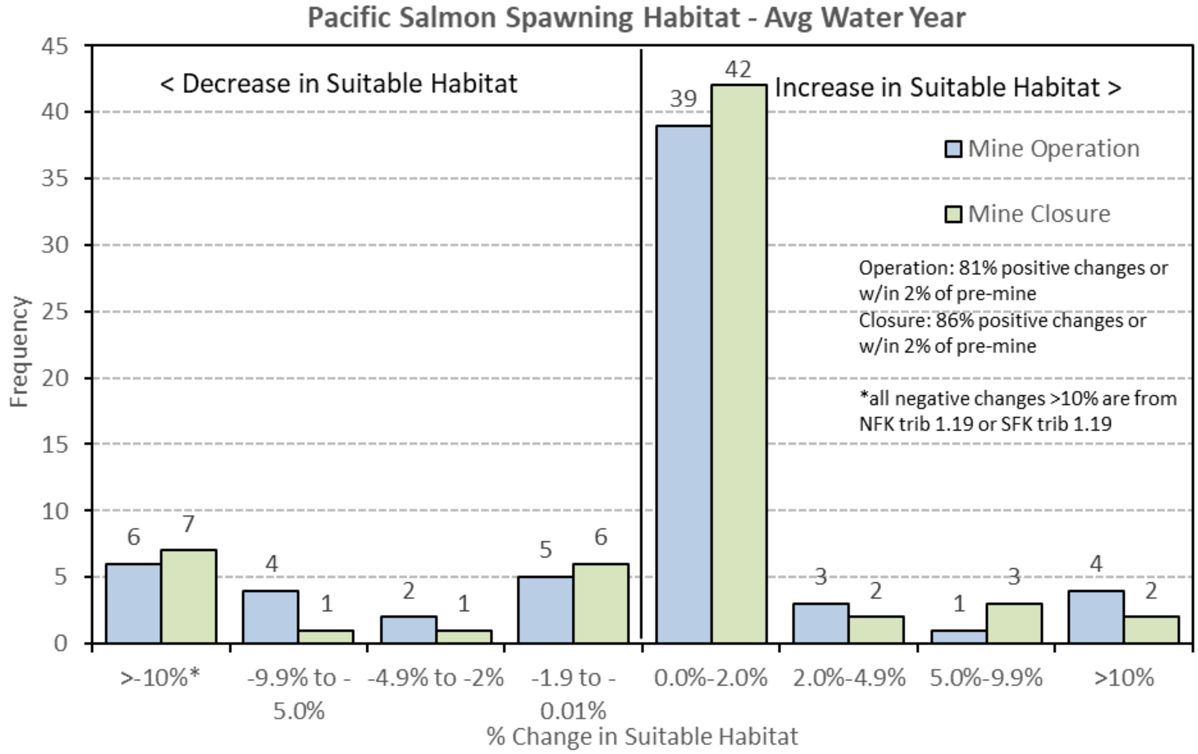
Figure 4.24-3 illustrates the relationship between predicted habitat for Chinook salmon spawning during pre-mine, operations, and closure with distance downstream of the mine site (see Table K4.24-1 for values representing other species and life-stages). More habitat occurs in reaches downstream of the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

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

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

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

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



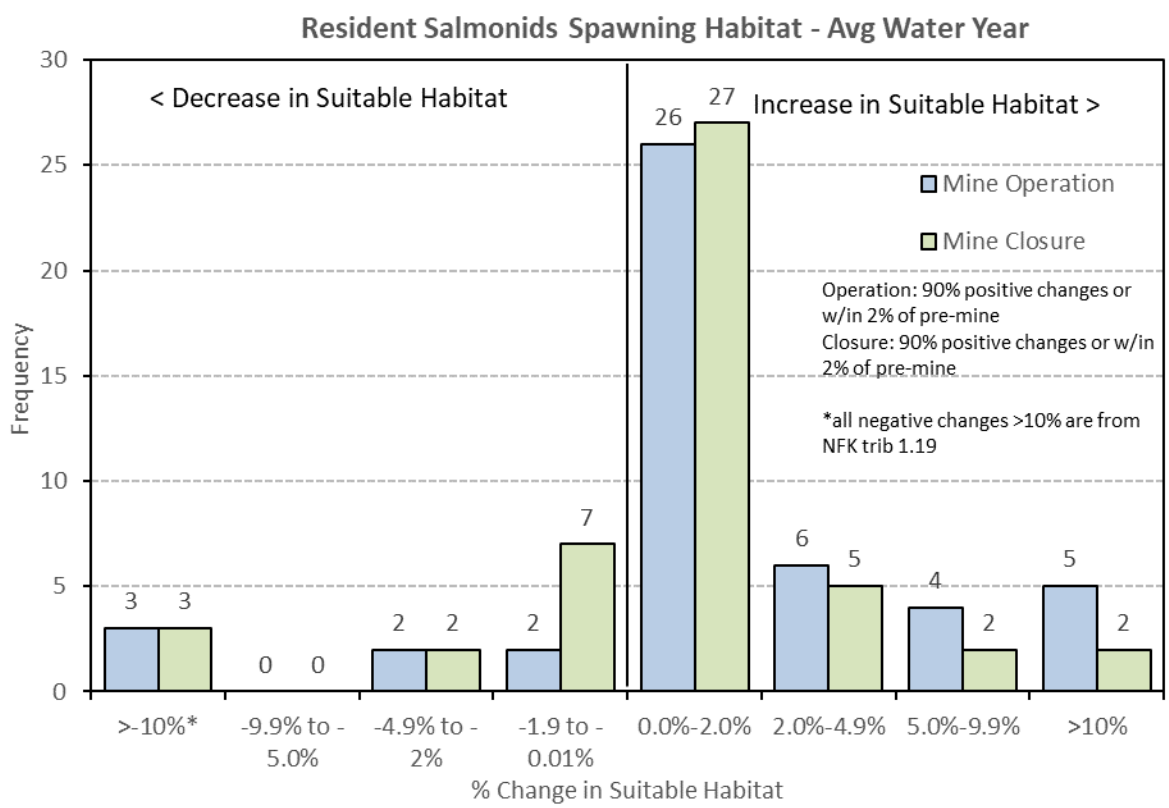


Figure 4.24-3: Predicted Changes in Suitable Habitat for Chinook Salmon Spawning during Average Water Year Scenario According to Reach and Project Phase

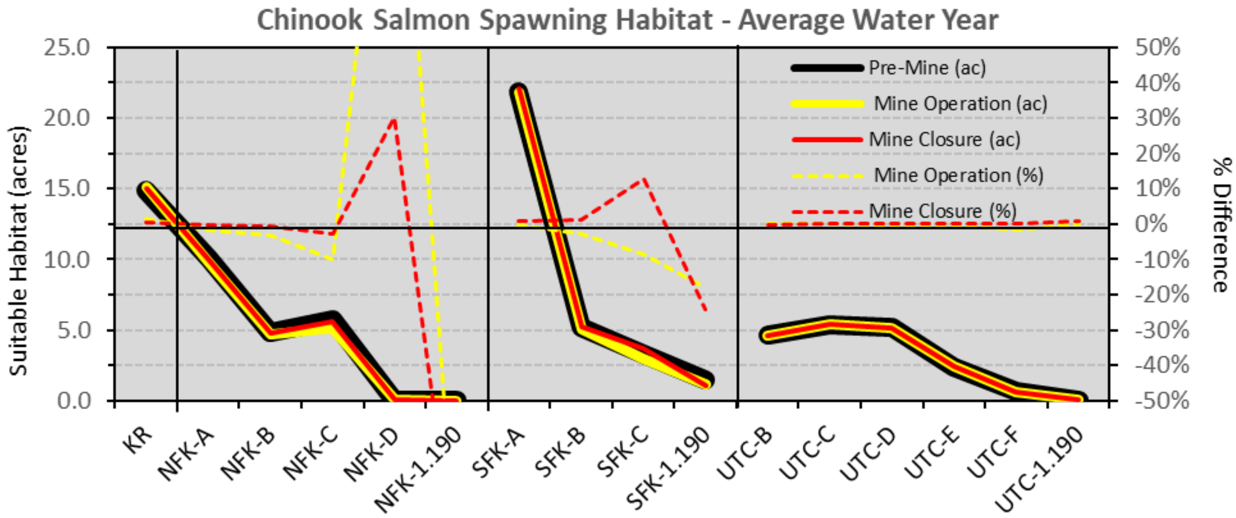
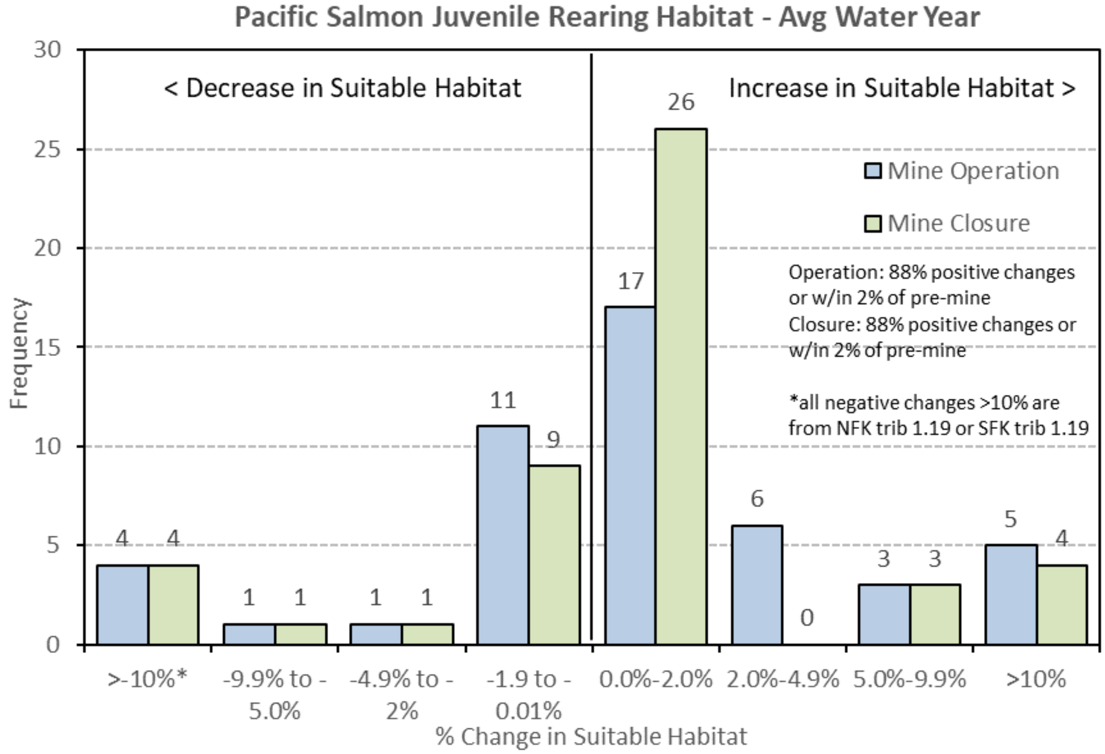


Figure 4.24-4: Frequency of Percentage Change in Suitable Habitat for Rearing Juvenile Salmonids from Pre-Mine to Operations or Closure during Average Water Year Scenario



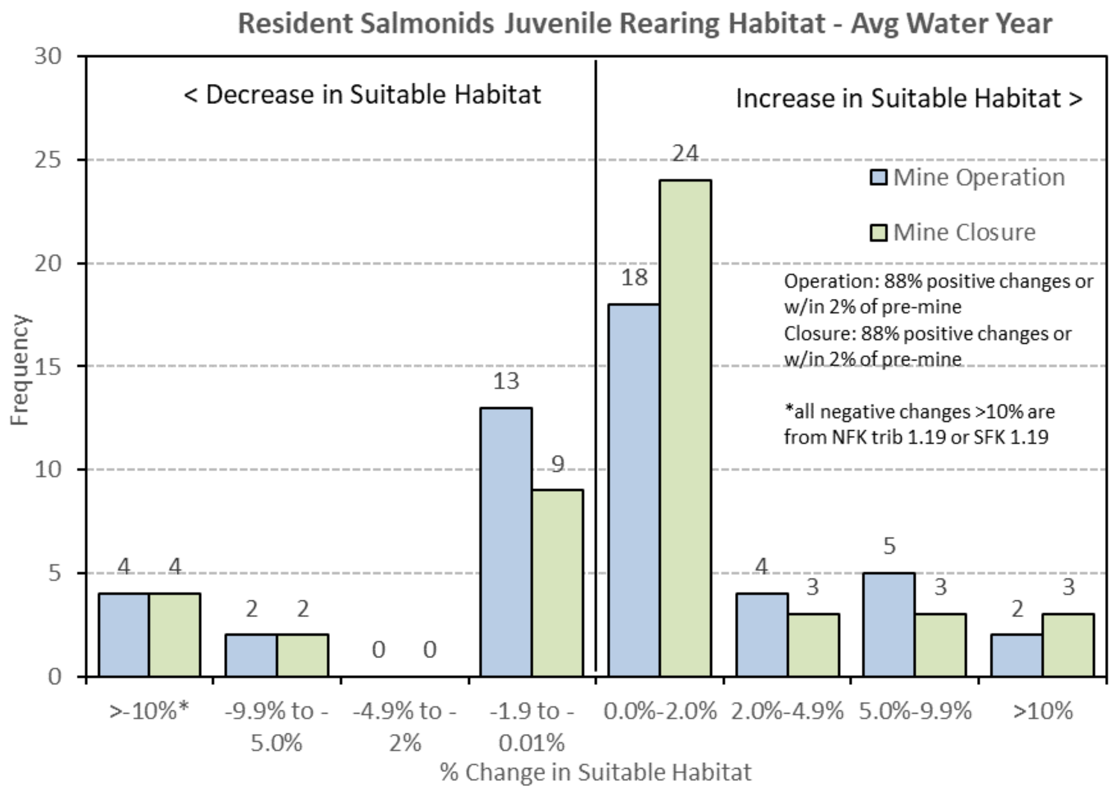
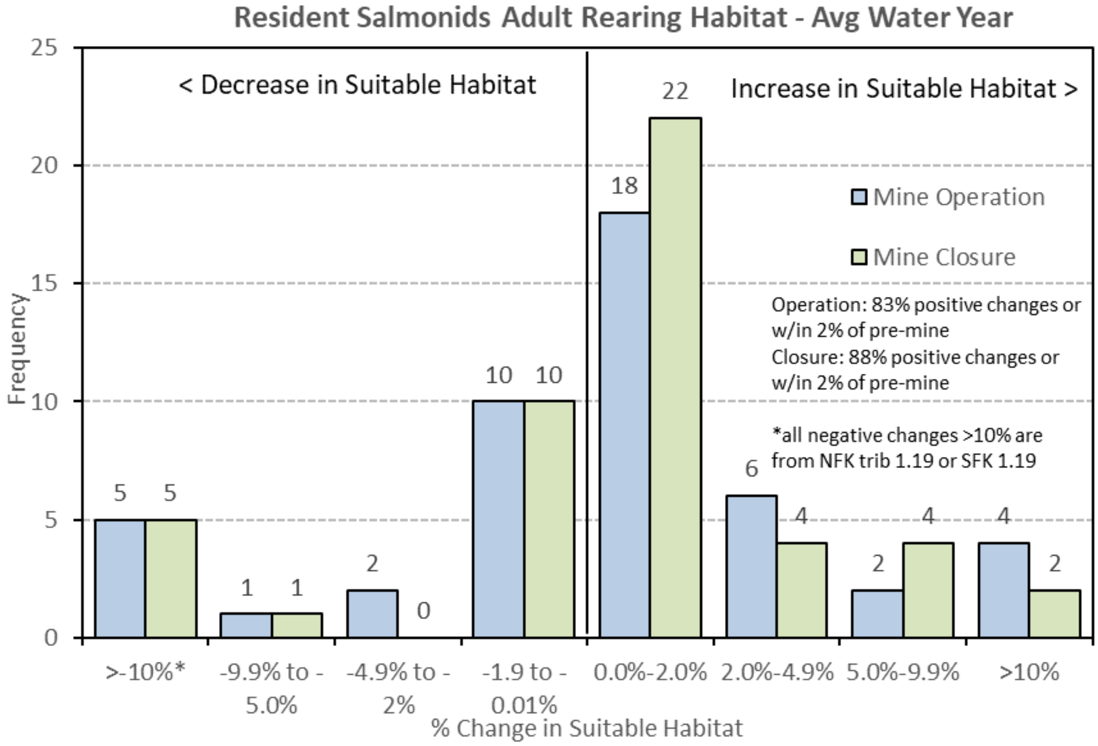


Figure 4.24-5: Frequency of Percentage Change in Suitable Habitat for Rearing Adult Resident Salmonids from Pre-Mine to Operations or Closure during Average Water Year Scenario



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

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

Impacts to Fish Habitat from Alterations to Groundwater Hydrology

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

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

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

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

Impacts to Off-Channel Habitat

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

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

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

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

Impacts to Nutrients and Productivity

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

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

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

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

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

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

Impacts to Fish Values from Increased Stream Sedimentation and Turbidity

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

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

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

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

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

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

Impacts to Fish Migration

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

Changes to Surface Water Temperatures at Treated Water Discharge Locations

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

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

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

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

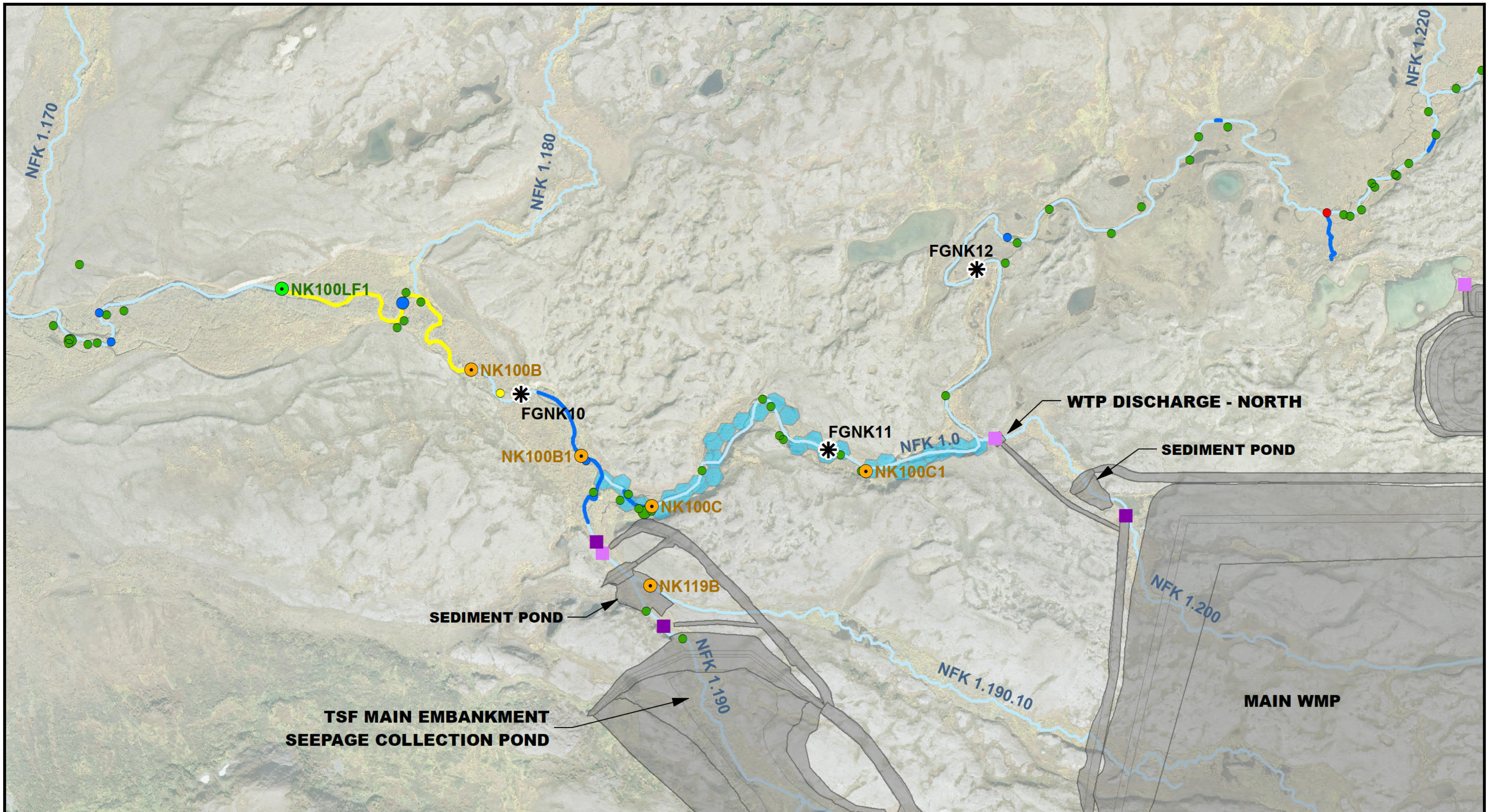
Stream	Winter		Summer	
	Pre-Mine °C	With Treated Water °C	Pre-Mine °C	With Treated Water °C
NFK River	0.2	1.4 to 3.0	6.3 to 14.5	7.2 to 12.9
SFK River[1]	0	0.85	3.3 to 14.1	3.7 to 14.6
UT Creek	0.2	0.4 to 0.7	3.2 to 12.5	3.4 to 12.7

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

North Fork Koktuli River

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

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



Sources: PLP 2019-RFI153; HDR

US Army Corps of Engineers

1,000 0 1,000 2,000

Feet

Observed Species, Count

- CH; 1 - 5
- CS; 1 - 5
- CS; 6 - 20
- KS; 1 - 5
- KS; 6 - 20
- SS; 1 - 5

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

Alternative 1a

- GW Quality Monitoring and Pump Back
- Water Quality Monitoring Point
- Mine Site

WATER TREATMENT PLANT NORTH DISCHARGE GROUND WATER HYDROLOGY/SPAWNING HABITAT

PEBBLE PROJECT EIS

FIGURE 4.24-6

South Fork Koktuli River

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

Upper Talarik Creek

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

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

Changes to Surface Water Chemistry

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

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

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

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

Toxicity and Bioaccumulation

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

Summary of Mine Site Impacts—Alternative 1a

Direct Effects

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

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

Indirect Effects

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

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

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

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

4.24.5.2 Transportation Corridor and Natural Gas Pipeline Corridor

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

Direct Loss of Aquatic Habitat

Mine and Port Access Roads and Onshore Natural Gas Pipeline

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

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

Iliamna Lake—Ferry Terminals and Natural Gas Pipeline

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

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

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

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

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

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

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

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

Cook Inlet Portion of the Natural Gas Pipeline

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

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

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

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

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

Displacement, Injury, and Mortality of Fish and Benthic Organisms

Mine and Port Access Roads and Overland Gas Pipeline

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

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

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

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

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

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

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

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

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

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

Iliamna Lake—Ferry Terminals and Natural Gas Pipeline

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

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

Iliamna Lake Ferry Operations

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

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

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

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

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

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

Pipeline-Only Overland Portion of the Natural Gas Pipeline

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

Cook Inlet Portion of the Natural Gas Pipeline

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

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

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

<u>Changes in Surface Water Flows and Iliamna Lake Circulation</u>

Mine and Port Access Roads and Overland Gas Pipeline

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

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

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

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

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

Iliamna Lake

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

Changes to Stream and Lake Productivity

Access Roads and Overland Gas Pipeline

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

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

Iliamna Lake—Ferry Terminals and Natural Gas Pipeline

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

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

Changes to Marine Productivity

Cook Inlet Portion of the Natural Gas Pipeline

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

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

Increased Stream and Lake Sedimentation and Turbidity

Mine and Port Access Roads

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

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

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

Overland Gas Pipeline

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

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

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

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

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

Iliamna Lake—Ferry Terminals and Natural Gas Pipeline

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

Cook Inlet Portion of Natural Gas Pipeline

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

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

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

Impacts to Fish Migration

Access Roads and Overland Gas Pipeline

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

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

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

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

Iliamna Lake—Ferry Terminals

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

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

Changes to Surface Water Temperatures and Chemistry

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

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

Direct Effects

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

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

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

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

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

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

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

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

Indirect Effects

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

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

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

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

4.24.5.3 Amakdedori Port

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

Direct Loss of Marine Habitat

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

Displacement, Injury, and Mortality of Fish and Benthic Organisms

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

Propeller Entrainment or Injury

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

Wake Impacts

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

Changes to Marine Productivity

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

Increased Sedimentation and Turbidity

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

Impacts to Fish Migration

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

Summary of Amakdedori Port Impacts—Alternative 1a

Direct Effects

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

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

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

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

Indirect Effects

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

4.24.5.4 Summary—Alternative 1a Impacts

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

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

4.24.6 Alternative 1

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

4.24.6.1 Mine Site

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

4.24.6.2 Transportation Corridor and Natural Gas Pipeline Corridor

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

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

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

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

Mine and Port Access Roads and Overland Gas Pipeline

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

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

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

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

Iliamna Lake—Ferry Terminals and Natural Gas Pipeline

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

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

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

Pipeline-Only Overland Portion of the Natural Gas Pipeline

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

Cook Inlet Potion of the Natural Gas Pipeline

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

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

Displacement, Injury, and Mortality of Fish and Benthic Organisms

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

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

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

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

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

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

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

Changes in Surface Water Flows and Iliamna Lake Circulation

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

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

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

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

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

Changes to Marine Productivity

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

Impacts to Fish Migration

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

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

4.24.6.3 Amakdedori Port

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

Direct Loss of Marine Habitat

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

Displacement, Injury, and Mortality of Fish and Invertebrates

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

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

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

Increased Sedimentation

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

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

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

Impacts to Fish Migration

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

4.24.6.4 Alternative 1 Variants

Summer-Only Ferry Operations Variant

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

Kokhanok East Ferry Terminal Variant

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

Direct Loss of Aquatic Habitat

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

Fish Displacement, Injury, and Mortality

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

Changes in Streamflow, Productivity, Sedimentation, and Turbidity

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

Impacts to Fish Migration

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

Pile-Supported Dock Variant

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

Direct Loss of Aquatic Habitat

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

Fish Displacement, Injury, and Mortality

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

Changes to Marine Productivity

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

Marine Sedimentation and Turbidity

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

Impacts to Fish Migration

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

4.24.6.5 Summary—Alternative 1 Impacts

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

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

4.24.7 Alternative 2—North Road and Ferry with Downstream Dams

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

4.24.7.1 Mine Site

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

4.24.7.2 Transportation Corridor and Natural Gas Pipeline Corridor

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

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

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

Direct Loss of Aquatic and Marine Habitat

Mine and Port Access Roads and Overland Gas Pipeline

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

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

Iliamna Lake—Ferry Terminals

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

Pipeline-Only Overland Portion of the Natural Gas Pipeline

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

Cook Inlet Portion of the Natural Gas Pipeline

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

Displacement, Injury, and Mortality of Fish and Benthic Organisms

Mine and Port Access Roads and Overland Gas Pipeline

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

Iliamna Lake—Ferry Terminals

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

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

Cook Inlet Portion of the Natural Gas Pipeline

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

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

Mine and Port Access Roads and Overland Natural Gas Pipeline

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

Iliamna Lake—Ferry Terminals

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

Cook Inlet Portion of the Natural Gas Pipeline

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

Impacts to Fish Migration

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

Mine and Port Access Roads and Overland Gas Pipeline

Impacts would be the same as Alternative 1a.

Iliamna Lake—Ferry Terminals

Impacts would be the same as Alternative 1a.

Cook Inlet Portion of the Natural Gas Pipeline

Impacts would be the same as Alternative 1a.

Changes to Surface Water Temperature and Chemistry

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

4.24.7.3 Diamond Point Port

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

Direct Loss of Marine Habitat

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

Sedimentation and Turbidity

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

Displacement, Injury, and Mortality of Fish and Benthic Organisms

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

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

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

Propeller Entrainment or Injury

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

Wake Impacts

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

4.24.7.4 Alternative 2 Variants

Summer-Only Ferry Operations Variant

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

Pile-Supported Dock Variant

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

Newhalen River North Crossing Variant

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

4.24.7.5 Summary of Alternative 2 Impacts

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

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

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

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

4.24.8 Alternative 3—North Road Only

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

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

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

4.24.8.1 Mine Site

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

4.24.8.2 Transportation Corridor and Natural Gas Pipeline Corridor

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

4.24.8.3 Diamond Point Port

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

4.24.8.4 Concentrate Pipeline Variant

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

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

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

4.24.8.5 Summary of Alternative 3 Impacts

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

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

4.24.9 Cumulative Effects

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

4.24.9.1 Past and Present Actions

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

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

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

4.24.9.2 Reasonably Foreseeable Future Actions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Notes:

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

4.25 THREATENED AND ENDANGERED SPECIES

Under the federal Endangered Species Act (ESA) of 1973, applicants for projects requiring federal agency action that could adversely affect threatened and endangered species (TES) are required to consult with and mitigate impacts in consultation with the US Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS). Adverse impacts are defined as “take” (defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in such conduct”), which is prohibited except as authorized through consultation with USFWS and NMFS. The USFWS or NMFS may issue an Incidental Take Statement under Section 7 or Section 10 of the ESA, depending on whether there is a federal nexus (federal permit required, or funding involved). Because the US Army Corps of Engineers (USACE) is the lead federal agency for the National Environmental Policy Act (NEPA) review of the Applicant’s permit application, the agency is required to consider the effects that a federal action may have on all listed species in the Environmental Impact Statement (EIS) analysis area. To analyze the potential effects that a federal action may have on a listed species, separate biological assessments for species under the jurisdiction of the USFWS and NMFS have been prepared. These biological assessments are included as Appendix G and Appendix H, and are referenced in this section because they provide additional details and analyses specifically for Alternative 3.

All marine mammals are also protected under the Marine Mammal Protection Act (MMPA). Under the 1994 Amendments to the MMPA, harassment is statutorily defined as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment), or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns (Level B harassment). The two levels are discussed in terms of impacts in this section as they apply to TES. Non-TES marine mammals are discussed separately in Section 3.23, Wildlife Values; and Section 4.23, Wildlife Values. Additional information on the ESA and MMPA is provided in Appendix E, Laws, Permits, Approvals, and Consultations Required. Although MMPA permitting would be necessary to construct and operate the project, it is beyond the scope of this EIS to discuss whether the submission of an application for Incidental Take Authorizations or regulations under the MMPA would result in issuance of such an authorization.

This section details the potential impacts of the project alternatives and their variants on TES in the EIS analysis area, which are detailed in Section 3.25, Threatened and Endangered Species. TES considered in this analysis include beluga whale (*Delphinapterus leucas*, Cook Inlet stock), humpback whale (*Megaptera novaeangliae*, western North Pacific Distinct Population Segment [DPS], and Mexico DPS), fin whale (*Balaenoptera physalus*, northeast Pacific stock), blue whale (*Balaenoptera musculus*, North Pacific Stock), sperm whale (*Physeter macrocephalus*, North Pacific Stock), sei whale (*Balaenoptera borealis*, North Pacific Stock), gray whale (*Eschrichtius robustus*, Western North Pacific DPS), North Pacific right whale (*Eubalaena japonica*, Eastern North Pacific Stock), Steller sea lion (*Eumetopias jubatus*, western DPS), northern sea otter (*Enhydra lutris kenyoni*, southwest Alaska DPS), Steller’s eider (*Polysticta stelleri*, Alaska breeding population), and short-tailed albatross (*Phoebastria albatrus*; worldwide population). Furthermore, federally designated and proposed critical habitat occurs in the analysis area for Cook Inlet beluga whale, humpback whale, northern sea otter, and Steller sea lion.

4.25.1 Summary of Key Issues

Table 4.25-1 details the key issues for TES across all alternatives. Because potential impacts to TES would be restricted to the marine environment, all terrestrial components of the project (including the mine site and overland portions of the transportation corridor and natural gas pipeline) are considered to have no direct impact on TES. Quantified acreages of impacted habitat are presented in Table 4.25-2, and are specific for marine components of the project only.

Table 4.25-1: Summary of Key Issues for TES

<table>
<tr><th>Impact Causing Project Component</th><th>Alternative 1a</th><th>Alternative 1 and Variants</th><th>Alternative 2 and Variants</th><th>Alternative 3 and Variant</th></tr>
<tr><td colspan="5">Port</td></tr>
<tr><td>Behavioral Changes</td><td colspan="2">Physical presence of vessels (for the life of the project) and aircraft (primarily during construction, but may also occur throughout the life of the project) may temporarily displace marine TES. Marine mammals are anticipated to move away (swim or dive) from project equipment and vessels during construction and operations. Eiders may swim, dive, or fly away from approaching vessels and aircraft (Ward and Stehn 1989; Frimer 1994).</td><td colspan="2">Same as Alternative 1a and Alternative 1; however, there would be no airport at Diamond Point port, and aircraft would land at the existing airstrip inland at Pedro Bay. Therefore, there would be no impacts to TES from project-related flights into and out of Pedro Bay. There would be a greater potential for Steller's eider disturbance in Iliamna and Iniskin bays because they occur in greater numbers in these protected bays compared with Amakdedori.</td></tr>
<tr><td rowspan="2">Injury and Mortality</td><td colspan="4">There is a potential for TES to collide with port infrastructure (including lights on the causeway and lighted navigation buoys) and vessels. Steller's eiders have a potential to collide with the communication tower at the on-land portion of the port.</td></tr>
<tr><td>Construction of the caisson dock would reduce underwater noise impacts to TES, with only a potential for Level B acoustic harassment from construction.</td><td colspan="2">Depending on the dock variant selected, underwater noise could exceed injury (Level A) and disturbance (Level B) acoustic harassment thresholds during construction, as defined by NMFS and USFWS.</td><td>Construction of the caisson dock would reduce underwater noise impacts to TES, with only a potential for Level B acoustic harassment from construction.</td></tr>
<tr><td>Habitat Changes</td><td colspan="2">Both permanent and temporary impacts to habitat for TES would vary depending on the dock variant selected. Table 4.25-2 details the habitat acreages for each alternative and variant for the different TES critical habitats that would be impacted.</td><td colspan="2">Similar to Alternative 1a and Alternative 1, but dredging of a navigation channel to access the port would be required, then maintenance dredging approximately every 5 years would continue to disturb the habitat in the navigation channel. Construction of the port access road would involve impacts to the intertidal zone from the road at Diamond Point.</td></tr>
<tr><td colspan="5">Lightering Locations</td></tr>
<tr><td>Behavioral Changes</td><td colspan="3">Avoidance of lightering locations and the immediate vicinity while vessels are moored and loading concentrate for all TES. This would last for the life of the project.</td><td>Similar to other alternatives, but only one lightering location is proposed in Iniskin Bay.</td></tr>
<tr><td>Injury and Mortality</td><td colspan="3">Potential for collision for all TES with mooring buoys, anchor chains, and vessels. This would last for the life of the project.</td><td>Similar to other alternatives, but reduced potential due to only one lightering location in Iniskin Bay.</td></tr>
<tr><td>Habitat Changes</td><td colspan="3">Construction would result in the permanent loss of 0.15 acre of benthic marine habitat (inclusive of both lightering locations regardless of alternative). This would last for the life of the project.</td><td>Loss of 0.07 acre of benthic marine habitat from anchors for one lightering location.</td></tr>
</table>

Table 4.25-1: Summary of Key Issues for TES

Impact Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Natural Gas Pipeline				
Behavioral Changes	Physical presence of vessels (during pipeline and adjacent fiber-optic cable installation and maintenance) may temporarily displace marine TES. This would last during one June-to-August construction period and potential for behavioral changes would be similar regardless of the alternative.			
Injury and Mortality	Underwater noise (with the dominant noise source from vessel cavitation noise) may exceed disturbance (Level B) acoustic harassment thresholds, but not injury (Level A) acoustic harassment thresholds, during pipeline and fiber-optic cable installation as defined by NMFS and USFWS. The noise from vessel cavitation would be greater than potential noise levels generated by various dredging technologies. Specific underwater noise impacts from various dredging technologies are detailed in Table K4.25-3 in Appendix K4.25, Threatened and Endangered Species. There is a potential for vessels to collide with TES during construction. This would last during one June-to-August construction period and the potential for injury and mortality would be similar regardless of the alternative.			
Habitat Changes	There would be temporary disturbance to habitat for one summer period while the natural gas pipeline and adjacent fiber-optic cable are trenched into Cook Inlet. This would result in potential disturbance to the seafloor and benthic marine environment, with the acreage of disturbance varying by alternative, as detailed below in Table 4.25-2. The width of the corridor would vary depending on the depth of Cook Inlet and the amount of seafloor disturbance from trenching or placing the pipeline on top of the seafloor (which would vary by alternative). There would be additional temporary seafloor disturbance from moving the station holding anchors for the pipelay barge during trenching of the pipeline. The station holding anchors would extend out on either side of the pipeline centerline and vary in width from 650 feet to 4,101 feet (up to a maximum diameter of 8,202 feet wide). This width would vary with the depth of Cook Inlet where the pipeline is trenched. In addition, not all habitat within the maximum width of 8,202 feet would be disturbed. There would be increased turbidity on the seafloor during trenching and while the station holding anchors are moved. The trench for the pipeline is expected to fill in from tidal flows. This would last during one June-to-August construction period, and potentially longer depending on the recovery time for benthic marine species that were disturbed during trenching.			
Vessel Routes				
Behavioral Changes	Physical presence of vessels may temporarily displace marine TES. This would last for the life of the project, but to a lesser extent after post-closure due to reduced need for barging. The potential for behavioral changes would be similar regardless of the alternative.			
Injury and Mortality	Underwater noise (with the dominant noise source from vessel cavitation noise) may exceed disturbance (Level B) acoustic harassment thresholds, but not injury (Level A) acoustic harassment thresholds, from vessel traffic as defined by NMFS and USFWS. There is a potential for vessels to collide with TES during project construction phases, with an increase in potential during summer, when whale species are more common in the analysis area. This would last for the life of the project, but to a lesser extent after post-closure due to reduced need for barging. The potential for injury and mortality would be similar regardless of the alternative.			
Habitat Changes	There are no habitat changes anticipated from use of vessel routes. Although vessel routes go through critical habitat for several species (Cook Inlet beluga whale, humpback whale, Steller sea lion, and northern sea otter), project-related vessels would be traveling slowly (less than 10 knots) through critical habitat for Cook Inlet beluga whale and northern sea otter in lower Cook Inlet. There are no anticipated habitat changes to proposed critical habitat for humpback whale. Vessel routes would pass through the 20-nautical-mile buffer around Steller sea lion haulouts and rookeries. However, the closest that vessel traffic would pass by a major haulout or rookery is approximately 5 nautical miles.			

Notes:

NMFS = National Marine Fisheries Service
TES = Threatened and Endangered Species
USFWS = US Fish and Wildlife Service

Table 4.25-2: Summary of Physical Impact Acreages to TES Critical Habitat

	Alternative 1a		Alternative 1 and Variants			Alternative 2 and Variants			Alternative 3 and Variant	
Species Critical Habitat	Caisson Dock[1]	Natural Gas Pipeline Corridor[2]	Earthen Causeway/ Sheet Pile Dock[1]	Pile-Supported Dock[1]	Natural Gas Pipeline Corridor[2]	Earthen Causeway/ Sheet Pile Dock,[1] Port Access Road, and Dredge Area	Pile-Supported Dock,[1] Port Access Road, and Dredge Area	Natural Gas Pipeline Corridor[2]	Caisson Dock,[1] Port Access Road and Dredge Area	Natural Gas Pipeline Corridor[2]
Beluga Whale	3.5 acres	33.8 acres	10.7 acres	3.1 acres	33.8 acres	95.3 acres (inclusive of 57.7 acres from the temporary dredge area)	93.1 acres (inclusive of 57.7 acres from the temporary dredge area)	126 acres	100.6 acres[3] (inclusive of 75.7 acres from the temporary dredge area)	118.7 acres
Humpback Whale (proposed habitat for Mexico DPS)	0 acres	554 acres	0 acres	0 acres	554 acres	0 acres	0 acres	496 acres	0 acres	496 acres
Northern Sea Otter[4]	3.5 acres	76.2 acres	10.7 acres	3.1 acres	76.2 acres	95.3 acres (inclusive of 57.7 acres from the permanent dredge area)	93.1 acres (inclusive of 57.7 acres from the permanent dredge area)	171 acres	100.6 acres[3] (inclusive of 75.7 acres from the permanent dredge area)	164.8 acres

Notes:
[1] All dock footprints are considered permanent impacts and acreages represent the entire above-water dock footprint, which includes all underwater dock support structures. The Alternative 2 and Alternative 3 footprints include maintenance dredge areas, which are considered temporary impacts for beluga whales (because they do not forage heavily on benthic prey), but are considered permanent impacts for northern sea otters (because they forage in the benthic environment). There is an additional 30-foot temporary construction buffer around all in-water project footprints (which is not included in the acreages listed above), with specific acreages detailed by project component for Alternative 3 in Tables 12 and 11 in Appendix G, ESA Biological Assessment—USFWS; and Appendix H, ESA Biological Assessment—NMFS, respectively.
[2] The natural gas pipeline corridor footprints are considered temporary impacts and include the fiber-optic cable route. If the fiber-optic cable is not installed coincidentally with the natural gas pipeline corridor, there would be repeated habitat disturbance during installation for the cable following the natural gas pipeline corridor.
[3] These acreages are based on the concentrate pipeline variant port design. The base case for Alternative 3 would have 0.03 acre less due to no concentrate bulk loader attached to the dock.
[4] Although no critical habitat for Steller sea lion or Steller's eider occurs in Iliamna, Iniskin, or Kamishak bays, loss of foraging habitat would occur and acreages of habitat impacted are assumed to be similar to northern sea otter.
DPS = Distinct Population Segment TES = Threatened and Endangered Species

The magnitude and extent of physical impacts to TES and their critical habitats would vary depending on the alternative and dock design selected (Table 4.25-2). Table 4.25-2 does not include the area of ensonification that would result during the various project activities, but focuses on physical impacts to TES critical habitat. Although no critical habitat for Steller sea lion or Steller's eider occurs in Iliamna, Iniskin, or Kamishak bays, loss of foraging habitat would occur and acreages of habitat impacted are assumed to be similar to northern sea otter The natural gas pipeline and fiber optic cable corridor is shorter for Alternative 2 and Alternative 3 (and therefore, less habitat is disturbed during installation); however the need to dredge a navigation channel and then maintain the depth of the dredged navigation channel is a greater physical impact to the benthic marine environment compared with Alternative 1a and Alternative 1. In terms of noise impacts, the caisson dock under Alternative 1a and Alternative 3 would result in the lowest magnitude of noise impacts to TES, because no sheet or pile-driving would be necessary. Therefore, underwater noise impacts would be greatly reduced when compared with the Earthen Causeway Dock and Pile-Supported Dock variants. A port at Amakdedori would generally have lower impacts to TES because there are fewer TES at Amakdedori compared to Iliamna Bay. The primary lightering location for Alternative 1a and Alternative 1 would have a lower magnitude of impacts to TES compared to the primary lightering location under Alternative 2 and the one lightering location under Alternative 3 (in Iniskin Bay). Regardless of alternative, the extent of impacts would encompass the port, lightering locations, and shipping routes in the analysis area. The duration of impacts would differ between construction and operations, but the main impacts would be the permanent footprint of the port and lightering locations and increase in vessel traffic during operations that would last for the life of the project.

4.25.2 Analysis Area

The EIS analysis area is composed of all components of the project, including the mine site, transportation, and natural gas pipeline corridors, port, lightering locations, and natural gas compressor station on the Kenai Peninsula. Specifically, for TES, the analysis area focuses on the marine components of the project in Cook Inlet, the Gulf of Alaska, along the Aleutian Islands, and the Bering Sea, because no TES have been documented in the terrestrial portions of the project. Terrestrial components of the project that include the mine site, ferry terminals, terrestrial portions of the transportation and natural gas pipeline corridors, and compressor station on the Kenai Peninsula are not discussed below because TES do not have ranges that overlap these terrestrial areas. Only marine components of the project in lower Cook Inlet and the proposed vessel routes through the Gulf of Alaska, along the Aleutian Islands, and through the Bering Sea out to the exclusive economic zone are included in the analysis area. In particular, no TES are known to occur in the vicinity of the Newhalen, Gibraltar, or Iliamna River bridge crossings (including all the variants) for the transportation and natural gas pipeline corridors; therefore, these river crossings will not be discussed further for TES.

The analysis area is defined in Section 3.25, Threatened and Endangered Species, and is briefly reiterated here as it relates to project impacts. The analysis area encompasses Iliamna, Iniskin, Cottonwood, Kamishak, and several other adjacent bays, and includes all marine project components during all phases of the project (construction, operations, and closure) regardless of the alternative or variant. This includes installation (including noise from various potential dredge technologies) of the natural gas pipeline, projected flight paths into and out of the proposed airstrip at Amakdedori, and project-related vessel traffic between the port and lightering locations. The analysis area was also designed to encompass impacts of project-related vessel traffic, including potential vessel routes in Cook Inlet and beyond.

Proposed vessel routes include waters of lower Cook Inlet and marine areas crossed by marine transport vessels, including concentrate bulk carriers, from Cook Inlet through Shelikof Strait, and through the Aleutian Islands out to the limits of the exclusive economic zone; marine line haul barges from Cook Inlet transiting to West Coast ports through the Gulf of Alaska out to the limits of the exclusive economic zone; and potential fuel barge traffic between the project port and Nikiski Port. Each vessel route was designed as a 4-nautical-mile-wide corridor, plus a 1.2-nautical-mile general vessel noise ensonified area on either side of the corridor, based on Warner et al. (2014), to account for possible noise effects to marine mammals, or a total vessel corridor width of 6.4 nautical miles.

Because the EIS analysis area was determined based on the extent of potential impacts from the project, one of the largest potential impacts is the area of ensonification during project activities, including dredging during installation of the natural gas pipeline and from project-related vessel traffic, which are detailed below under impacts from underwater noise. Specific underwater noise impacts from various dredging technologies are detailed in Table K4.25-3.

4.25.2.1 Impacts Analysis

Impacts are assessed by four factors: magnitude, extent, duration, and likelihood of impacts to TES and/or TES habitat (including federally designated critical habitat). The magnitude of impact from the project depends on the specific species' sensitivity to the disturbance and the type of disturbance; the extent and duration of impacts depends on the location and season in which the disturbance occurs (e.g., during whale migrations), and the timeframe the project is in operation. The duration of impacts also depends on whether the impact is considered temporary or permanent. Generally, any project components that would remain in place for the life of the project (20 years of operations) and potentially beyond are considered permanent. For example, the placement of structures in Cook Inlet associated with the port are considered permanent impacts. Impacts with a temporary duration include those that would be allowed to naturally recover after the initial disturbance or are buried beneath the ground or Cook Inlet sea floor, such as the footprint of the natural gas pipeline. The likelihood of impact occurring is based on whether or not the project is permitted, and depends on the alternative (and variant, if applicable) selected. It is assumed that if the project is permitted, there is a likelihood that impacts are possible, depending on incorporation of impact minimization measures. Therefore, each impact section discusses the magnitude, duration, and extent of the potential impact on the species, and the likelihood is assumed if the project is permitted.

Potential direct and indirect impacts on TES include:

- Behavioral disturbance, including:
  - Noise (causing stress and auditory masking) as defined by the NMFS acoustic harassment thresholds outlined in Table K4.25-1: Summary of NMFS Acoustic Thresholds (Level A [injury] and B [disturbance])
  - Presence of humans, vehicles and equipment, vessels, and aircraft (causing stress and auditory masking)
- Injury and mortality (from collisions with structures [including port facilities], vessels, or other marine components, and entanglement)
- Habitat changes (such as loss of and disturbance to prey resources and foraging habitat), including potential invasions of marine invasive species (discussed in Section 4.26, Vegetation)

Scoping comments expressed concern that the port site at Amakdedori is in designated critical habitat for Cook Inlet beluga whales and northern sea otters. Comments also noted that northern sea otters and Steller's eiders occur in the waters of Cook Inlet and Kamishak Bay. These concerns and comments are addressed in the impact discussions below based on the alternative considered and species potentially impacted.

Additional concerns that have been expressed include the potential for impacts to marine mammals from project-related underwater noise sources. Underwater noise that could potentially impact marine mammals is regulated by NMFS for industrial noise sources such as pile-driving (NMFS 2018b). This EIS does not provide a detailed calculation of acoustical thresholds of specific project components under the alternatives. It also does not provide a detailed assessment of estimated numbers of marine mammal “take” through noise disturbance and harassment. This detailed information would be analyzed further in a MMPA authorization request to the regulatory agencies to meet Level A and B guidelines. Although USFWS uses the NMFS acoustic guidelines for estimates of take attributable to activities that produce underwater noise, they also use behavioral criteria for take estimation. To issue an Incidental Harassment Authorization (IHA) under Section 101(a)(5)(A) of the MMPA, NMFS must set forth the permissible methods of taking pursuant to such activity, and other means of effecting the least practicable impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for taking for certain subsistence use. NMFS strives to develop mitigation and monitoring measures that would minimize the severity of such taking to the extent practicable. Mitigation is mainly focused on close-range injury effects, defined as the onset of permanent threshold shifts (PTS) and temporary threshold shifts (TTS) in marine mammal hearing (NMFS 2018b). As detailed in the biological assessments (Appendices G and H), Pebble Limited Partnership (PLP) would develop a Marine Mammal Monitoring and Mitigation Plan (4MP) in association with an IHA to apply mitigation measures to reduce impacts to whales and pinnipeds. The plan would include employing protected species observers (PSOs) to monitor these areas and initiate activity shutdown as needed to prevent Level A and minimize Level B harassment of marine mammals. In evaluating how mitigation may or may not be appropriate to ensure the least practicable adverse impact on species or stocks and their habitat, as well as subsistence uses where applicable, two primary factors are considered: 1) the manner in which, and the degree to which, the successful implementation of the measure(s) is expected to reduce impacts to marine mammals, marine mammal species or stocks, and their habitat; and 2) the practicability of the measures for Applicant implementation, which may consider such things as cost, impact on operations, and other factors. As mentioned previously, it is beyond the scope of this EIS to discuss whether the submission of an application for IHA or Regulations under the MMPA would result in issuance of such an authorization.

Potential impacts to TES, their prey, and habitats from various spill scenarios are not discussed in this section, but are detailed in Section 4.27, Spill Risk. This includes potential impacts to TES, prey species (e.g., fish, invertebrates, benthic organisms) and their habitats. Potential impacts on water quality are detailed in Section 4.18, Water and Sediment Quality, and all water released back into the environment (including wastewater) would meet or exceed water quality standards. Additional information on impacts to water quality from potential unintended releases and spills is detailed in Section 4.27, Spill Risk.

4.25.2.2 Project Variants

The different alternative variants that are considered outside of Cook Inlet (Kokhanok East Ferry Terminal Variant, Summer-Only Ferry Operations Variant, and Newhalen River North Crossing Variant) would not change the overall impact to TES. Specifically, under the Summer-Only Ferry Operations Variants for Alternative 1 and Alternative 2, there would be no change to the year-round concentrate lightering schedule from the ports to the lightering locations, and therefore no change in impacts to TES in Cook Inlet. The only variants that would impact TES in Cook Inlet are the Pile-Supported Dock Variant (under Alternative 1 and Alternative 2) and the Concentrate Pipeline Variant (for Alternative 3). Because this section is organized by species rather than by component, separate variant subheadings are not included (this structure differs from other sections of Chapter 4, Environmental Consequences). Discussion of the Pile-Supported Dock Variant and Concentrate Pipeline Variant are integrated into the discussion where appropriate below.

4.25.2.3 Mitigation

Impacts to TES would be minimized or mitigated to the extent feasible through a variety of processes. Consultation with the USFWS and NMFS (collectively, the Services) and any resulting biological opinions would contain reasonable and prudent measures that would minimize impacts to TES. Measures that are included in the draft biological assessments to the Services (Appendix G and Appendix H) are included in Table 5-2; and Appendix M1.0, Mitigation Assessment. Furthermore, consultation under the MMPA may result in additional mitigation measures required by the Applicant. Implementation of these measures is designed to avoid and reduce potential impacts. Additional measures that may be incorporated are included in Appendix M1.0, Mitigation Assessment.

To summarize measures that would minimize potential impacts to TES, the project would use Best Management Practices (BMPs) for prevention, control, and management of invasive species, including implementation of an Invasive Species Management Plan (Owl Ridge 2019d) to avoid the importation of invasive species into the project area due to project activities during construction, operations, and closure. The invasive species management strategy would be developed at a later stage in the permitting process. Invasive species are discussed in greater detail in Section 4.26, Vegetation. In addition, tug and barge speeds in Kamishak and Iliamna Bay (defined as a longitudinal line west of 153°15′0″ west [a vertical line between Oil Bay and Cape Douglas]) would be controlled to minimize the potential impacts to the species (Figure 3.25-1). This would involve regulating vessel speeds to less than 10 knots (knot is a unit of measure for speed of aircraft or boats; 1 knot equals 1.15 miles per hour) in Kamishak Bay to reduce the potential for collision and disturbance for all TES. A lighting plan would be developed to reduce construction and operational lights around the port that might attract Steller’s eiders, or lighting that might assist eiders in early detection of structures. Finally, a Wildlife Interaction Plan would be developed that deals primarily with terrestrial wildlife interactions. Guiding principles of wildlife reporting, adaptive management, and BMPs would be implemented for marine wildlife.

The following measures are detailed in the NMFS Biological Assessment (Appendix H) (which is specific to Alternative 3) and summarized in this section. Measures that are already listed elsewhere (such as spill response measures in Table 5-2) are not repeated below. These measures are preliminary, and not considered final until conclusion of the consultation process with the NMFS.

- The project would employ PSOs to monitor shutdown exclusion zones during project construction activities that produce underwater noise levels above harassment or injury take thresholds.
- To mitigate for construction noise impacts to cetaceans and pinnipeds during construction, the Applicant would develop and implement a 4MP. Details of the 4MP include the use of PSOs, ramp-up procedures, monitoring of zones, and others.
- Blasting in Iliamna Bay above the high tide line for construction of the Diamond Point port access road would be timed to coincide with times when tides are at or near minimum elevation to avoid in-water transfer of sound.

- Vessel speeds would be limited to 10 knots in lower Cook Inlet north of Augustine Island to mitigate potential vessel strike with marine mammals.
- The mooring systems and components of the anchor cable would be annually inspected each fall after the close of the Cook Inlet salmon setnet fishery to ensure they are in good working order. Any debris caught on the cables would be removed and properly disposed of at that time.
- Measures to reduce accidental spills would include the use of marine radar to assist in avoidance of other vessels and with accurate approach to the wharf.
- The concentrate conveyor would be fully enclosed to contain dust and shed snow.
- The barge loader would be fitted with a mechanical dust collection system; each barge would have a cover system to minimize fugitive dust and protect the concentrate from precipitation. During lightering operations, the barge's internal system would retrieve and convey concentrate to the bulk carrier via a self-discharging boom conveyor. The boom would be fully enclosed and equipped with a telescoping spout; it would also have mechanical dust collection to prevent spillage of fugitive dust.

The following measures are detailed in the USFWS Biological Assessment (Appendix G) (which is specific to Alternative 3) and summarized herein. For measures that are already listed elsewhere (such as spill response measures in Table 5-2), they are not repeated below. These measures are preliminary, and not considered final until conclusion of the consultation process with the USFWS.

- The project would employ PSOs to monitor shutdown exclusion zones during project construction activities that produce underwater noise levels above harassment or injury take thresholds for northern sea otter.
- To mitigate for construction noise impacts to sea otters, the Applicant would develop and implement a 4MP. Details of the plan include the use of PSOs, ramp-up procedures, monitoring of 984-foot exclusion zones around fill placement activities, and others.
- Vessel speeds would be limited to 10 knots for all project construction vessels operating inside the northern sea otter critical habitat.
- During operations, supply barges, fuel barges, and concentrate bulk vessels would travel at their normal cruising speeds when entering lower Cook Inlet, but would reduce speeds to less than 10 knots when entering sea otter foraging habitat (delimited by the 66-foot depth contour). All lightering barges would operate at speeds less than 10 knots.
- Guide cables would not be used to secure the communications tower to minimize avian collision risk.
- A lighting plan would be developed to reduce construction and operation lights that might attract eiders, or lighting would be implemented that might assist eiders in early detection of structures.
- Measures to reduce accidental spills would include the use of marine radar to avoid other vessels and accurately approach the wharf.
- The concentrate conveyor would be fully enclosed to contain dust and shed snow.
- The barge loader would be fitted with a mechanical dust collection system, and each barge would have a cover system to minimize fugitive dust and protect the concentrate from precipitation. During lightering operations, the barge's internal system would retrieve and convey concentrate to the bulk carrier via a self-discharging boom conveyor. The boom would be fully enclosed and equipped with a telescoping spout, and would have mechanical dust collection to prevent spillage of fugitive dust.

4.25.3 No Action Alternative

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

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

4.25.4 Alternative 1a

Potential project sources of behavioural disturbance, injury and mortality, and habitat changes may occur to TES through construction, operations, and decommissioning of the marine portions of the Amakdedori port, natural gas pipeline in Cook Inlet, lightering locations, and lighted navigation buoys. This may occur through the presence of various project-specific vessels and aircraft in Kamishak Bay and lower Cook Inlet.

This section briefly highlights the project components that have a potential to impact TES and their critical habitat during construction. The in-water portion of the port at Amakdedori would be constructed during ice-free months between May and September in 1 year. The in-water portion of the Amakdedori Port would be constructed using a series of various-sized caissons placed in Cook Inlet that would support a concrete dock.

The caissons (pre-cast open-top concrete cubes with bottom measurements of 60 by 60 feet or 60 by 120 feet, depending on location) would be filled with water or fill material and allowed to settle on the sea floor. Minor seafloor excavation of 2 to 3 feet would be necessary to ensure the caissons are positioned correctly. A 30-foot temporary construction buffer is assumed to be necessary around each caisson during placement. Caissons would be floated into place using tugboats, and allowed to settle on the seafloor as the tide drops; or filled with material and sunk into place. Bridge beams would be placed on top of the caissons to support the main service deck of the dock. Two lighted navigation buoys (3 feet in diameter) would be placed on the subtidal reefs framing the entrance to Amakdedori port. The buoys would be placed on the reef using 3-foot-cubed concrete block anchors, with an anchoring design that prevents excessive anchor chain drag or swinging (PLP 2018-RFI 093). Permanent structures mounted on the causeway and or dock would include a fuel pipeline for unloading barges, a powerline for vessel shore power, a water supply line for firefighting, and illumination and navigation lights. No permanent cranes or fuel storage would be on the dock.

The construction and operations of the on-land portion of Amakdedori Port are not anticipated to impact marine mammal TES. Radio and/or cell service would be provided for communications at the port, with the required antennas being co-located with the port office facilities. A single communications tower may be required to support very high frequency (VHF) ship-to-shore communications, and for local area cellular telephone use by project staff. PLP would use a monopole tower arrangement that does not require support cables, to avoid potential impacts to avian species from the use of supporting cables. The tower would be between 100 and 150 feet in height; and in accordance with FAA (FAA 2018b) and USFWS guidelines, would be marked with high-visibility paint bands, and may include flashing red lights at the top, if required. The communications tower at the port may pose a collision hazard to Steller's eiders, and are discussed below.

The two lightering locations would be constructed the same way and would have the same underwater footprint. The lightering locations would be constructed of a spread anchor mooring system approximately 2,300 feet by 1,700 feet, in approximately 80 feet of water. Each lightering location would consist of six mooring buoys held in place by 10 anchors total. Each mooring buoy would be attached via a 2-inch-diameter chain to gravity anchors (one station-keeping anchor [typically 3 feet by 3 feet by 3 feet] and one or two large mass rock/concrete anchors [typically 40 feet by 8 feet by 8 feet] connected by chain) placed on the bottom of Cook Inlet. The total footprint of both lightering locations for all anchors would be approximately 0.15 acre, and require a barge, support tugs, and supply vessels for installation.

The construction of the natural gas pipeline from Anchor Point to Amakdedori has the potential to impact TES. The construction of the Cook Inlet crossing of the pipeline would be expected to take 30 to 40 days, and may include up to 10 construction, support, and survey vessels. Pipeline construction is anticipated to occur between June through August in a single year. The 12-inch-diameter pipeline would be installed via horizontal directional drilling from the compressor station out into waters that are deep enough to avoid navigation hazards (PLP 2019-RFI 011a). From this point, the heavy-wall pipe would either be placed on the sea floor and anchored or supported as required, or trenched using a clam shell dredge, extended-reach backhoe, suction dredge, or jet sled working from barges. The temporary construction area corridor width would be 30 feet to include space for pipeline placement activities (PLP 2018-RFI 082). A fiber-optic cable would be co-located with the natural gas pipeline and may require additional vessels for installation depending on timing of installation.

During project construction, work crews would access sites by helicopter or boat until the port access road to the south ferry terminal is constructed. A permanent airstrip would be built at Amakdedori port to facilitate the construction phase of the port access road. Twin Otter or similar aircraft would make 20 to 40 flights per month (average of 5 to 10 flights per week) during the construction phase to Amakdedori port, before Kokhanok can be accessed by road. Once road access to Kokhanok is established, flights to and from Amakdedori port would occur infrequently for incidental/emergency access only.

Operations of the port and lightering locations would occur year-round. Each year, approximately 27 concentrate vessels and 33 supply barges (inclusive of 4 fuel barges) would be needed for transport (an average of one vessel per week). Each concentrate vessel would require 10 trips by a lightering barge between the port site and lightering location to fill the bulk carrier, which would be moored for 4 to 5 days. There would also be oceanic tugboats to pull the supply barges, and port-based tugboats would be used to assist the bulk carrier with mooring and to move the lightering barges. This would substantially increase vessel traffic in Kamishak Bay above current levels. As detailed in Section 3.12, Transportation and Navigation; and Section 4.12, Transportation and Navigation, there are currently low levels of vessel activity in Kamishak Bay. Areas crossed by marine transport include lower Cook Inlet, and extend to marine areas crossed by marine transport vessels, including concentrate bulk carriers from Cook Inlet through Shelikof Strait, and through the Aleutian Islands; and marine line haul barges from Cook Inlet to West Coast ports either through established marine routes across the Pacific Ocean or following near coast maritime routes along the Gulf of Alaska and Southeast Alaska. Based on the most recent vessel traffic studies, the increase in traffic during the operations phase would represent an approximately 12.5 percent vessel traffic increase in lower Cook Inlet when compared to 2010 data (Eley 2012). Vessel traffic through the Aleutian Islands would increase by approximately 1 percent based on 2008-2009 traffic (ERM-West Inc. and Det Norske Veritas 2010). Vessel traffic studies specific to the Gulf of Alaska are not available, but traffic is expected to be similar to that of the North Pacific Great Circle route through the Aleutian Islands.

Reclamation of project infrastructure is detailed in Chapter 2, Alternatives. Some infrastructure would remain in place to support the long-term management of the water treatment facilities at the mine site. This may include the need for several barge trips annually to support post-closure and long-term maintenance activities. The Amakdedori port facilities would be removed, except for those required to support shallow draft tug and barge access to the dock for the transfer of bulk supplies. Limited barging activity would be necessary to supply fuel and water treatment consumables to support long-term water treatment and monitoring activities. The marine port facilities would eventually be removed and reclaimed after closure activities are completed (PLP 2018-RFI 024). The final details of physical reclamation and closure for the natural gas pipeline are currently undetermined, but it would be pigged and cleaned and either abandoned in place or removed, subject to state and federal regulatory review and approval at the decommissioning stage of the project. Impacts on TES from reclamation and closure activities are assumed to be similar to those for construction, but to a lesser extent. No impacts that are specific to reclamation and closure activities are anticipated for TES; therefore, reclamation is not discussed in detail in this section.

Table 4.25-3 summarizes the construction and operational impacts in the marine waters of Cook Inlet that may impact TES under Alternative 1a.

4.25.4.1 Cook Inlet Beluga Whale

<u>Behavioral Disturbance</u>

Underwater and Airborne Noise

As detailed in Section 3.25, Threatened and Endangered Species, Cook Inlet beluga whales have generally been observed north of the analysis area during summer months (primarily in upper Cook Inlet) and are less concentrated in the lower portions of Cook Inlet. Recently, there have been scattered reports of beluga whales in Kachemak Bay and outside Port Graham, which indicate that the species still occasionally uses lower Cook Inlet. Portions of Kamishak Bay were included in Critical Habitat Area 2 due to the potential to serve as fall and winter foraging and transit habitat for beluga whales, as well as spring and summer habitat for smaller concentrations of beluga whales (76 FR 20180). Project-specific surveys have not documented Cook Inlet Beluga whales around Amakdedori, but there are scattered records in Iliamna, Iniskin, and Chinitna bays. Cook Inlet beluga whales have a potential to be exposed to project-related airborne and underwater noise from a variety of sources during construction and operations. This may range from construction of the port, the natural gas pipeline, and fiber-optic cable, lightering locations, navigation buoys, and aircraft flights into and out of the airstrip at Amakdedori. Operations-related noise would be primarily from vessel activities at the port and lightering locations. An in-depth discussion on the hearing abilities of affected marine mammals and a general discussion on the effects of noise (primarily underwater) on marine mammals are presented in Appendix K 4.25, Threatened and Endangered Species.

Table 4.25-3: Summary of Construction and Operations Impacts for Alternative 1a

Project Component[1]	Impacts
Construction	
Caisson Dock	2.1 acres (permanent in-water footprint) plus 4.4 acres of temporary impacts from a 30-foot construction buffer around the permanent in-water footprint. 3.5 acres (permanent above-water footprint)
Lightering Locations[2]	The total spread of the anchors per lightering location is approximately 2,300 by 1,700 feet. The total substrate covered by the anchors is 0.15 acre from the combined footprints of all anchors necessary to hold the mooring buoys in place.
Lighted Navigation Buoys	3-foot cubes, one per buoy, two buoys total, placed on the surface of the subtidal reef at the entrance to Amakdedori port. Habitat impact would be 18 square feet of benthic marine habitat for both buoys.
Natural Gas Pipeline (and adjacent fiber-optic cable)	The maximum corridor width from anchors placed for the pipe-lay barge may extend out to 8,202 feet spanning the pipeline corridor (depending on the depth of Cook Inlet). On average, the pipeline corridor width would be about 1 mile wide and include both the physical trenching footprint and the station-holding anchors for the pipelay barge. The total pipeline length in Cook Inlet is approximately 104 miles. The pipeline would be trenched in or placed on top of the substrate, and result in approximately 626.6 acres of temporary disturbance to Cook Inlet. 33.8 acres (3.2 corridor miles) are in designated Cook Inlet beluga whale critical habitat, and 76.2 acres (10.7 corridor miles) are in designated northern sea otter critical habitat. 554 acres (95 corridor miles) of the pipeline traverse humpback whale critical habitat. The primary noise source during pipeline and fiber-optic cable placement emanates from tugboats during dynamic positioning. It was determined that a 1.7-mile radius was a conservative distance for the extent of underwater noise generated by the tugboats during anchor handling activities, which exceeds the 120-decibel harassment threshold for continuous noise sources. This 1.7-mile radius would encompass all potential noise sources, including those from various dredging technologies and from anchor handling. The average width of impacts (both physical and from underwater noise) would extend approximately 4.4 miles in width along the length of the pipeline though Cook Inlet.
Aircraft Activity	Approximately 20 to 40 flights per week for 1 year during construction of the port access road.
Operations	
Vessel Activity	27 concentrate vessel shipments would depart the lightering locations annually. Each concentrate vessel would be moored for 4 to 5 days and require 10 lightering trips to fill each concentrate vessel. An additional 33 supply barges (inclusive of 4 fuel barges) would be required annually to supply consumables, fuel, reagent, etc. This equates to 330 annual project-related vessel trips in the analysis area. This would result in an increase of vessel traffic in Cook Inlet by 12.5 percent and through the Aleutian Islands by 1 percent. There would also be oceanic tugboats to pull the supply barges and port-based ice-breaking tugboats to assist the bulk carrier with mooring, and to move the lightering barges. Vessel routes (shipping lanes) would extend north to Nikiski and south through the Gulf of Alaska to West Coast ports, and west along the southern side of the Aleutian Islands through Unimak Pass, into the Bering Sea, and out to the exclusive economic zone. The width of the vessel routes would be approximately 7.4 miles, and would encompass the zone of ensonification from project-related vessels.
Aircraft Activity	Infrequent and primarily for emergency use only.

Notes:
[1] Acreage calculations were determined based on the intersection of project components and geographic information system critical habitat layers from the US Fish and Wildlife Service and the National Marine Fisheries Service (depending on the species under their purview), along with the written description of the critical habitat primary constituent elements. The in-water portion of the port, the lightering locations, and lighted navigation buoys are considered permanent impacts. The 30-foot construction buffer and trenching for the natural gas pipeline are considered temporary impacts.
[2] The lightering locations are outside of designated critical habitat for Cook Inlet beluga whale and northern sea otter, but are in proposed critical habitat for the humpback whale.

Like most small- to medium-sized odontocetes (toothed whales), beluga whales have exceptionally good hearing at the high frequencies that are used for echo-location (Richardson et al. 1995a). Beluga whales are categorized as mid-frequency hearing cetaceans with functional hearing in the 50-Hertz (Hz) to 200-kilohertz (kHz) range (Ciminello et al. 2012). Although they are known to hear a wide range of frequencies, their greatest sensitivity is around 10 to 100 kHz (Richardson et al. 1995a), well above sounds produced by most industrial activities (<100 Hz or 0.1 kHz) recorded in Cook Inlet. Above 100 kHz, their sensitivity drops rapidly; however, the bandwidth of their hearing extends up to 150 kHz (Au 1993). Below 8 kHz, the decrease in sensitivity is more gradual (Awbrey et al. 1988), and beluga whales are able to hear frequencies as low as 40 Hz (Johnson et al. 1989); however, at these frequencies, their sensitivity is quite poor.

The frequencies of most industrial noises are below the peak sensitivities of beluga whale hearing (Blackwell and Greene 2003). It is important to note that audiograms presented in Blackwell and Greene (2003) represent the best hearing of beluga whales, measured in very quiet conditions. These quiet conditions are rarely present in the wild, where high levels of ambient sound may exist, especially in Cook Inlet, where strong tidal currents can produce sound levels well above 100 decibels (dB) (Lammers et al. 2013; Castellote et al. 2019).

Castellote et al. (2016b) attempted to document the natural ambient noise levels in Cook Inlet by using acoustic recordings collected by the Cook Inlet Beluga Acoustics (CIBA) research program from July 2008 to May 2013. One goal was to describe anthropogenic sources of underwater noise for acoustic impacts to Cook Inlet beluga whales. A second goal was to try to determine the natural background noise levels at different locations in Cook Inlet. Their findings indicated that natural background noise in the quietest days ranged from 95 to 99 dB re 1 µPa rms, which is much lower that previously reported (Castellote et al. 2016b). The acoustic mooring location closest to the analysis area was at Tuxedni Bay, which had relatively low anthropogenic noise compared to other locations with noise from commercial shipping traffic. The quietest 24-hour period at Tuxedni Bay was 96.03 dB re 1 µPa rms, and the quietest 30-second period within the same day that had minimal anthropogenic noise was 95.28 dB re 1 µPa rms (Castellote et al. 2016b). Therefore, these levels may be representative of the ambient noise levels in other locations in lower Cook Inlet that have lower levels of anthropogenic noise sources. The study found that noise from commercial ships was widespread, which may have a negative effect on beluga communication at elevated levels; there is a potential for acute masking of beluga communication across a wide temporal and spatial scale in their critical habitat (Castellote et al. 2016b). Data from Castellote et al. (2016b) indicate that natural masking might occur during high current velocities in certain areas of the upper inlet (only for the beluga whale lower hearing range), which is opposite to the common belief that the majority of Cook Inlet is naturally a noisy environment. In the analysis area, the increase in vessel noise from the project would be concentrated between the port and lightering locations for the life of the project, and add to the current noise levels in Kamishak Bay.

Potential impacts to beluga whales can include temporary or permanent hearing impairment, non-auditory physical or physiological effects, behavioral disturbance, stress, and masking (Richardson et al. 1995a). Beluga whale responses to vessels noise varies greatly from tolerance to extreme sensitivity depending on the activity of the whale and previous experience with vessels (Richardson et al. 1995a). Beluga whale responses to vessel noise include changes in behavioral states (Richardson et al. 1995a), changes in vocalizations (Lesage et al. 1999; Scheifele et al. 2005; Gervaise et al. 2012) and avoidance (Blane and Jaakson 1994; Erbe and Farmer 2000). Lesage et al. (1999) observed changes in the vocal behavior of beluga whales in the presence of a 23-foot vessel powered by two 70-horsepower (HP) engines and a 2,173 gross-ton ferry, 260 feet long with two 2,000-HP engines, each fitted with a propeller 92.5 inches in diameter.

Vocal responses included a reduction in call rate, an increase in emissions of certain call types, repetition of specific calls, and a shift in frequency bands. Responses occurred more frequently when exposed to the ferry than the small vessel. Scheifele et al. (2005) documented the Lombard vocal response in beluga whales exposed to different vessel traffic in the St. Lawrence Estuary, Canada. The Lombard vocal response occurs when an animal increases the intensity of its vocalizations in response to a change in the environmental noise. Gervaise et al. (2012) suggest that the chronic anthropogenic noise associated with ship traffic in the mouth of the Saguenay River likely masks beluga whale communication and echolocation vocalizations. Ship traffic within a few miles can increase low-level frequencies of sound by 25 dB above background levels, which is sufficient to mask marine mammal communications (Holt et al. 2009; Bassett et al. 2012). Blane and Jaakson (1994) observed avoidance behavior by beluga whales in the presences of a 16-foot inflatable boat with an outboard motor. Avoidance behavior of the beluga whales included decreased surfacing, increased speed, and bunching into groups. Once the disturbance ceased, beluga whales resumed their previous behavior. In addition, Blackwell and Greene (2003) observed beluga whales in close proximity to the *Northern Lights* cargo-freight ship docked with motors running (126 dB re 1 μPa) at the Port of Alaska, indicating that the beluga whales were not particularly bothered by the ship.

Spatial displacements of beluga whales caused by loud sources of noise have been documented. Underwater noise from project-related activities during all phases of development could affect passage of Cook Inlet beluga whales in their critical habitat. Although the natural underwater soundscape of Cook Inlet is not considered a noisy environment for beluga whales, the Cook Inlet Beluga Whale Recovery Plan considers anthropogenic noise as a serious threat to the whale's recovery (Castellote et al. 2019). In addition, noise produced above water (e.g., from the increase in air transportation) may also impact beluga whales, who may alter behavior (e.g., by diving) to avoid noise from aircraft (Luksenburg et al. 2009).

The Alaska Fisheries Science Center deployed Ecological Acoustic Recorders (EARs) in Cook Inlet, year-round, as part of a CIBA research program between 2008 and 2013 (Castellote et al. 2019). Recorders that were deployed closest to the project were in Tuxedni Bay. The acoustic characteristics of most detected noise sources occurring across Cook Inlet beluga whale habitat have the potential to mask beluga hearing at certain frequencies, and also their communication (Castellote et al. 2019). Commercial shipping noise dominates the soundscapes, and events are longer in duration in lower Cook Inlet (Castellote et al. 2019). Shipping traffic in Cook Inlet is reduced in winter by 15 to 20 percent, and shipping speeds are lower when ice is present.

Construction of the port at Amakdedori, the lightering locations, and the natural gas pipeline and fiber-optic cable would be done during the ice-free summer months when Cook Inlet beluga whales are generally north of, and outside of the analysis area. However, the underwater noise generated during these construction activities may impact beluga whales if they are present. The main sources of noise impacts would be from excavation of the seafloor to seat the caissons at the port at Amakdedori in place and to fill them with material, and anchor-handling vessel activity, specifically the use of dynamic positioning on tugboats to set the pipelaying barge anchors in place during installation of the natural gas pipeline, as detailed in the following paragraphs.

Noise measurements specific to caisson filling and placement have not been recorded; therefore, a comparable surrogate noise-inducing activity was researched. In a recent programmatic consultation between the USACE and USFWS regarding effects to northern sea otters from activities permitted by the USACE, the USFWS found that all in-water use of heavy equipment for manipulating the substrate would result in a monitoring zone radius that could extend out to 984 feet from the sound source (USFWS 2015). The monitoring zone is a buffer that would require monitoring to avoid marine mammal Level A and minimize Level B harassment. The 984-foot monitoring zone radius is an appropriate monitoring buffer because a barge-mounted excavator would be necessary to manipulate the seafloor (by excavation to create a level surface) for placement of the caissons. Although the consultation was related to northern sea otters, the same monitoring zone radius has been used in this analysis because it is applicable to Cook Inlet beluga whales based on potential sound production. A similarly sized monitoring zone would be monitored during placement of the anchors associated with the lighted navigation buoys.

During installation (trenching/dredging) of the natural gas pipeline, a variety of vessels and equipment would be operating and generating underwater noise levels with a potential to disturb Cook Inlet beluga whales and other marine mammals. The draft NMFS biological assessment (Appendix H) details the potential noise sources and types of equipment that may be used during installation of the natural gas pipeline and fiber-optic cable that is specific to Alternative 3, but similar methods would likely be used for the other alternatives and are briefly discussed here for Alternative 1a.

During the pipe-laying operation, a suite of equipment would be deployed that generates continuous underwater noise exceeding 120 dB threshold level for disturbance (Level B) of marine mammals. Because individual equipment operation varies in time and location, and occurs simultaneously with other equipment, the loudest noise source would generate the most conservative distance to the Level B threshold. This is the approach that was taken by NMFS (2018d) in their assessment of Harvest Alaska's 2018 Cook Inlet Pipeline Cross Inlet Extension Project (CIPL), an analogous pipeline project. The primary noise source during pipeline and fiber-optic cable placement emanates from tugboats during dynamic positioning (because position-keeping in Cook Inlet is a challenge due to the strong currents) thruster operation while maneuvering the pipe-lay barge, and drive propeller cavitation noise produced while handling anchors. During the CIPL project, it was determined that a 1.7-mile radius was a conservative distance for the extent of underwater noise generated by the tugboats during anchor handling activities, which exceeds the 120-dB harassment threshold for continuous noise sources. The specific details for how this was determined are provided in the NMFS draft biological assessment (Appendix H). In addition to the 1.7-mile-radius buffer around tugboats, the average width of the trenching corridor can range from a radius of 650 to 4,101 feet on either side of the pipe-lay barge due to the width of the station-holding anchors at various depths in Cook Inlet. The average width of the anchor spread supporting the pipe-lay barge was determined to be 1 mile. Therefore, when the 1.7-mile-radius buffer is placed around a 1-mile-wide corridor for the pipe-lay barge, the total impact area during installation of the natural gas pipeline and fiber-optic cable is approximately 4.4 miles wide.

To confirm that the greatest noise source during pipeline installation would come from the tugboats operating dynamic positioning, noise generated by anchor handling itself (without dynamic positioning with bow thrusters) was estimated by Illingworth and Rodkin (2007) as 178.9 dB re 1 µPa rms (micropascal root mean square) at 3.3 feet. The distance to Level B disturbance threshold was estimated at 1.3 miles (Illingworth and Rodkin 2007). Therefore, the underwater noise generated solely from anchor handling is less than tugboats operating dynamic positioning in Cook Inlet. The zone that would be monitored to reduce impacts from dynamic positioning noise would encompass the zone for anchor handling.

Finally, the underwater noise generated solely from various dredging technologies was assessed to determine potential impacts. Underwater noise levels from various dredge technologies are detailed in Table K4.25-3 and in Table 4 in the NMFS draft biological assessment (Appendix H). The various underwater noise levels from dredge technologies range from around 146 to 178 dB re 1 µPa rms at 3.3 feet, which result in disturbance distances to the Level B threshold ranging from approximately 66 feet to 2,605 feet. These distances are all less than the 1.7-mile-radius distance for tugboats operating dynamic positioning. Therefore, the greatest underwater noise source from construction of the natural gas pipeline and fiber-optic cable installation is from the tugboats themselves (during anchor-handling operations), and not any specific dredging equipment. The EIS analysis area encompasses the entire 1.7-mile-radius buffer around the proposed natural gas pipeline and fiber-optic cable route.

Once construction is complete, the main underwater noise impact for Cook Inlet beluga whales would be from vessel operations at the port and lightering locations. Vessels are major contributors to the overall acoustic environment (Richardson et al. 1995a), particularly in the Alaska and the Arctic regions (Huntington et al. 2015). In a 2012 Cook Inlet Vessel Traffic Study Report (Eley 2012), patterns of activities were described for vessels over 300 gross tons operating during 2010. Results showed that there were 480 port calls or transits through Cook Inlet, with 80 percent of the transits made by 15 ships for the purpose of crude oil and product transport, packaged commodity shipments, and passenger/vehicle carriage. This class of vessel is characterized with source levels of 160 to 200 dB re 1 µPa rms at 3.28 feet within the 6- to 500-Hz range (Richardson et al. 1995a). Blackwell and Greene (2003) recorded underwater noise produced by both large and small vessels near the Port of Anchorage. The *Leo* tugboat produced the highest broadband levels of 149 dB re 1 µPa at a distance of approximately 328 feet, while the docked *Northern Lights* (cargo freight ship) produced the lowest broadband levels of 126 dB re 1 µPa at 328 to 1,312 feet. Ship noise was generally below 1 kHz.

Project-related vessel traffic would increase by 330 vessel trips in the analysis area, and specifically in Kamishak Bay, where there is currently relatively little vessel traffic. This would increase the ambient soundscape for whales transiting and feeding in the area from a variety of vessels including tugboats, lightering vessels, barges, and concentrate vessels. Potential noise impacts to beluga whales would be lower during the summer months, when beluga whales are generally in upper Cook Inlet. During the winter months, the ambient soundscape of lower Cook Inlet was much quieter than upper Cook Inlet (Castellote et al. 2019); therefore, the impact from project-related vessel traffic would be greater during winter, when Cook Inlet beluga whales are more likely to occur in the analysis area. Results from the CIBA research program indicate that the closest EARs buoy in Tuxedni Bay had low anthropogenic noise, because it is relatively isolated from anthropogenic activity compared to other EAR locations.

Part of the analysis area includes a vessel route that extends north to Nikiski and may include project-related barge traffic. During operations, the four annual fuel barges would most likely come from West Coast ports, although it is possible that some of the fuel could be sourced from the refinery in Nikiski. Based on current knowledge of beluga seasonal distribution, beluga whales could realistically be encountered during winter vessel activity to and from Nikiski, because vessels would pass near the mouth of the Kenai River where some portion of the beluga whale population still winter (Shelden et al. 2015). There is a potential for underwater noise from shipping traffic during operations to exceed the Level B disturbance threshold. To account for this potential noise from project vessels operating within the 4.6-mile-wide vessel route, a 1.4-mile buffer was placed on either side of the vessel route for a total 7.4-mile-wide vessel route. Therefore, any beluga whales within the 7.4-mile-wide vessel route may experience Level B disturbance if project-related vessels are transiting past at the same time beluga whales are present. However, this is unlikely, due to the use of the vessel route to Nikiski on an infrequent basis.

In summary, the duration that beluga whales may be exposed to underwater sound from construction-related vessels and aircraft would be short-term and temporary during pipeline installation and construction activities. The exposure would only be expected when seasonal distribution and habitat selection overlap in time and space with in-water project activities. Most Cook Inlet beluga whales spend the ice-free months in the upper portion of Cook Inlet (Goetz et al. 2012; Shelden et al. 2015), to the north of the analysis area. As Cook Inlet beluga whales shift south into the mid-inlet during fall and winter months (Hobbs et al. 2005), they have a higher potential to be affected by noise associated with the project as compared to the summer (when they are generally outside of the analysis area). The extent of noise impacts from operations would be limited to the port and lightering locations, and the duration would last through the life of the project. Underwater noise from vessels and aircraft would exceed disturbance (Level B) acoustic harassment thresholds; underwater noise from pile-driving would exceed injury (Level A) and disturbance (Level B) harassment thresholds. Mitigation and monitoring would be implemented to avoid Level A and minimize Level B harassment. Although temporary construction-related noise levels would be monitored to reduce and minimize potential impacts to Cook Inlet beluga whales and prevent potential harassment, there would be a localized permanent increase in underwater noise due to year-round project-induced vessel traffic that would last for the life of the project.

Physical Presence (Vessel and Aircraft)

An increase in vessel traffic would occur from construction and operations of Amakdedori port, the lightering locations, lighted navigation buoys, and placement of the natural gas pipeline. Currently, there is no baseline estimate for the number of vessels using Kamishak Bay, and specifically the area around Amakdedori port, but the number is expected to be low because this area is outside of major shipping lanes; has no nearby port or community; there are no large commercial fisheries in the immediate vicinity. Castellote et al. (2019) found that the main shipping route used by commercial vessels may change based on dense ice aggregations, with a shift towards the eastern part of the mid-inlet. The estimated timeframe for construction of the port, lightering locations, and natural gas pipeline corridor was summarized previously, and full details are provided in Chapter 2, Alternatives. There would be an increase in vessel traffic during construction and operations, as detailed above in Table 4.25-3.

NFMS researchers have witnessed avoidance and overt behavioral reactions by Cook Inlet beluga whales when approached by small vessels (Lerczak et al. 2000). Blackwell and Greene (2003) observed tolerance of beluga whales to large cargo-freight ships at the Port of Anchorage. Beluga whales reacted to aircraft flying 500 to 700 feet away, by diving for longer periods, reducing surfacing time, and sometimes swimming away; however, they did not respond to aircraft flying 1,640 feet away (Richardson et al. 1995a). However, in Cook Inlet, beluga whales, including adults with calves, appear to exhibit site fidelity, returning to estuary areas even after a disturbance (Moore et al. 2000). Beluga whales continue to occupy middle and upper Cook Inlet despite continued industrial development, vessel and aircraft traffic, and dredging operations. Moore et al. (2000) concluded that beluga whales appear to have become habituated to offshore oil and gas activities in central Cook Inlet.

The analysis area does not appear to currently be a major use area for beluga whales at any time of the year. Based on data presented in Section 3.25, Threatened and Endangered Species, beluga whales have not been regularly detected around Amakdedori port. Although vessel traffic is common in certain areas of Cook Inlet from fishing and existing industry activity, especially during the summer and early autumn months, the project-related vessel traffic would increase by 330 vessel trips in the analysis area, where there is currently relatively little vessel traffic. This would not only increase the ambient soundscape for whales feeding and transiting the area, but would increase the potential for interactions with animals. Vessel presence impacts would be lowest during the summer months when beluga whales are generally in upper Cook Inlet, and more pronounced during the winter months. However, project-related vessels would be traveling slowly (less than 10 knots), so the potential for vessel disturbance would be limited. Furthermore, the extent of the physical presence of vessels is expected to be limited to the area around Amakdedori port. The duration of time that Cook Inlet beluga whales may be exposed to physical presence of vessels would be for the life of the project, but would vary annually. Vessels associated with project activities would have a transitory presence in any specific location. It is expected that effects on Cook Inlet beluga whales may include behavioral changes such as in surfacing, breathing, and diving patterns, group composition, and vocalizations (Malcolm and Penner 2011). In Alaska, beluga whales were observed to stop feeding and move downstream in the presence of outboard motorboats. However, the same animals were less responsive to local fishing boats, to which they may have become habituated, suggesting that with time, beluga whales in the vicinity of the project have a potential to become more tolerant to vessel traffic (Malcolm and Penner 2011). Although vessels are transiting between Amakdedori port and the lightering locations, there is a period when vessel disturbance and presence of beluga whales may coincide. Because physical presence of vessels is expected to occur infrequently and concurrence with the presence of whales is likely to be short-lived, impacts of the physical presence of project vessels are not expected to cause more than a temporary effect on Cook Inlet beluga whales.

Cook Inlet beluga whales may be exposed to the physical presence of aircraft during construction of Amakdedori port. Aircraft traffic is projected to occur in the summer months; therefore, exposure to aircraft presence would occur primarily during the ice-free summer months when Cook Inlet beluga whales are primarily outside of the analysis area in upper Cook Inlet. The duration of time that Cook Inlet beluga whales may be exposed to physical presence of aircraft would be short-term and temporary, occurring only during the construction period of the port access road.

Impacts to Cook Inlet beluga whales that may occur as a result of disturbance from vessel and aircraft traffic associated with project activities would be changes in behavior, movement patterns, or habitat use. This may include brief behavioral responses such as reducing surface time and diving. Disturbance to Cook Inlet beluga whales from vessel presence is anticipated to be long-term and last for the life of the project. The extent would encompass the analysis area, primarily between Amakdedori Port and the lightering locations. The magnitude of impacts is anticipated to be low, because Cook Inlet beluga whales are not frequently observed in the analysis area, particularly in the area where vessels would be transiting. Aircraft traffic is anticipated to have minimal impact on Cook Inlet beluga whales for many of the same reasons; however, the duration would be much shorter, lasting only for construction of the port and port access road. Furthermore, aircraft overflight disturbance would be very brief, only occurring during take-off and landing near the port.

Injury and Mortality

Vessel Collision

Vessels in Cook Inlet generally transit year-round, primarily in established shipping routes (mainly on the eastern side of Cook Inlet) used by large vessels (Eley 2012). Eley (2012) details the main shipping lanes in Cook Inlet that occur east of Augustine Island in the middle of Cook Inlet and along the eastern edge. Based on a review of the Large Whale Ship Strike database, Jensen and Silber (2004) found that vessel speed was an important indicator of strike potential, with the mean speed that resulted in whale injury or mortality at over 18 knots. Data gathered by Jensen and Silber (2004) indicated that the number of vessel strikes by vessels traveling less than 10 knots was low. To reduce the potential for injury and mortality to North Atlantic right whales (*Eubalaena glacialis*), NMFS established a 10-knot speed limit for vessels over 65 feet in length during certain locations and times of the year (73 FR 60173). Following its implementation, this restriction was successful in reducing injury and mortality to the species. This is in line with the 10-knot speed limit for project-related vessels operating between the port and lightering locations.

Neilson et al. 2012 documented 108 ship strikes in Alaska from 1978 to 2011, and the data indicated that baleen whales are more susceptible to vessel strike than toothed whales. There are no records of lethal vessel strikes involving Cook Inlet beluga whales. No publicly available reports have been published since Neilson et al. 2012 that disclose more recent ship strike information across Alaska. A 2017 report from the National Park Service regarding humpback whale monitoring in Glacier Bay and adjacent waters provides the most updated information regarding vessel collisions for southeast Alaska (Neilson et al. 2018). In the report, all documented whale-vessel collisions were with humpback whales.

Generally, beluga whales are most often observed within a few miles of shore, so the probability of vessel strikes is lower in the middle of Cook Inlet, but may increase as vessels approach Amakdedori port. When vessels are transiting nearshore areas, speeds would be decreased, and vessels would be restricted to traveling at 10 knots or less (Chapter 5, Mitigation, Table 5-2). Encounters between beluga whales and project vessels could occur, although the probability based on current whale survey data is low. An encounter would be defined as observing an animal from the vessel, but not making contact. Lethal vessel strikes are not expected because vessels would be transiting between the port and lightering locations at slow speeds (less than 10 knots) that improve ability to detected and avoid marine mammals. Generally, supply, lightering, and fuel barges already operate at speeds less than 10 knots and only concentrate bulk carriers with normal cruising speeds of 13 to 15 knots would need to reduce their speed to 10 knots or less. Although lethal vessel strikes involving Cook Inlet beluga whales have not been directly confirmed, two dead beluga whales with blunt trauma indicative of ship strike were documented (one in September 2007, and one in October 2012), and reports and photographs of beluga whales with scarring patterns consistent with propeller injuries have been documented (NMFS 2016b). Due to the slower speeds and general straight-line movements of large ships, strikes from large vessels are not anticipated to pose a significant threat to Cook Inlet beluga whales (NMFS 2008a). Furthermore, based on the Cook Inlet beluga whale recovery plan, NMFS has no data to support that commercial shipping vessels, commercial fishing vessels, or other large vessels are presenting significant concerns related to ship strikes (NMFS 2008a).

Therefore, the probability of vessel collision with Cook Inlet beluga whales is low, the duration would last for the life of the project, and extent would be focused on the lower portion of the analysis area, primarily between the port and lightering locations. The magnitude of impact should a beluga whale be struck and killed would be high because any mortality of a species with a small population size has a greater impact at the population level.

Entanglement

Project components such as the anchor chains for the six mooring buoys at each lightering location are not anticipated to pose an entanglement hazard to beluga whales. Entanglement in mooring and anchor chain has not been recognized as a threat to the species. The 2-inch diameter chain would remain relatively taut, preventing kinking, and would not be slack. The anchor chain is anticipated to pose no entanglement risk for Cook Inlet beluga whales.

Habitat Changes

Cook Inlet beluga whale habitat use in the analysis area is discussed in detail in Section 3.25, Threatened and Endangered Species. The Cook Inlet beluga whale's primary foraging locations include the Susitna River Delta (the Big and Little Susitna Rivers), Eagle Bay, Eklutna River, Ivan Slough, Theodore River, Lewis River, and Chickaloon Bay and River (NMFS 2008a; 2016b). All of these locations are considerably north of and outside the analysis area. Cook Inlet beluga whales are found farther south in Cook Inlet during the fall and winter months, resulting in a higher probability of overlap with project activities during that time. Physical disturbance to habitat would occur at the dock, lighted navigation buoys, lightering locations, and the pipeline corridor. These impacts are further discussed in the critical habitat section below.

Overall, potential impacts to habitat may include increased erosion/soil displacement and run-off/ pollution from the port access road and Amakdedori port. However, runoff, sedimentation, and potential discharges into the environment would be minimized per mitigation measures outlined in Chapter 5, Mitigation, Table 5-2.

Critical Habitat

Cook Inlet beluga whale critical habitat is discussed in detail in Section 3.25, Threatened and Endangered Species, and shown in Figure 3.25-1. In summary, Critical Habitat Area 2, the only designated critical habitat that exists in the analysis area, includes nearshore areas along western Cook Inlet and Kachemak Bay. Area 2 encompasses known fall and winter foraging and transit habitat for beluga whales, as well as spring and summer habitat for smaller concentrations of beluga whales.

Cook Inlet beluga whale critical habitat includes intertidal and subtidal waters of Cook Inlet with depths less than 30 feet mean lower low water, and within 5 miles of high- and medium-flow anadromous fish streams (50 Code of Federal Regulations [CFR] Part 226.220(c)(5)]). The potential project impacts on the physical or biological features of beluga whale critical habitat would include disturbance and resuspension of sediments in the water column, installation of structures, and discharges of fill into marine waters during construction. Additional critical habitat Primary Constituent Elements (defined in CFR as the principal biological or physical constituent elements for this species) that may be impacted include disturbance to primary prey species, and in-water noise levels resulting in abandonment of critical habitat areas. Because construction of the port would occur during summer months when beluga whales are generally absent, and mitigation measures would be implemented to prevent harassment of beluga whales, in-water noise levels during construction are not likely to cause abandonment of critical habitat areas.

The potential impacts to Cook Inlet beluga whale critical habitat from construction of project components would include seafloor disturbance and habitat alteration in the form of increased turbidity and habitat loss from project activities. Permanent direct impacts (detailed in Table 4.25-3) would be placement of fill in approximately 2.1 acres of designated Cook Inlet beluga whale critical habitat. Although the combined footprints of the caissons are 2.1 acres, the overhead dock footprint is 3.5 acres. There is a 30-foot temporary disturbance buffer around each caisson footprint to allow for maneuvering and settling the caisson in place, which equates to 4.4 acres of temporary seafloor disturbance. There would also be minor habitat loss from placement of the lighted navigation buoy anchors, and an additional 33.8 acres (3.2 miles in corridor length) of critical habitat would be temporarily disturbed during installation of the natural gas pipeline. These acreages were calculated based on the area of critical habitat (derived from NMFS geographic information system layers) that overlaps with project components. All impacts to beluga whale critical habitat represent a small fraction of the available habitat in Critical Habitat Area 2. The lightering locations are not in critical habitat for Cook Inlet beluga whales, so there would be no impact or loss of habitat from installation of the anchors for the mooring buoys at the lightering locations.

Overall, the magnitude of impacts to Cook Inlet beluga whale Critical Habitat Area 2 would be minor, given the large amount of available critical habitat (3,013 square miles) that would not be impacted. The extent of impacts would be localized, and limited to the dock, lighted navigation buoys, and natural gas pipeline corridor. The duration of impacts would be permanent, for the life of the project for the dock and lighted navigation buoys, and temporary for installation of the natural gas pipeline.

Food Sources

Beluga whales feed on a variety of fish, shrimp, squid, and octopus (Burns and Seaman 1986). Common prey species in the Susitna Delta and Knik Arm (where beluga whales concentrate during the summer to feed) include salmon, eulachon, and cod. The concentrated feeding areas for Cook Inlet beluga whales are in upper Cook Inlet, north of the analysis area. Prey species may be slightly impacted by vessel activities during construction due to increased water turbidity during installation of the natural gas pipeline. In addition to habitat disturbance, a discussion on the potential impacts from sound on food sources is provided in Appendix K4.25, Threatened and Endangered Species. Based on the noise analysis in Appendix K4.25, minor temporary disturbance to fish may occur during construction activities. Fish could avoid highly turbid areas during construction, and are not expected to suffer negative impacts. Based on the size of Cook Inlet, where beluga whale primarily occurs, versus the localized area where impacts may occur in the analysis areas, any missed feeding opportunities would be minor because other suitable feeding areas exist elsewhere.

In addition, beluga whale primary prey fish species could swim between the caissons, and their distribution and movement patterns in Kamishak Bay are not anticipated to be altered by the presence of the port.

Overall, the magnitude of impacts on food sources would be low. Cook Inlet beluga whales rarely feed on benthic fauna, and it is not expected that these animals would be impacted by disturbances to the benthic environment during installation of the natural gas pipeline or port (NMFS 2017c). Potential effects from seafloor disturbance on foraging quality would be temporary during construction and occur at a time when most beluga whales are north of the analysis area. Only the direct footprint of the port would remain permanently impacted.

4.25.4.2 Humpback Whale

Behavioral Disturbance

Underwater and Airborne Noise

Humpback whales have similar hearing thresholds in-air and underwater to other mysticetes. The underwater audiogram shows the typical mammalian U-shape with sensitivity to frequencies from 700 Hz to 1 kHz. Maximum relative sensitivity is between 2 to 6 kHz (Houser et al. 2001). NMFS has separated marine mammals into functional hearing groups with the generalized hearing range of low-frequency cetaceans, of which the humpback whale is categorized, between 7 Hz and 35 kHz. Humpback whale vocalizations generally range from 30 Hz to 8 kHz.

Humpback whales have shown a general avoidance reaction at distances from 1.2 to 2.5 miles from cruise ships and tankers (Baker et al. 1982, 1983), although they have displayed no reactions at distances of 0.5 mile when feeding (Watkins et al. 1981; Krieger and Wing 1986), and temporarily disturbed whales often remain in the area despite the presence of vessels (Baker et al. 1998, 1992). Dunlop (2016) considered the effect of vessel noise and natural sounds on migrating humpback whale communication behavior. Results showed that humpbacks did not change frequency or duration of common vocal sounds in response to increases in either wind or vessel noise. However, increases in vocal source levels and the use of non-vocal sounds (e.g., flipper and tail slaps on the water surface) were observed in response to wind noise, but not vessel noise. Dunlop suggested that humpbacks may be susceptible to masking from vessel sounds, but differences in the spectral overlap of wind and vessel sounds with humpback whale communication signals could also be contributing factors. Tsujii et al. (2018) determined that vessel noise caused humpback whales in Ogasawara, Japan waters to stop singing temporarily rather than modifying the sound characteristics of their song through frequency shifting or source level elevation. Fournet et al. (2018) noted that humpback foraging calls in Southeast Alaska were approximately 25 to 65 dB lower than those reported by Thompson et al. (1986) in Hawaii, Mexico, Bermuda, and the West Indies, and that average source level estimates for humpback whale calls in the eastern Australian migratory corridor were 29 dB higher than those in Glacier Bay (Dunlop et al. 2013). This could be the result of overall lower ambient noise in Alaskan waters and shows that humpback whale calls on foraging grounds may be at risk for acoustic masking (Fournet et al. 2018; McKenna 2011).

Humpback whales have the potential to be impacted by vessel noise associated with the construction and operations of Amakdedori port, lightering locations, and construction of the natural gas pipeline corridor. Operations of the port and lightering locations would add 330 project-related vessel trips annually in the analysis area (including supply barges, concentrate barges, lightering vessels, and tugboats) for 20 years. This increase in vessel traffic, especially in areas around lightering locations in deeper water, would occur where humpback whales have been detected during the summer season. Potential noise impacts during operations would last for the life of the project, and may result in humpback avoidance of the area around the lightering locations.

This increase in the number of vessel trips in lower Cook Inlet could result in an interruption of normal behavior and result in humpback whales avoiding or leaving the area. After this response, surfacing, respiration, and diving cycles could be affected; although vessels moving slowly away from whales usually would not elicit such strong reactions (Richardson and Malme 1993). After single-disturbance incidents, at least some whales would be expected to return to their original locations, so the duration of impacts is anticipated to be short-term.

As detailed previously for Cook Inlet beluga whales, noise measurements specific to caisson filling and placement have not been recorded. Based on a recent programmatic consultation between the USFWS and USACE, in-water use of heavy equipment for manipulating the substrate would result in a monitoring zone radius that could extend out to 984 feet from the sound source (USFWS 2015). This is an appropriate monitoring zone radius, because a barge-mounted excavator would be necessary to manipulate the seafloor during placement of the caissons. Although the consultation was related to northern sea otters, the same noise monitoring radius is conservative, and applicable to humpback whales. A similarly sized monitoring area would be monitored during placement of the anchors associated with the lighted navigation buoys. The extent of potential noise impacts to humpback whales would be localized to the immediate vicinity of the caisson dock. Measures to avoid and minimize impacts from caisson placement to humpback whales would be determined through consultation with NMFS.

Noise would also be generated during trenching for natural gas pipeline installation, and humpback whales would likely have behavioral responses such as avoidance of the immediate area. The installation of the pipeline would span 104 miles across Cook Inlet, and coincide with summer months when humpback whales are present in Cook Inlet. Potential noise impacts would be similar to those for Cook Inlet beluga whales, and may extend out to 1.7 miles on either side of the tugboats operating dynamic positioning for the pipelaying barge. The general corridor width that would experience ensonification impacts and vessel activity would be 4.4 miles wide. This corridor width would extend along the entire length of the natural gas pipeline and fiber-optic cable route through Cook Inlet. Humpback whales may avoid the area during pipeline installation, and this could extend for the 30- to 40-day summer installation period.

During operations, there is a potential for noise impacts to humpback whales from vessels in the shipping lanes that would be used by the concentrate bulk carriers. Noise levels exceeding 120 dB from a concentrate bulk carrier vessel when traveling at cruise speed (13 to 15 knots) would be contained within the 7.4-mile-wide travel corridor. Vessel traffic was evaluated in detail in the draft NMFS biological assessment (Appendix H) for Cook Inlet and the Gulf of Alaska, through Unimak Pass and into the Bering Sea. During operations, project-related vessel traffic would increase the estimated vessel traffic through the Aleutian Islands by approximately 1 percent (compared with 2008-2009 levels) (ERM-West Inc. and Det Norske Veritas 2010).

The extent and duration of effects on humpback whales due to noise from aircraft at Amakdedori port would be temporary disturbance and displacement during construction of the port access road. However, most humpback whales were not observed close to the Amakdedori port location, but were found closer to Augustine Island in deeper water. The airstrip would be used infrequently once the port access road from Amakdedori port to Kokhanok and the south ferry terminal are completed, because flights would land at Kokhanok instead of Amakdedori. Noise produced by aircraft above the water's surface does not pose a direct threat to the hearing of marine mammals in the water. However, short-term behavioral responses of cetaceans to helicopters have been documented in several locations, including Alaska (Patenaude et al. 2002).

Overall, impacts from construction noise would be short-term, and occur during summer months for up to 2 years during port construction. Underwater noise from vessels and aircraft would exceed disturbance (Level B) acoustic harassment thresholds. Mitigation and monitoring would be implemented to avoid Level A and minimize Level B harassment. Noise impacts would extent around the port and in the vicinity of the natural gas pipeline corridor during summer-time installation. Vessel noise would last for the life of the project during operations, especially when vessels transit to the secondary lightering location where humpback whales have been more frequently detected. Vessel noise would also extend throughout the shipping lanes. The magnitude of impacts would be evaluated through MMPA consultation. As part of the MMPA consultation process, a 4MP may be required in association with an Incidental Harassment Authorization to implement a robust monitoring strategy during construction activities to mitigate exposures and impacts from noise. This plan may be developed at a later stage in the permitting process, and is not included herein.

Physical Presence (Vessel and Aircraft)

Humpback whales' reactions to approaching boats are variable; ranging from approach to avoidance (Salden 1993). Humpback whales show general avoidance behavior to cruise ships and tankers at distances from 1.5 to 2.5 miles (Baker et al. 1983), but no reaction at distances beyond 0.5 mile when the whales were feeding (Krieger and Wing 1986). In addition, humpback whales are especially responsive to fast-moving vessels (Richardson et al. 1995a), exhibiting aerial behaviors such as breaching or tail/flipper slapping. However, temporarily disturbed whales often remain in the area despite the presence of vessels (Baker et al. 1992, 1998).

The magnitude of impacts to humpback whales from the physical presence of aircraft at Amakdedori port would be avoidance of the area or departure from the area. Only a few animals would likely be impacted because humpback whales are not expected near Amakdedori port; sightings of humpback whales in the vicinity of the port are limited (Shelden et al. 2013). The duration of exposure of humpback whales to the physical presence of aircraft would be temporary, during the 2 years of construction before flights are moved to Kokhanok.

The extent of impacts from the physical presence of vessels and aircraft would be the area near Amakdedori port, lightering locations (vessels only), and on the vessel routes. Data from ABR (2018c, 2018e) and from May 2018 northern sea otter surveys (Garlich-Miller et al. 2018) demonstrated the presence of humpback whales west and southwest of Augustine Island. The alternate lightering location for the project is in an area with a greater number of humpback whale sightings. Therefore, the magnitude of impacts from the physical presence of vessels would be greater at the alternate lightering location compared to the primary lightering location. Humpback whales would experience impacts from the physical presence of vessels between the port and the lightering locations during the operations phase for the life of the project. Based on the short duration of potential exposure to the physical presence at any given location when vessels are present or aircraft pass over, the magnitude of effects on humpback whales would be limited to brief behavioral responses. Impacts from the presence of aircraft are unlikely during construction of the port due to the general lack of humpback whales around the port. However, impacts to humpback whales would be more likely because vessels travel between the port and lightering locations, particularly the alternate lightering location, where humpback whales are more regularly detected. In terms of likelihood, these impacts would be expected to occur if the project is permitted and constructed.

Injury and Mortality

Vessel Collision

There were 93 reports of humpback whale-vessel collisions in Alaska waters between 1978 and 2011, with only one confirmed record in upper Cook Inlet (Neilson et al. 2012). Between 2008 and 2012, the mean minimum annual human-caused mortality and serious injury rate for humpback whales, based on vessel collisions in Alaska, was 0.45 whale per year, as reported in the NMFS Alaska Regional Office stranding database (Allen and Angliss 2015). Based on Neilson et al. 2018, whale-vessel collisions involving humpback whales in 2017 in Southeast Alaska were comparable to previous years, with most incidents involving vessels traveling 20 knots or faster (for incidents where the boat speed was recorded).

Impacts to humpback whales as a result of injury or mortality from vessel collisions are not expected during construction of the port, because humpback whales are not usually found in the waters around the port, and vessels would be traveling slowly (less than 10 knots) enough to avoid encounters with whales.

The duration of impacts due to potential vessel collisions would be for the life of the project, and these impacts are more likely to occur during summer (as opposed to winter), when humpback whales are present in Cook Inlet. The likelihood for encounters between humpback whales and project vessels would be higher during operation of the mine, because vessels would be regularly transiting between the port and lightering locations. Currently, Kamishak Bay has a low number of vessels, and the project would add at least 330 vessel trips annually in the analysis area. Coupled with known humpback whale locations south and west of Augustine Island, this increases the potential for strike. However, slow vessel speeds (less than 10 knots) have been shown to have a reduced potential for vessel strike (Jensen and Silber 2004).

Because humpback whales are more common in the shelf and shelf edge waters of the Gulf of Alaska and Bering Sea, they are expected to occur in the vicinity of the vessel routes outside of Cook Inlet. The majority are expected to be members of the non-listed Hawaii DPS (Wade et al. 2016). They have a potential for increased risk to injury and mortality from additional project-related vessel traffic. The project would increase vessel traffic (from concentrate bulk carriers) by approximately 1 percent compared with 2008-2009 levels through the Aleutian Islands. Because there is no speed restriction imposed on project-related vessel traffic outside of Kamishak Bay, the concentrate bulk carriers would be traveling at their normal operating speeds between 13 and 15 knots. All concentrate ships would follow the shipping route through Shelikof Strait to Unimak Pass, where they would link with the Great Circle Route travel lane to Asia. The ships would remain over continental shelf waters for several hundred miles between Cook Inlet and Unimak Pass. Ships would traverse through areas known to be used by summering populations of humpback whales (Zerbini et al. 2006), especially Shelikof Strait and along ocean banks near the Semidi and Sanak Islands. Neilson et al. (2012) noted that vessel strikes of humpback whales occurred most often where whale concentrations overlapped with shipping lanes, especially in narrow choke areas. Shelikof Strait may qualify as an area of higher vessel strike risk; because vessels would be operating at faster speeds, there would be a greater risk of lethal strike. Neilson et al. (2012) evaluated whale-ship strike data from 1978 to 2011, and found the majority (93 of 108 definite or possible whale collisions) to be from humpback whales. There was one instance of a humpback whale collision between Cook Inlet and Unimak Pass, but in shallow waters outside of the shipping routes. Based on the data from the 34-year study, there were approximately three whales stuck annually, with less than one per year as a definite mortality. Because project-related vessel traffic would increase overall vessel traffic slightly, the potential for a project-related vessel to cause a humpback whale mortality is low. The potential for a whale strike would last for the life of the project, until concentrate bulk carriers are no longer needed after operations cease.

Entanglement

Humpback whales have been documented becoming tangled in heavy-gauge cables/anchor lines (Neilson et al. 2018). Entanglement in anchor lines is uncommon, but in one instance near Craig, Alaska, a whale became tangled in a 1-inch cable line that get caught in its mouth and wrapped around its body. The cable connected a log barge to an anchor. A second instance, in Holkham Bay, a humpback whale became entangled in a 7/8-inch anchor chain from a commercial tour vessel that got caught in the whale's mouth and wrapped around its body. In both cases the chain was cut, and whales freed, but only after sustaining significant soft tissue injuries (Neilson et al. 2018). The anchor chains for the mooring buoys at the lightering locations would be in deep water where humpback whales have been documented. In particular, the alternate lightering location had multiple humpback whales sighted during the summer of 2018. The 2-inch anchor-chain size would keep the chain relatively taut and reduce the potential for kinking. The anchor chain in both cases was significantly smaller in diameter than the chain proposed at the lightering locations. Although entanglement in anchor lines is considered uncommon, there is a low potential for humpback whales to become entangled in the mooring chain.

Habitat Changes

The magnitude and duration of impacts from construction of the Amakdedori port and installation of the natural gas pipeline would be a temporary increase in sound levels from construction activities during summer months, when humpback whales are present in Cook Inlet. Vessel noise and physical presence would have a low impact on humpback whale habitat because the area potentially impacted covers a small percentage of the total habitat available to humpback whales in Cook Inlet. Humpback whales would be able to move away from project activities to feed, rest, or migrate in other nearby areas should they occur at the time of construction. The construction of the port is not likely to impact feeding areas for humpback whales because they rarely feed on benthic fauna. There would be a permanent loss of 0.15 acre of benthic marine habitat from placement of the mooring buoy anchors and temporary disturbance to the seafloor during natural gas pipeline installation. However, humpback whales rarely feed on benthic fauna, and they are not expected to be impacted by temporary disturbance in the benthic environment (NMFS 2017c). Because humpback whales do not feed in the benthos, the extent and duration of impacts from habitat alteration is considered minimal. Impacts from the loss of foraging opportunity and potential impacts on food sources are discussed in the next section.

Food Sources

A general discussion on the potential impacts from sound on food sources is provided in Appendix K4.25, Threatened and Endangered Species. Specific information on the humpback whale follows. The magnitude and duration of impacts from construction of Amakdedori port and installation of the natural gas pipeline would be a temporary alteration of humpback whale foraging habitat in the form of increased turbidity. Humpback whales feed on small schooling fishes, euphausiids, and other large zooplankton. Humpback also feed on eulachon, Atka mackerel, Pacific cod, saffron cod, Arctic cod, juvenile salmon, and rockfish (Hain et al. 1982). Increased turbidity may have temporary impacts on small schooling fish and krill, which are important prey species for humpback whales. Any impacts around Amakdedori port would be minimal because humpback whales are not common in the vicinity of the port. Any feeding areas potentially avoided during construction of the natural gas pipeline or during installation of the mooring anchors would be minimal, because other feeding areas exist elsewhere. Therefore, the activities included in the analysis area are not expected to have any permanent habitat-related effects that could cause significant or long-term consequences for humpback whales. The extent of humpback whale prey habitat alteration is expected to be limited to the vicinity of the Amakdedori port site and the natural gas pipeline alignment. The duration of impacts from increased turbidity on humpback whale prey would be short-term, occurring only during construction. Increased turbidity from in-water work is expected to last a short time, as the tides and wave action in the marine environment flush the system.

Critical Habitat

On October 9, 2019, NMFS proposed designated critical habitat for the endangered humpback whale management stocks (84 FR 54354). NMFS proposed critical habitat for the Mexico DPS and Western North Pacific DPS, which overlap with the analysis area. The main consideration in developing this critical habitat is the presence of prey species. This project would not permanently affect prey species, as discussed above. There would be no impact to humpback whale critical habitat from construction of the port because proposed critical habitat is farther offshore. Construction of the natural gas pipeline may temporarily disturb 554 acres (95 miles) of humpback whale feeding areas due to the presence of vessels, pipelaying, trenching, and other activities while the natural gas pipeline is installed. Because Cook Inlet is highly turbid, increased turbidity on the seafloor from trenching activities is unlikely to affect feeding opportunities. In addition, the increased turbidity would occur in the benthic environment, and not in the upper water column where humpbacks typically feed.

The vessel routes through the Gulf of Alaska and along the Aleutian Islands to the Bering Sea traverse several critical habitat units for both the Mexico and Western North Pacific DPSs. Vessel traffic is not expected to impact the presence of prey species, but would temporarily increase the sound scape while project vessels transit through summer feeding areas. The vessel routes through proposed critical habitat are approximately 7.4 miles wide to account for a shipping lane, plus an area of ensonification from project vessels. The area that would temporarily be affected by noise while ships are passing through is small, compared to the overall size of the area proposed for critical habitat.

4.25.4.3 Fin Whale

<u>Behavioral Disturbance</u>

Underwater and Airborne Noise

Fin whales generally prefer deep marine waters in offshore areas, and their occurrence in lower Cook Inlet is infrequent and limited to the eastern side closer to the mouth of Cook Inlet. No fin whales have been detected around Amakdedori Port or around the lightering locations. The potential that fin whales may be impacted by project-related construction and operational noise at the port and lightering locations is low due to their lack of occurrence in Kamishak Bay. No studies have directly measured the sound sensitivity of fin whales. Summaries of the best available information on marine mammal hearing are provided in Richardson et al. (1995a), Erbe (2002), Southall et al. (2007), and NMFS (2016b). The NMFS has separated marine mammals into functional hearing groups with the generalized hearing range of low frequency cetaceans; the fin whale is classified between 7 Hz and 35 kHz. However, fin whale vocalizations have been studied extensively. Fin whales produce a variety of low-frequency sounds in the 10- to 200-Hz band, with the most typical signals occurring in the 18- to 35-Hz range (USDOI 2015).

Vessels in transit to the analysis area during construction and operations of Amakdedori port and lightering locations have the potential to overlap with the fin whales' range. Sound masking is of concern for baleen whales that vocalize at low frequencies over long distances because their communication frequencies may overlap with anthropogenic sounds, such as shipping traffic. Fin whales have been shown to reduce their calling rate in response to boat noise (Watkins 1986). The effects of sounds from shipping vessels on fin whale calls were investigated by Castellote et al. (2012). They found that in locations with heavy shipping traffic, fin whale 20-Hz notes had a shortened duration, narrower bandwidth, decreased center frequency, and decreased peak frequency. These results indicate that fin whales likely modify their call characteristics to compensate for increased background noise conditions, which may help reduce potential impacts from anthropogenic sounds.

Impacts to fin whales from underwater and airborne noise around the port and lightering locations are not expected due to the species rarity in Cook Inlet. However, if the species is present in the analysis area during construction activities, based on details provided for the previous whale species, underwater noise associated with excavation for caisson placement could extend out to 984 feet from the sound source (USFWS 2015).

Noise would also be generated during trenching for the natural gas pipeline installation, and fin whales, if present, would likely have behavioral responses such as avoidance of the immediate area. Potential noise impacts would be similar to those for the previous whale species, and may extend out to 1.7 miles on either side of the tugboats operating dynamic positioning for the pipelaying barge. A similarly sized monitoring zone would be monitored during placement of the anchors associated with the lighted navigation buoys.

Operations of the port and lightering locations would add 330 project-related vessel trips annually in the analysis area. This would increase the vessel traffic, especially in areas around the lightering locations in deeper water where fin whales have a greater potential to occur. Potential noise impacts during operations would last for the life of the project, and may result in fin whale avoidance of the area around the lightering locations.

During operations, there is a potential for noise impacts to fin whales from vessels in the shipping lanes that would be used by the concentrate bulk carriers. Noise levels exceeding 120 dB from a concentrate bulk carrier vessel when traveling at cruise speed (13 to 15 knots) would be contained within the 7.4-mile-wide travel corridor. Vessel traffic was evaluated in detail in the draft NMFS biological assessment (Appendix H) for Cook Inlet and the Gulf of Alaska, through Unimak Pass and into the Bering Sea. During operations, project-related vessel traffic would increase the estimate vessel traffic through the Aleutian Islands by approximately 1 percent (compared with 2008-2009 levels) (ERM-West Inc. and Det Norske Veritas 2010).

Overall, impacts from construction noise would be short-term, and occur during summer months for up to 2 years during port construction. Underwater noise from vessels and aircraft would exceed disturbance (Level B) acoustic harassment thresholds. Mitigation and monitoring would be implemented to avoid Level A and minimize Level B harassment. Noise impacts would extent around the port and in the vicinity of the natural gas pipeline corridor during summer-time installation. Vessel noise would last for the life of the project during operations, especially when vessels transit to the lightering locations. The magnitude of impacts would be reduced through implementation of mitigation measures (such as marine mammal monitoring) that would be further defined through MMPA consultation. As part of the MMPA consultation process, a 4MP may be required in association with an Incidental Harassment Authorization to implement a robust monitoring strategy during construction activities to mitigate exposures to noise and impacts to fin whales from noise exposure.

Physical Presence (Vessel and Aircraft)

Fin whales are rarely observed in Cook Inlet, with most sightings occurring near the entrance of the inlet (Shelden et al. 2013, 2015, 2016). Fin whales are more common in deeper waters of Shelikof Straight, and in the Gulf of Alaska on proposed vessel routes. Fin whales may exhibit varying reactions to the presence of vessels, ranging from attraction to avoidance (NMFS 2017b). Jahoda et al. (2003) studied the responses of fin whales in feeding areas when they were closely approached by inflatable vessels. The study concluded that close vessel approaches caused the fin whales to swim away from the vessel and to stop feeding. These animals also had increases in blow rates and spent less time at the surface (Jahoda et al. 2003). This indicates that the species would likely avoid project-related vessel traffic. However, due to fin whale's rarity in Cook Inlet, impacts to fin whale behavior as a result of the physical presence of vessels and aircraft from project construction and operations of the port and lightering locations would be low. There would be increased disturbance to fin whales in proposed vessel routes in the Gulf of Alaska, Shelikof Strait, and along the Aleutian Islands.

Injury and Mortality

Vessel Collision

Globally, fin whales are injured in collisions with vessels more frequently than any other whale species (Neilson et al. 2012). Three of the 108 reported whale-vessel collisions in Alaska between 1978 and 2011 were fin whales, none of which occurred in Cook Inlet (NMFS 2015). In 2015, one dead fin whale came into the Port of Anchorage on the bulbous bow of a ship traveling from Seattle with unknown initial strike occurrence (NMFS 2017c). Fin whales have a unique feeding habit of lunge feeding instead of skim feeding. These quick lunge movements put them at higher risk of collisions, especially with vessels, because their quick movements make it harder for vessel captains to avoid them (NMFS 2017c). Vessels would be traveling slowly (less than 10 knots) while transiting between the port and lightering locations. Vessel speeds of less than 10 knots have been shown to have reduced potential for whale collisions (Jensen and Silber 2004; 73 FR 60173). Because fin whales are uncommon in Cook Inlet, have not been detected around either the port or lightering locations, and vessels would be traveling slowly, impacts from injury or mortality from vessel collision in Cook Inlet not expected to occur.

Outside Cook Inlet, in the Gulf of Alaska, fin whales are much more common, especially in Shelikof Strait and along the shelf edge (Zerbini et al. 2006). Fin whales are also common along the Bering Sea shelf. During the summer months, they are likely to be found in the vicinity of shipping lanes traversing these areas. The project would increase vessel traffic (from concentrate bulk carriers) by approximately 1 percent compared with 2008-2009 levels through the Aleutian Islands. Because there is no speed restriction imposed on project-related vessel traffic outside of Kamishak Bay, the concentrate bulk carriers would be traveling at their normal operating speeds, between 13 and 15 knots, which results in an increased potential for whale-vessel collisions. Neilson et al. (2012) evaluated whale-ship strike data from 1978 to 2011, and three collisions (out of 108) were from fin whales. There was one instance of a fin whale collision between Cook Inlet and Unimak Pass, but in shallow waters outside of the shipping routes. Because project-related vessel traffic would increase overall vessel traffic slightly, but an analysis of 34 years of whale-strike data show few instances of fin whale strikes, the potential for a project-related vessel to strike a fin whale is low. The potential for a whale strike would last for the life of the project, until concentrate bulk carriers are no longer needed after operations cease.

Entanglement

Similar to humpback whales, fin whales are potentially at risk of entanglement, with one documented fin whale mortality due to entanglement with an anchor line. In mid-April 2011, a fishing vessel was anchored via anchor line (consisting of a solid anchor, anchor chain, and anchor cable) in 210 feet of water in central Uyak Bay, Kodiak Island, where many fin whales had been sighted feeding on dense aggregations of larval fish (Benjamins et al. 2014). A mature fin whale became entangled in a fishing vessel anchor line after the chain was lodged in its mouth while feeding at depth. Once the chain (and possibly the anchor) became wedged in its mouth, the whale twisted, knotting the cable in several locations around its body. Ten days later, the carcass of the whale was found in Uyak Bay with the anchor chain and cable wrapped around it. This is unusual because it involved a fatality for a large whale with a relatively thick anchor line. Similar anchor lines are used widely around the world and are not considered to pose a risk to marine mammals (Benjamins et al. 2014). However, under circumstances with high concentrations of prey in low-light conditions, foraging baleen whales may have difficulty detecting or avoiding large cables and chains that are vertically suspended in open waters (Benjamins et al. 2014).

The lightering location mooring buoy anchor cables would be composed of a thick 2-inch diameter chain vertically suspended in water that is taut and relatively non-kinking. Fin whales have not been documented in the waters around the lightering locations and are rare in Cook Inlet. The potential risk of entanglement is considered low, especially because the case in Kodiak Island is considered a rare and unusual event.

<u>Habitat Changes</u>

The magnitude of impacts to fin whales from construction of Amakdedori port and installation of the natural gas pipeline would be a temporary disturbance of habitat in the form of increased turbidity. There would be a permanent loss of 0.15 acre from placement of the mooring buoy anchors in deeper waters at the lightering locations and 626.6 acres of temporary disturbance during natural gas pipeline installation. The habitat around the port is not likely used by fin whales due to the shallow depths where the port would be located. In addition, no fin whales have been documented around the port or lightering locations; therefore, minor loss of benthic habitat is unlikely to impact the species.

The magnitude and duration of potential habitat effects from seafloor disturbance such as changes to water quality and increased turbidity would be a temporary reduction in the foraging quality of the disturbed area for a short time during construction of the port and natural gas pipeline. Cook Inlet has ample foraging habitat in undisturbed areas around the natural gas pipeline where fin whales could feed during construction. Impacts from construction of the natural gas pipeline corridor would occur over one summer; afterwards, conditions are anticipated to return to pre-disturbance levels.

Food Sources

Fin whales in the North Pacific prefer euphausiids and large copepods, followed by schooling fish such as herring, walleye pollock, and capelin as prey. Because fin whales are not benthic feeders, or feed on benthic fauna only rarely (NMFS 2017c), it is not anticipated that these animals would be impacted by disturbances to the benthic environment from construction of the port or natural gas pipeline. They feed by lunging into schools of prey with their mouth open, using throat pleats to gulp large amounts of food and water. A discussion on the potential impacts from sound on food sources is provided in Appendix K4.25, Threatened and Endangered Species; they are not anticipated to affect fin whale prey.

Critical Habitat

No critical habitat has been designated for the fin whale; therefore, none occurs in the analysis area and no impacts to fin whale habitat are anticipated.

4.25.4.4 Blue, Sperm, Sei, Gray, and North Pacific Right Whales

Five endangered whale species have a potential to occur in the project shipping routes in the Pacific Ocean, including the Gulf of Alaska, along the Aleutian Islands, and the Bering Sea. The North Pacific stocks of blue, sperm, and sei whales occur in the EIS analysis area along with the Western North Pacific DPS of the gray whale, and the Eastern North Pacific stock of North Pacific right whale. Because these species do not normally occur in Cook Inlet, where the majority of project-related impacts are anticipated to occur, but their ranges overlap with proposed vessel routes in the Gulf of Alaska, along the Aleutian Islands, through Unimak Pass, into the Bering Sea and out the exclusive economic zone, these species are discussed collectively herein. The same impacts from vessels (noise, physical disturbance, and potential for injury and mortality) previously detailed above for humpback and fin whales have a potential to occur for blue, sperm, sei, gray, and North Pacific right whales. The main potential impacts to listed populations of these whale species is a potential for behavioral disturbance, including disturbance from underwater noise from project vessels, and a potential for injury and mortality from vessel strikes.

Behavioral Disturbance

Underwater Noise

Noise from passing vessels could briefly disturb individual whales that are migrating or feeding in the area. Most whale species are more likely to be present during summer months, when many whales migrate north to feed. Some whale species (such as humpbacks and North Pacific right whales) may be found year-round in Alaska. Vessel routes are 7.4 miles wide and include a buffer around vessels from underwater noise that encompasses the Level B disturbance threshold. Vessel traffic would be greatest during operations when concentrate bulk carriers are transiting the area, but project vessels are only anticipated to increase vessel traffic by 1 percent. The magnitude of impacts would be that individual whales may be exposed to underwater noise from passing vessels, with impacts highest during summer months, when more whales are present. The duration would last for the life of the project, and be greatest during operations, when bulk carriers are transiting the vessel routes. The extent would encompass the various shipping routes. Overall, the impact of underwater noise on these five whale species is anticipated to be low.

Injury and Mortality

Vessel Collision

The vessel strike risk to whales is low from supply and fuel barges traveling along the proposed southern coastal and offshore travel corridors because these vessels typically travel at speeds of less than 10 knots. The vessel strike risk increases along the proposed western travel corridor, where the concentrate bulk carrier vessel would travel at speeds between 13 and 15 knots through areas (such as Shelikof Strait) where these species feed and migrate. Neilson et al. 2012 reviewed 108 instances of whale strikes between 1978 and 2011 in Alaskan waters, and found one definite strike of a sperm whale (from the Gulf of Alaska), one of a gray whale (from unknown DPS in southeast Alaska), and no recorded strikes for blue, sei, and North Pacific right whale. However, based on the very low rate of recorded vessel strikes per year (approximately three) in Alaskan waters, and the low number of concentrate bulk carriers that would transit Alaskan waters for the project (approximately 27 per year), the risk of a project-related concentrate bulk carrier vessel strike is low.

Although the risk of ship strikes to these five primarily pelagic whale species is low, there have been additional instances where whales have died from vessel strikes. In a recent case in Southeast Alaska, a dead male sperm whale was found washed up on a beach in the Inside Passage (NOAA 2019e). The whale had three deep propeller slices to its side, plus fractured vertebrae consistent with a ship strike.

Habitat Changes

There are no habitat changes anticipated to any of these five whale species from use of the vessel routes. The analysis area does not overlap with the critical habitat for North Pacific right whale.

4.25.4.5 Steller Sea Lion

Behavioral Disturbance

Underwater and Airborne Noise

Steller sea lions have the potential to be seasonally affected by vessel noise associated with the project components during both the construction and operation phases. As detailed in Section 3.25, Threatened and Endangered Species, Steller sea lions have been detected as individuals and in low numbers around Amakdedori, along the coastline, and around the lightering locations. Shaw Island, a recognized haulout location, would experience increased vessel noise as vessels transit between Amakdedori Port and established shipping lanes in Cook Inlet. Shaw Island is approximately 32 miles southeast of Amakdedori port and 13.5 miles south of where the natural gas pipeline would be located in Cook Inlet. In addition, there are several haulouts and rookeries outside of Cook Inlet that would be transited past (but vessels would not come within 5 nautical miles) by the vessel routes on the southern side of the Alaska Peninsula and along the Aleutian Islands.

Steller sea lions have hearing thresholds in-air and underwater that are similar to other otariids. In-air hearing range is 0.250 to 30 kHz, with a region of best hearing sensitivity from 5 to 14.1 kHz (Muslow and Reichmuth 2010). The underwater audiogram shows the typical mammalian U-shape, with the range of best hearing 1 to 16 kHz. Higher hearing thresholds indicating poorer sensitivity were observed for signals below 16 kHz and above 25 kHz (Kastelein et al. 2005). One study of sea lion hearing found that California sea lions can detect realistic, complex acoustic signals in the presence of masking vessel noise better than predicted by a basic hearing model (Cunningham et al. 2014).

Noise that exceeds Level B harassment levels associated with caisson placement, previously detailed above, can extend out to 984 feet (USFWS 2015). A similarly sized area would be monitored during placement of the anchors associated with the lighted navigation buoys. Noise from construction of the natural gas pipeline and fiber-optic cable installation can result in noise levels that would require monitoring out to 1.7 miles on either side of the tugboats operating dynamic positioning for the pipelaying barge.

Mitigation and monitoring would be implemented to minimize Level B harassment. The duration that Steller sea lions may be exposed to sounds from vessels and aircraft would be temporary during port construction and pipeline installation. Once port construction is complete, primary noise impacts would come from operations of vessels transiting the port, lightering locations, and in the vessel routes outside of Cook Inlet. Impacts from vessel noise would last for the life of the project, because at least 330 annual project-related vessel trips would be added in Kamishak Bay.

Physical Presence (Vessel and Aircraft)

Generally, sea lions in water show tolerance to close and frequently approaching vessels, and sometimes show interest in fishing vessels. Sea lions may become accustomed to repeated slow vessel approaches, resulting in minimal response (NMFS 2008c). Although low levels of occasional disturbance may have little long-term effect, areas subjected to repeated disturbance may be permanently abandoned. Regulations are in place to minimize disturbance of animals by humans, especially on rookeries (NMFS 2008c). Steller sea lions are less tolerant when hauled out on land; however, they rarely react unless the vessel approaches within 330 to 660 feet (Richardson et al. 1995a). Sea lion pups on land are vulnerable to trampling if adults are panicked by low-flying aircraft. Small numbers of Steller sea lions use areas around the port and lightering locations; those individuals or groups could be disturbed by project activities. Shaw Island, a recognized haulout location, is approximately 32 miles southeast of Amakdedori port and 13.5 miles south of where the natural gas pipeline would be in Cook Inlet. Ships that are transiting to the port would likely pass several miles north of Shaw Island, and are not likely to impact the haulout location by their physical presence.

Overall, Steller sea lions are more abundant near the mouth of Cook Inlet, which has a high level of vessel activity during summer from recreation, commercial fisheries, barging, and other vessel traffic. Steller sea lions inhabit waters of Alaska year-round; however, large numbers of individuals may widely disperse from concentrated breeding areas and rookeries after the breeding season (late May through early July), likely to access seasonally important prey resources (Muto et al. 2018).

Calkins (1979) reported that the reaction of Steller sea lions to aircraft is variable. Aircraft associated with the project would not be expected to operate in the vicinity of Steller sea lion haulouts or rookeries such as Shaw Island; therefore, Steller sea lions haulouts would not be disturbed by the noise or presence of aircraft. Scattered records of individual Steller sea lions have been recorded around Amakdedori port, and responses of Steller sea lions to aircraft would be limited to a few individuals in the vicinity. Although there is vulnerability and potential for pups to be trampled by adults if panicked from low-flying aircraft, the port area is not known to support Steller sea lion pups, and no haulouts or rookeries are beneath the projected flight path into and out of Amakdedori. Aircraft flying overhead and landing at Amakdedori are not expected to cause more than a temporary disturbance to Steller sea lions, should they occur in the nearby vicinity.

The magnitude and extent of impacts to Steller sea lions from the physical presence of project vessels and aircraft would be disturbance during foraging in the area around Amakdedori port, the lightering locations, and on the vessel routes. The duration of the impact on Steller sea lions from vessel disturbance would be long-term, lasting for the life of the project, but would be expected to occur infrequently, while vessels are transiting between the port and lightering locations, and as vessels transit past haulouts and rookeries outside of the vessel routes. The duration of impacts from aircraft would be temporary, during construction of the port and port access road. Once the port and access road are complete, aircraft flights into Amakdedori port would be restricted to emergencies only.

Injury and Mortality

Vessel Collision

Injury or mortality of Steller sea lions as a result of collisions with project vessels has a low potential to occur during construction and operations of the port. Although pinnipeds are less susceptible to vessel strikes than other marine mammals, in part because of their visual awareness both above and below the water, one vessel collision with a Steller sea lion in Cook Inlet was reported near Homer in 2002, approximately 80 miles east of Amakdedori port (NMFS 2017a). There are no haulouts or rookeries near the port area, and vessels would be traveling at slow speeds (less than 10 knots) between the port and lightering locations, and animals in the water could be avoided. The only haulout in the western side of lower Cook Inlet is Shaw Island, which is south, and away from direct shipping routes between the port and lightering locations. There is a potential for increased vessel collisions with ships coming into Cook Inlet and then heading towards the port if Steller sea lions are in the water transiting to and from Shaw Island. Because ships would be transiting up the center of lower Cook Inlet (in established shipping lanes) before turning west into Kamishak Bay, vessels would pass by Shaw Island several miles to the north. The extent of potential encounters between project vessels and Steller sea lions would range from Amakdedori port to the lightering locations, and then east to the Kenai Peninsula along the natural gas pipeline corridor (only during one summer of construction). Encounters could occur over the long-term, lasting from construction through the life of the project as vessels transit between the port and lightering locations. However, injury and mortality from vessel collisions are low, given the slow speeds of project-related vessels and mitigation measures that PLP would employ through consultation with NMFS.

There would be a low potential for vessels to strike Steller sea lions that are swimming through the vessel routes while concentrate bulk carriers are transiting past. Because the bulk carriers travel faster (13 to 15 knots) than supply barges, there is an increased risk of vessel strike, particularly when bulk carriers are closest to haulouts and rookeries. However, bulk carriers would be traveling in established shipping lanes, and the 27 annual bulk carriers expected during operations add a small percentage to the overall vessel traffic in the area. The risk to Steller sea lions from project vessels would remain low, but would last for the life of the project, and the extent would include the vessel routes.

Entanglement

Steller sea lions are unlikely to become entangled in the 2-inch mooring anchor chain at the lightering locations. According to Benjamins et al. (2014), pinnipeds (which include Steller sea lions) have the least risk of inadvertently becoming entangled in moorings associated with marine renewable energy devices. Pinnipeds have acute mechanosensitivity through their whiskers that allows them to detect wakes formed downstream of a rope, mooring, or cable (Benjamins et al. 2014). Because the 2-inch chain that would be used to attach the mooring buoys to anchors would be relatively taut and non-kinking, the likelihood of entanglement is negligible.

Habitat Changes

The magnitude and extent of impacts from project construction would be permanent loss of Steller sea lion foraging habitat in the vicinity of the Amakdedori port, and temporary disturbance along the natural gas pipeline corridor. Seafloor disturbance may limit the foraging quality of the disturbed area during construction of the Amakdedori port, and installation of the pipeline across Cook Inlet from Amakdedori port to the Kenia Peninsula. As detailed in Table 4.25-3, construction of the port would result in a permanent loss of 2.1 acres of benthic habitat based on the caisson footprint. There would be 3.5 acres of habitat that would be modified by the introduction of shade from the elevated dock, and 0.15 acre of impacts from the lightering locations. Additional temporary impacts to the benthic marine environment would occur from the natural gas pipeline construction. Temporary habitat alteration is not expected to directly affect Steller sea lions because they are highly mobile and rarely feed on benthic fauna. Therefore, they are not likely to be impacted by disturbances to the benthic environment (NMFS 2017c). However, the magnitude and extent of effects from increased turbidity during construction may potentially deter Steller sea lions from accessing prey in the water column. The duration of these effects would be short-term, and last for the duration of construction. Habitat loss from the caisson dock would last for the life of the project.

Food Sources

A discussion of the potential impacts from sound on food sources is provided in Appendix K4.25, Threatened and Endangered Species. Steller sea lions are generalist predators that consume a variety of fish and cephalopods (Pitcher and Calkins 1981). The magnitude and duration of impacts from construction of the Amakdedori port and installation of the natural gas pipeline would be a minor, temporary alteration of Steller sea lion foraging habitat in the form of increased turbidity, and a permanent alteration of foraging habitat from infrastructure placement. Increased turbidity may have temporary, localized impacts on prey species for Steller sea lions during placement of the natural gas pipeline in Cook Inlet. There is nearby suitable habitat where Steller sea lions could forage if temporarily displaced by construction activities. The extent of Steller sea lion prey habitat alteration is expected to be limited to the vicinity of the Amakdedori port site and the natural gas pipeline alignment. The duration of impacts from increased turbidity on Steller sea lion prey would be short-term, occurring only during construction. Increased turbidity from in-water work is expected to last a short time, as the tides and wave action in the marine environment flush the system. Potential impacts to food sources directly within the port footprint would be considered permanent and last for the life of the project.

Critical Habitat

Project activities are anticipated to have no physical impact on Steller sea lion critical habitat because it is outside of areas that would be physically disturbed by the project (the port and lightering locations). Project vessels would transit through the 20-nautical-mile buffer (established to restrict some fisheries activities) placed around major haulouts and rookeries while traveling on proposed vessel routes. This buffer is not a restriction on maritime traffic; the closest a vessel would pass by a haulout or rookery is 5 nautical miles, which is outside of the 3-nautical-mile buffer no-entry zone for rookeries west of 144°W. The project is anticipated to have no impact on federally designated critical habitat for Steller sea lion.

4.25.4.6 Northern Sea Otter

<u>Behavioral Disturbance</u>

Underwater and Airborne Noise

Sea otters are common and abundant in Kamishak Bay throughout the year. Section 3.25, Threatened and Endangered Species, provides an overview of their distribution; they are restricted primarily to nearshore or shallow waters, often in association with underwater features such as reefs. In the analysis area, they are found offshore of Amakdedori port, around the lightering locations, and in the waters between the port and lightering locations. Sea otters also occur in the nearshore waters along the southern side of the Alaska Peninsula, around islands in the Gulf of Alaska, along the Aleutian Islands, and many other areas that would be transited past by project vessels. Both construction and operation activities have a potential to cause underwater and airborne noise disturbance to northern sea otters. Sea otters are generally resistant to the effects of sound; changes in presence, distribution, and behavior resulting from acoustic stimuli have not been commonly observed (Ghoul and Reichmuth 2012). Sea otters have the potential to be affected by underwater noise associated with increased vessel traffic and construction activities at the Amakdedori port, lightering locations, and natural gas pipeline corridor; with vessel operations at the port and at lightering locations; and from project aircraft using the airstrip near the port site. Houghton et al. (2015) proposed that vessel speed is the most important predictor of received noise levels, with low vessel speeds (such as those expected during project activity) resulting in lower sound levels. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20 to 300 Hz (Richardson et al. 1995a); however, some energy is also produced at higher frequencies (Hermannsen et al. 2014). The effects of noise on sea otters would be a behavioral response (e.g., escape response) or physiological response (e.g., increased heart rate or hormonal stress response) (Atkinson et al. 2009). A discussion on noise levels from vessel and aircraft operations is included in Appendix K4.25, Threatened and Endangered Species.

Studies show that sea otters have similar hearing thresholds in-air and underwater to ottarids (eared seals), and the underwater audiogram shows the typical mammalian U-shape (Ghoul and Reichmuth 2014). The range of best hearing is from 1 to 16 kHz. Sea otter hearing sensitivity is similar to that of the sea lion (Ghoul and Reichmuth 2014), where sea lion's in-air hearing range is 0.250 to 30 kHz, with a region of best hearing sensitivity from 5 to 14.1 kHz (Muslow and Reichmuth 2010). Ghoul and Reichmuth (2016) reported that sea otter hearing is most sensitive underwater at 8 to 16 kHz. Higher hearing thresholds indicating poorer sensitivity were observed for signals below 16 kHz and above 25 kHz (Kastelein et al. 2005).

During construction of the port and port access road, the airstrip at Amakdedori would have 20 to 40 flights per month (average of 5 to 10 flights per week) before Kokhanok can be accessed by road. On final approach or take-off, aircraft would be low above the water, and any sea otters in the immediate vicinity would be exposed to elevated noise levels. If sea otters are hauled out on the offshore reefs in Kamishak Bay, there is a potential for them to be disturbed during aircraft overflights. Several offshore reefs were used by sea otters based on ABR surveys in 2019, with as many as 150 sea otters using one haulout during repeated surveys. Figures and additional information are provided in Section 3.25, Threatened and Endangered Species.

Richardson et al. (1995a) recorded sounds produced by a Bell 212 helicopter during two flights. At the surface of the water, the received sound level from a helicopter flown at 500 feet was 81 dB re 20 μPa, and at 1,000 feet was roughly 75 dB re 20 μPa (Richardson et al. 1995a). Although these levels would make a temporary or permanent threshold shift extremely unlikely (USFWS 2019), there is a potential for disturbance during take-offs and landings. Because loud screams are used to communicate between pups and mothers at the surface (McShane et al. 1995), any loud noises that mask the ability for otters to communicate could have an impact. Because sea otters do not appear to communicate vocally underwater, and do not use sound to detect prey (USFWS 2019), underwater noise from project construction and operations is less likely to impact sea otters.

Sea otters spend a great deal of time at the surface feeding and grooming (Wolt et al. 2012). Therefore, their potential exposure to noise from underwater anthropogenic sound sources is lower than for many other marine mammal species. Most of the noises associated with the project are within the effective hearing range of sea otters (0.125 kHz to 32 kHz; Ghoul and Reichmuth 2014). Sea otters in close proximity to project-related noise may exhibit a behavioral avoidance response. Construction of the port is anticipated to have the greatest potential noise impact on sea otters. Because there are no noise thresholds established specifically for northern sea otters, the USFWS uses noise thresholds that have been established by NMFS for pinnipeds (USFWS 2015a). The USFWS recognizes the 160 dB re 1 μPa rms as the Level B disturbance threshold for sea otters for both impulsive and non-impulsive noise types. Based on a recent programmatic consultation between the USACE and USFWS regarding effects to northern sea otters from activities permitted by the USACE, the USFWS found that all in-water use of heavy equipment for manipulating the substrate would result in a monitoring zone radius that could extend out to 984 feet from the sound source (USFWS 2015a). This is the monitoring zone radius that is necessary to ensure that the typical maximum sound production levels reached by heavy equipment manipulating the substrate underwater attenuate to levels below those that are expected to cause injury. This is an appropriate monitoring zone radius because a barge-mounted excavator would be necessary to manipulate the seafloor (to excavate 2 to 3 feet down for each caisson) during placement of the caissons. A similarly sized monitoring area would be monitored during placement of the anchors associated with the lighted navigation buoys.

Noise from anchor handling tugs during installation of the natural gas pipeline and fiber-optic cable could also result in temporary disturbance to sea otters. Based on LGL et al. (2014) a conservative estimate of 188 dB from anchor-handling tugboats, the radius to the 160 dB harassment threshold for sea otters is 243 feet. This is elaborated on in the draft USFWS biological assessment provided in Appendix G. All noise associated with the project (including installation of the natural gas pipeline and fiber-optic cable) would be from continuous sources, and no noise would reach levels considered harmful to sea otters (noise would reach harassment levels only). None of the noise sources would result in Level A harassment or injury to sea otters.

Because northern sea otters in Kamishak Bay have little exposure to vessels, construction activities may temporarily displace otters from feeding or resting areas. The duration of potential impacts from these construction activities would be temporary and short-term, lasting a single June-to-August period during pipeline installation.

Vessel presence and subsequent noise during operations may affect sea otters in the analysis area. Underwater noise from vessels and aircraft would exceed disturbance (Level B) acoustic harassment thresholds. Mitigation and monitoring would be implemented to avoid harassment. The magnitude of impact of the airborne noise during construction to sea otters rafting in the immediate vicinity (especially for otters directly below the flight path) would be a temporary disturbance and lead to departure from the area. During operations, noise from vessels transiting the port and the lightering locations may result in disturbance to sea otters. Some sea otters in eastern Cook Inlet appear to have become tolerant of vessel traffic and noise caused by vessels (USFWS 2019), whereas on the western side of Cook Inlet, operations activities would be a novel disturbance source that is likely to elicit a more intense behavioral avoidance response. Although the western side of Kamishak Bay has a high density of sea otters that have not been exposed to routine vessel traffic, experience from other locations has shown there is a potential for sea otters to eventually habituate or tolerate regular presence of vessels (Calkins 1979). The extent of potential impact from underwater or airborne noise on sea otters would be limited to the port, lightering locations, and vessel routes. Measures to minimize and reduce impacts to northern sea otters are provided in Chapter 5, Mitigation; and Appendix G, ESA Biological Assessment—USFWS.

Physical Presence (Vessel and Aircraft)

Vessel disturbance was ranked low as a threat to recovery, and as 'low importance' in the northern sea otter recovery plan (USFWS 2013b). The reaction of sea otters to disturbance: 1) is highly variable between seasons, sexes, and populations; and 2) may be modified by experience (reactions often decline in intensity with habituation and may increase where populations are harassed or hunted) (USFWS 2013b). Although male sea otters sometimes habituate to heavy boat traffic, female sea otters, particularly those with pups, are sensitive to disturbance. Boat traffic could also disturb the resting patterns of sea otters.

Sea otters spend approximately 80 percent of their time on the water surface (Wolt et al. 2012). Sea otters are slow swimmers relative to other marine mammals and spend much of their time at the surface resting, grooming, and nursing their young. The magnitude of impacts to individual sea otters from the physical presence of project-related vessels would be a modification of behavior. This may include swimming away, submerging underwater, or getting into the water, if the otters were hauled out on land. As described in Section 3.25, Threatened and Endangered Species, the most recent project-specific aerial surveys in March, May, June, and October of 2019 documented hundreds of northern sea otters in Kamishak Bay, with an average of 749 otters per survey (ABR 2019a, 2019b, 2019c, 2019f). Although the locations of otters sifted slightly during surveys, they showed a strong preference for the northern part of Kamishak Bay, especially between Amakdedori and Augustine Island. Operations of the project would add 330 project-related vessel trips annually in the analysis area. Vessel trips between Amakdedori port and the lightering locations would traverse northern sea otter high-density areas, including passing by haulout sites. There are several haulout locations that occur within 1 to 3 miles from where vessels may transit while heading into the port. One of these haulout locations contained 150 northern sea otters during surveys in March and June 2019 (ABR 2019b, 2019c). Because sea otters in Kamishak Bay currently have little exposure to vessel traffic, any repeated disturbance may displace feeding or resting otters (including females with pups) and lead to increased stress. Specific impacts from vessel presence would be disturbance and displacement of sea otters that are hauled out or rafting (USDOI, MMS 2003). Females and pup pairs may be separated due to vessel presence. Impacts to behavior from vessel and aircraft presence are expected to be short-term, while a vessel or aircraft passes by. Aircraft impacts would likely only occur during 2 years of construction for the port, but vessel traffic would last from construction through the life of the project. Currently, mitigation measures in Chapter 5, Mitigation, Table 5-2, include reducing vessel speed to 10 knots in Kamishak Bay. Additional measures may be developed in consultation with the USFWS to reduce impacts to northern sea otters.

Injury and Mortality

Vessel Collision

Vessel strike mortality has been documented across all three stocks of northern sea otters in Alaska. Since 2002, the USFWS has undertaken a health and disease study of sea otters in Alaska to determine cause of death, disease incidence, and status of general health parameters. Of 1,433 necropsies conducted, boat strike or blunt trauma was identified as a definitive or presumptive cause of death in 64 cases (4 percent) (USFWS 2019). In most cases, there was a contributing factor such as disease or biotoxin exposure that made affected individuals more susceptible to boat strike. The likelihood of vessel strikes involving sea otters is primarily related to vessel speed, with most collision reports from small, fast-moving vessels (NMFS 2003). Injury and mortality of sea otters from collisions with vessels has a low potential to occur during construction and operation of the port because sea otters are highly mobile, and vessel speeds would be low (less than 10 knots) around the port and lightering locations, and animals in the water could be avoided. Because sea otters spend a considerable portion of their time at the surface of the water, they are typically visually aware of approaching boats and are able to move away if a vessel is not traveling too quickly (USFWS 2019).

There is additional potential for sea otters to experience vessel collisions with vessels transiting the vessel routes outside of Cook Inlet because they would not be restricted to a 10-knot speed limit. Sea otters are in nearshore waters along the southern side of the Alaska Peninsula, around

Kodiak Island, and along the Aleutian Islands. Most otters remain close to shore within a 66-foot depth contour. Project vessels would not come into waters that shallow; therefore, the potential for project-vessels to collide with sea otters would be minimal.

The probability of project activities causing sea otter/vessel collisions is low. Project work would involve slow-moving vessels that sea otters can generally avoid. The areal extent of encounters between project vessels and sea otters would be concentrated between Amakdedori port and the lightering locations, with the greatest potential for vessel encounters at the alternate lightering due to higher sea otter densities, compared to the immediate vicinity of the port. The duration would be for the life of the project, and the likelihood would be low due to sea otter's ability to avoid vessels, especially those that travel at low speeds. Measures detailed in Chapter 5, Mitigation, Table 5-2, and measures implemented as part of the consultation process would further reduce the potential for vessel collisions.

Entanglement

Northern sea otters are not expected to experience entanglement from the mooring buoy anchor chains. The 2-inch anchor-chain size would keep the chain relatively taut, and reduce the potential for kinking; therefore, the potential for northern sea otters to become entangled in the mooring chain is considered negligible.

Habitat Changes

The construction of the port would result in permanent loss of 2.1 acres of benthic habitat based on the caisson footprint. There would be 3.5 acres of habitat that would be modified by shading from the elevated dock. There would be additional temporary habitat modification during installation of the natural gas pipeline, as detailed below under the critical habitat section.

These activities would change the physical characteristics of localized areas of habitat. Docks can increase seafloor shading, which affects the amount of light penetration on the seafloor. Water quality may be affected by construction causing turbidity. The magnitude and duration of potential effects from increased turbidity would be a reduction in the foraging quality of the disturbed area for a short time during construction, and permanent loss of foraging habitat in critical habitat at the Amakdedori port site. Habitat loss was ranked as 'low importance' in the recovery plan for the southwestern stock of northern sea otters (USFWS 2013b). The extent of the impacts would be limited to the locally disturbed portions of the analysis area, and the duration would be long-term, lasting from construction through the life of the project.

Food Sources

A discussion on the potential impacts from sound on food sources is provided in Appendix K4.25, Threatened and Endangered Species. Sea otters forage in nearshore waters on benthic invertebrates (e.g., mussels, crabs, and clams). Sea otter prey, such as urchins, crabs, and clams, may be impacted by seafloor disturbance from port construction and natural gas pipeline installation. The magnitude and duration of impacts from construction of the Amakdedori port and installation of the natural gas pipeline would be a temporary alteration of sea otter foraging habitat in the form of increased turbidity, and a permanent alteration of sea otter foraging habitat from infrastructure placement. Increased turbidity may have temporary impacts on important prey species for sea otters. Because the area that would temporarily be disturbed during pipeline installation is a small fraction of Cook Inlet, there are other nearby locations where sea otters could forage, and they are not expected to experience loss of foraging opportunities. The extent of sea otter prey habitat alteration is expected to be limited to the vicinity of the Amakdedori port site and the natural gas pipeline corridor. The duration of impacts from increased turbidity on sea otter prey would be short-term, occurring during construction. The magnitude and extent of effects from seafloor disturbance of prey would be a limitation in the foraging habitat quality of the disturbed area during construction of the Amakdedori port, and the pipeline corridor across Cook Inlet. Increased turbidity from in-water work is expected to last a short time, as the tides and wave action in the marine environment flush the system.

Critical Habitat

The project is in Critical Habitat Unit 5: Kodiak, Kamishak, and Alaska Peninsula. Critical habitat is also in the western vessel route through the Gulf of Alaska and out to the Aleutian Islands. Construction of the dock at the port, lighted navigation buoys, and construction of the natural gas pipeline have the potential to adversely affect critical habitat, but the vessel routes would have no impact on critical habitat. Northern sea otter critical habitat primary constituent elements (discussed in detail in Section 3.25, Threatened and Endangered Species) could be directly affected through construction of the port facilities. The magnitude of impacts to critical habitat from construction of the port would be a direct loss and permanent modification of 2.1 acres of benthic habitat from construction of the caisson dock, and 4.4 acres of temporary disturbance during installation. The above-water footprint of the port would be 3.5 acres; although sea otters would be able to swim or dive between the caissons, the habitat shading may impact sea otter prey species. There would be 76.2 acres (10.7 linear corridor miles) of temporary impacts to critical habitat through installation of the natural gas pipeline. The duration of impacts from port construction would be long-term, lasting through the life of the project. The extent of effects would be localized around the port.

4.25.4.7 Steller's Eider

All phases of mine site activities are anticipated to have no direct or indirect impacts on Steller's eider (*Polysticta stelleri*) because the species is not known to breed, stage, or migrate through the mine site. Steller's eiders are generally not found more than 60 miles inland, and therefore would be unlikely to occur at the mine site (USFWS 2002). Steller's eiders were never detected inland during any of the project-specific biological surveys conducted by ABR, and there is no indication that the species historically occurred around the mine site. Therefore, potential impacts to Steller's eiders landing on the pit lake, tailings ponds, or other areas of ponded water in the mine site are not expected, and are not discussed herein.

In addition, no impacts to Steller's eiders are anticipated from the terrestrial portion of the transportation corridor or natural gas pipeline corridor (the portion that occurs west of Cook Inlet), because there would be no elevated structures that could pose a collision hazard, such as powerlines. Towers, powerlines, and other overhead structures may pose a collision hazard to Steller's eiders because they are known to fly low and fast over land and water, and are believed to migrate at night (USFWS 2014e). A migration study conducted between 2002 and 2004 of all four eider species around Northstar Island (offshore in the Beaufort Sea west of Prudhoe Bay, Alaska) documented eiders flying at a mean altitude of approximately 20 feet above ground/sea level in a straight-line direction, and at high mean velocities around 45 miles per hour (Day et al. 2005). This low, fast, and direct method of flying increases the risk of colliding with structures that are near the ground level.

The only project-related collision hazards are at the port and project components in Kamishak Bay. The extent of impacts to Steller's eiders would be the potential for collision with moored vessels at lightering locations in Kamishak Bay, the 100- to 150-foot monopole communication tower and port structures at Amakdedori, and potential collisions with the lighted navigation buoys. Steller's eiders are known to molt and winter in the nearshore waters of Kamishak Bay (generally from late November through early April). They undergo a 3-week flightless molt (which may occur anytime from late July through late October) in nearshore waters, including Kamishak Bay. In Kamishak Bay, the primary molt location is around the Douglas River Shoals area, approximately 17 miles south of Amakdedori port, where birds have been recorded beginning in late August through early September. Birds tend to move farther north up the western side of Cook Inlet later in the fall and winter, as stormy weather conditions and icing begin to push birds north. Therefore, birds using the nearshore waters around Amakdedori port and farther north are generally observed later in the season after molt is complete. The most recent aerial surveys conducted by ABR on October 30, 2019 documented one small group of Steller's eiders on the southern side of Augustine Island.

Potential impacts to Steller's eiders from port construction noise are not considered herein because the in-water portion of the port would be constructed primarily during one May-to-September period, when Steller's eiders are generally not present. Although Steller's eiders may occur at Douglas River Shoals beginning in mid-August, they have not been detected around the port location until later in winter. Impacts from construction of the natural gas pipeline are also not expected to occur, because construction is anticipated to occur primarily during a single June-to-August period, when Steller's eiders are primarily not present in Cook Inlet. In addition, the natural gas pipeline corridor does not traverse areas where Steller's eiders commonly molt or winter. Potential impacts to eiders from vessel and aircraft noise are discussed under behavioral disturbance, below.

Behavioral Disturbance

Steller's eiders wintering in Kamishak Bay could be disturbed by aircraft and vessels. Studies on Steller's eiders show variable degrees of tolerance to vessel traffic. They commonly overwinter in areas of high activity near the Homer Spit and the Unalaska airport, and do not flee in response to human activities on adjacent shorelines; however, they have been observed to be sensitive to boat traffic in Izembek Lagoon (USFWS 2012g). In Unalaska, the USFWS has observed that Steller's eiders move and maintain a distance of at least 328 feet from humans (USFWS 2007). In a study of responses of wintering waterfowl to aircraft traffic, Ward and Stehn (1989) found that Steller's eiders flushed when aircraft came within approximately 984 feet. Disturbance from boat traffic can cause Steller's eiders to fly away from preferred foraging and resting sites, thereby disrupting foraging or resting periods. Disturbance of sufficient frequency, duration, or severity can lower individual fitness through increased time spent in flight, and reduced time spent feeding or resting (USFWS 2012g).

Studies have documented a variety of behavioral responses by waterbirds to vessel-related disturbance, including increased alert behavior, flight, swimming, and a reduction in foraging (Agness 2006). Waterbird responses to vessel traffic may be dependent on species, biological cycle (e.g., breeding, migrating, stopover, and wintering), and/or vessel attributes (e.g., vessel type, size, speed, and distance from the birds). Schwemmer et al. (2011) found that flush distances of four sea duck species differed substantially, with flush distance being positively related to flock size. The study also found indications of habituation in sea ducks in areas of channeled traffic. Because vessel traffic would follow established travel lanes and would approach nearshore habitats (used by molting Steller's eiders) slowly (less than 10 knots) as they near the port, the potential for disturbance or collisions in the vicinity of Amakdedori port would be limited. The majority of Steller's eiders in the area molt and winter approximately 17 miles south of Amakdedori port around the Douglas River Shoals (Larned 2006). Although Larned (2006) documented small groups of Steller's eiders around Amakdedulia Cove, these small groups would likely move out of the way while vessels approached the port. Steller's eiders prefer nearshore areas where water depths are shallow, and vessel speeds are slower. Vessel and aircraft traffic is anticipated to occur year-round at the port. The summer is the only season when Steller's eiders are not expected to be in the nearshore areas around the port. Molting Steller's eiders may begin to appear in Kamishak Bay (primarily around the Douglas River Shoals area) in July, with the peak of molting between August and October. Wintering Steller's eiders are anticipated to reach their highest numbers in late winter and early spring, prior to their departure for the Alaska coastline and northern spring migration.

Vessel speeds would be slow (i.e., less than 10 knots) while approaching and departing the port, providing time for any Steller's eiders in the immediate vicinity to move out of harm's way. Steller's eiders are known to become accustomed to the presence of vessels at ports where they winter (USFWS 2012h). Therefore, the magnitude, duration, and extent of effects of project vessels on Steller's eiders would be a short-term, temporary disturbance around the Amakdedori port while vessels are transiting the port. In addition, aircraft flying into and out of the airstrip may cause Steller's eiders to avoid the area at the eastern end of the runway (closest to Cook Inlet), and any areas directly under the flight approach path. Depending on the altitude of aircraft above the water (when landing from the east), Steller's eiders are anticipated to fly, dive, or move out of the way while aircraft approach the airstrip. Based on a study of king eiders (*Somateria spectabilis*) (an appropriate surrogate for Steller's eiders) in western Greenland, they dove underwater when aircraft approached, and over 50 percent remained submerged until the plane passed (Mosbech and Boertmann 1999). King eiders appeared sensitive to aircraft engine noise, and flushed, dove, or swam away, sometimes leaving the area for several hours (Frimer 1994). Steller's eiders are anticipated to return to the area from which they were flushed after vessels or aircraft have passed. Because eiders typically fly close and fast over the water's surface at low altitudes (i.e., less than 20 feet) (Day et al. 2005), they are unlikely to be struck by aircraft landing at the port locations.

Although the majority of molting and wintering Steller's eiders tend to prefer shallow waters around Douglas River Shoals, a few small flocks of eiders may occasionally forage in the nearshore waters around the port. The magnitude and duration of impacts from project vessels would be behavioral disturbance during construction of the port and natural gas pipeline, which would occur primarily during summer months when Steller's eiders are absent. The extent of impacts would be limited to the area immediately around the port, with shallow waters and reefs where eiders may forage. The duration of behavioral disturbance and avoidance due to operation of vessels between the port and lightering locations would be for the life of the project, but only between fall and early spring when Steller's eiders are present in the analysis area. The duration and extent of impacts from aircraft overflights would be temporary and limited to the construction of the port and port access road.

Injury and Mortality

Because Steller's eiders tend to fly low and fast over water, they are susceptible to collisions with stationary or slow-moving objects, especially during periods of poor visibility. The chance of collision increases with fog or darkness, especially in areas that have lights that could attract and disorient birds. Steller's eiders are believed to be attracted to artificial light, which may increase their risk of collision with structures and vessels (USFWS 2014e). Steller's eiders have a potential to collide with the lighted navigation buoys and port structures (including the communication tower at Amakdedori port). The magnitude and extent of impacts would be the potential for direct injury and mortality to Steller's eiders from collision with the port structures and vessels using the port. Steller's eiders have been documented to collide with illuminated crab boats, and powerlines and towers, especially during periods of inclement weather (USFWS 2012g). Permanent project structures mounted on the causeway and or dock would include a fuel pipeline for unloading barges, a powerline for vessel shore power, a water supply line for firefighting, and illumination and navigation lights. Although most of these components would be along the causeway at ground level, any lights on the causeway, or other elevated structures, may pose a collision hazard in an area where there is currently no artificial light or structures.

The communications tower inside the port facilities at Amakdedori may also pose a collision hazard to eiders. There is evidence that lights on structures, particularly steady-state red lights, can result in disorientation and increased collision risk for avian species (Manville 2000). In accordance with FAA and USFWS guidelines, the tower would be marked with high-visibility paint bands and may include flashing red lights at the top if required. The eider flight path to molting and wintering areas in Kamishak Bay is currently unknown; therefore, the potential risk of collision is unknown. In addition, the large bulk carrier ships that would be moored at the lightering locations, along with any cranes to load concentrate into the bulk carrier ships, would pose a collision hazard for eiders flying in Kamishak Bay. This is especially important if the bulk carrier ships have large flood lights that are not adequately shielded and point inward, away from the open ocean.

The USFWS calculated the collision risk for Steller's eiders in the Chukchi Sea for the installation of subsea fiber-optic cable based on actual collisions events during exploratory drilling operations in 2012 (USFWS 2016d). Although those numbers are not completely comparable to the analysis area, they provide insight into collision risks for an area with high eider abundance. The collision risks were determined to be very low for Steller's eiders. Per the project description in Chapter 2, Alternatives, bulk carriers (which pose the greatest collision risk to Steller's eiders due to their large size, high gunwales, crane, and external lights) would be moored at lightering locations for 4 to 5 days, with 27 annual trips, which would extend for the life of the project. There would also be 33 supply barges that annually dock at Amakdedori port that would present an additional collision hazard.

Injury or mortality to molting and wintering Steller's eiders has a low potential to occur during construction of the port and natural gas pipeline because construction would primarily occur when Steller's eiders are absent. Construction of the pipeline is projected to wrap up in September, and Steller's eiders begin to arrive in the area in mid-August; therefore there is a potential for temporal overlap. During project operations there is an increased potential for eider injury or mortality, primarily from collision with the port infrastructure and vessels. The potential for collision would increase during migration periods and inclement weather, including low fog. The extent of impacts would be limited to the port area and lightering locations, with the duration lasting for the life of the project.

Habitat Changes

There is no Steller's eider critical habitat in Cook Inlet, and the vessel routes outside of Cook Inlet would have no impact on critical habitat on the northern side of the Alaska Peninsula. The magnitude and extent of impacts due to the construction of the Amakdedori port would be a loss of nearshore foraging habitat for Steller's eiders. The species generally forages for a variety of benthic organisms (including bivalves, gastropods, and crustaceans) in marine waters up to 30 feet deep (65 FR 13262). Because Steller's eiders prefer to winter in shallow waters, they are usually found within 1,200 feet of shore (USFWS 2002). The magnitude of impacts from construction of the port would be loss of 3.5 acres of foraging habitat from the above-water portion of the port, which includes the caisson footprints. There would be additional acreage (potentially similar to the acreage of habitat disturbance for northern sea otters) of temporary impacts to benthic habitat through installation of the natural gas pipeline in the nearshore environment. Steller's eiders may eventually habituate to the presence of the port, as shown in other studies. One study in Norway documented Steller's eiders frequently foraging between fishing vessels inside several harbor complexes (Fox et al. 1997). In addition, Steller's eiders have been observed foraging and resting adjacent to docks at Sandpoint, Alaska (USFWS 2012h). Less than

1 percent of the available foraging habitat in Kamishak Bay would be impacted. The extent of the impacts would be limited to the small in-water footprint of the port; the duration would be for the life of the project.

4.25.4.8 Short-Tailed Albatross

The short-tailed albatross was considered for inclusion due to its presence in Alaskan waters in areas that overlap with proposed project shipping routes. Although short-tailed albatross have not been recorded in Cook Inlet, they are included in the EIS because they may be encountered by project-related offshore vessel traffic in the Gulf of Alaska, along the Alaska Peninsula, and in the Bering Sea. Project vessels have a potential to disturb short-tailed albatrosses that are resting on the ocean's surface or foraging in the shipping lanes. During the non-breeding season, short-tailed albatross range widely, foraging in the Bering Sea and around the Aleutian Islands at the water's surface mainly at night or twilight, and rest during the day. Albatrosses are known to fly around vessels (especially fishing vessels), and there is a collision risk at night and during periods of inclement weather. The shipping lanes that project-related vessels would take are used annually by thousands of vessels, and the addition of project-related vessels would add close to a 1 percent increase in existing shipping traffic (based on 2008-2009 traffic volumes [ERM-West Inc. and Det Norske Veritas 2010]), which would add a small increase in the overall collision risk to the species. The magnitude of impacts would be negligible, the duration would last during operations, and extent would encompass mainly the western vessel route.

4.25.5 Alternative 1

There are no new geographical areas in the marine environment of Cook Inlet under Alternative 1 beyond those detailed above for Alternative 1a. The analysis area for Alternative 1 is the same as Alternative 1a, including the vessel routes. The only difference between Alternative 1a and Alternative 1 with a potential to impact TES and their critical habitats are two different dock designs or variants at Amakdedori. The on-land portion of the port on the beach and bluff at Amakdedori would be the same regardless of the variant. The two in-water variants of the port are:

- An earthen causeway and wharf (sheet pile dock structure)
- A pile-supported dock variant

Both port variants would result in different impacts to the marine environment, including the amount of disturbance to the benthic marine environment and the amount of noise generated during construction. The earthen causeway and wharf would have the greatest level of disturbance to the benthic marine environment (largest in-water footprint), followed by the pile-supported (48-inch diameter piles) dock variant. Both the earthen causeway and pile-supported dock variants would generate differing levels of sheet/pile-driving associated underwater noise. Once construction of the port is complete, port operations would be the same regardless of dock construction design. There would be no change in the level of vessel or aircraft traffic, which was previously analyzed under Alternative 1a. There would be no change in the installation of the natural gas pipeline, and it would follow the same route detailed above for Alternative 1a. Impacts to TES from vessel and aircraft traffic and installation of the natural gas pipeline and fiber-optic cable were previously detailed under Alternative 1a and are not repeated here. In addition, all dock variants would require two lighted navigation buoys (3 feet in diameter) located on the subtidal reefs framing the entrance to the Amakdedori port. The buoys would be anchored to the reef using 3-foot-cubed concrete block-anchors, with an anchoring design that prevents excessive anchor chain drag or swinging (PLP 2018-RFI 093). Permanent structures mounted on the causeway and or dock would include a fuel pipeline for unloading barges, a powerline for vessel shore power, a water supply line for firefighting, and illumination and navigation lights. No permanent cranes or fuel storage would be located on the dock. Table 4.25-4 summarizes the construction impacts from the two dock designs, because all operations impacts are previously detailed under Alternative 1a.

Table 4.25-4: Summary of Construction Impacts for the Dock Variants Analyzed under Alternative 1

Project Component[1]	Acres of Impacts[2]
Construction	
Earthen Causeway and Wharf (Sheet Pile Dock)	10.7 acres (permanent in-water footprint) plus 2.9 acres of temporary impacts from a 30-foot construction buffer around the permanent in-water footprint. These acreages represent permanent and temporary impacts to Cook Inlet beluga whale and northern sea otter critical habitat.
Pile-Supported Dock Variant	3.1 acres (which includes 0.07 acre from the combined footprint of all pilings) plus 5.7 acres of temporary impacts from a 30-foot construction buffer. These acreages represent permanent and temporary impacts to Cook Inlet beluga whale and northern sea otter critical habitat.

Notes:

[1] All other project components in the marine environment of Cook Inlet, apart from the dock variants, are the same as those under Alternative 1a.

[2] Acreages were calculated based on the written description of primary constituent elements (PCEs) of critical habitat designation for Cook Inlet beluga whale and northern sea otter that overlap with the various dock footprints.

Details for the two dock variants are included in Chapter 2, Alternatives. The earthen causeway and wharf (sheet pile dock) (maximum width of 500 feet by 1,200 feet long) would extend from shore out to a marine jetty located in -15 feet mean lower low water. One side of the jetty would be occupied by a roll-on/roll-off barge access berth; a separate berth for loading lightering barges would be on the opposite side. The jetty (maximum width of 120 feet by 700 feet long) is expected to be constructed as a sheet pile cell structure filled with granular material. The pile-supported dock would consist of 76 trestle piles and 177 dock piles, for a total of 253 piles. All piles would be 48 inches in diameter, with a 1.5-inch wall thickness. The piles would be vibrated into place and then driven to refusal with an impact hammer.

The main source of disturbance to TES and their critical habitats would be noise from sheet/pile-driving, and habitat loss. These are the only impacts discussed below per species. Critical habitat is only designated for Cook Inlet beluga whale and northern sea otter around Amakdedori. Although the other TES could forage around the port, the main impacts to TES habitat would apply to beluga whales and northern sea otters.

Behavioral disturbance to TES from airborne noise and physical presence is the same as Alternative 1a, and not repeated here. Likewise, impacts from injury and mortality from vessel collisions and entanglement, and potential impacts on food sources from habitat changes are not repeated below. Only behavioral disturbance from underwater noise and impacts to critical habitat (for species where critical habitat is present in the analysis area) are discussed below.

4.25.5.1 Cook Inlet Beluga Whale

Construction of the earthen causeway and wharf (sheet pile dock) would result in underwater noise from sheet pile-driving and rock laying for the causeway. A summary of NMFS acoustic thresholds for various marine mammals is provided in Table K4.25-1. Thresholds for Level A (injury) acoustic harassment are separated into functional hearing groups, of which beluga whales are considered mid-frequency cetaceans. Thresholds for Level B (disturbance) acoustic harassment do not vary according to species; they are 160 dB rms for impulsive sounds and

120 dB rms for non-impulsive sounds. Potential noise levels from sheet pile-driving are included in Table K4.25-5. To determine the radius from sheet pile-driving where beluga whales may experience non-impulsive Level B disturbance thresholds requires that a variety of factors be known regarding construction materials and techniques. To determine the appropriate radius or buffer that would need to be monitored for beluga whales to minimize harassment during construction of the dock, projects with similar activities in Cook Inlet were assessed. A variety of studies (URS 2007; SFS 2009; Illingworth and Rodkin 2007; Denes et al. 2016) has been conducted to document noise levels from pile-driving activities in Cook Inlet. Although none of these studies are precisely comparable to conditions at Amakdedori, and there is a wide variety of factors that affect the transmission of underwater noise (i.e., environmental factors, water depth, substrate composition, tidal currents), the most conservative model for underwater noise attenuation would yield a maximum radial distance to Level B disturbance threshold of 11.3 miles. This range illustrates a maximum area of sound ensonification that could lead to behavioral harassment of beluga whales, depending on the type of sheet pile-driving during construction. This distance would require monitoring to ensure beluga whales are not present during sheet pile-driving construction activities to minimize harassment. The magnitude of noise levels exceed NMFS disturbance thresholds (provided in Table K4.25-1), but mitigation measures would reduce Level A and Level B harassment. The extent of potential impacts to beluga whales would be localized to the immediate vicinity of the causeway. Because construction of the port would occur during the summer months, when beluga whales are generally in the upper portion of Cook Inlet, the occurrence of beluga whales around the port during summer construction is unlikely. Measures to avoid and minimize impacts to Cook Inlet beluga whales would be determined through consultation with NMFS.

A second potential dock for Amakdedori port would be a Pile-Supported Dock Variant. Under the Pile-Supported Dock Variant, the underwater noise associated with pile-driving could result in impacts to beluga whales. Underwater sound from pile-driving varies with size and type of piles and type of hammer. Impact pile-driving results in higher peak sound levels, which have greater potential for injury and disturbance; whereas vibratory pile-driving results in lower overall sound levels, with potential for disturbance (Level B), but typically not injury (Level A). Illingworth and Rodkin (2007) estimated the sound levels for impact pile-driving measured from 33 feet away for 48-inch-diameter steel pipe at 210 dB peak levels, 200 dB rms, and 185 dB SEL. The distance to Level B noise disturbance impacts could extend out to 2.9 miles from the port for 48-inch impulsive impact pile-driving. Pile-driving activity is a well-studied acoustic disturbance of primary concern for the impact on marine mammals, and NMFS and USFWS currently evaluates any IHA application for pile-driving in Cook Inlet, with particular concern to potential impacts on beluga whales, and multiple mitigation measures are requested as part of the permitting process (Castellote et al. 2019).

Impacts to critical habitat are detailed above in Table 4.25-4, depending on the dock variety. All other impacts to Cook Inlet beluga whales are anticipated to be the same as Alternative 1a. The magnitude of impacts would be minor loss of habitat from construction of the port and disturbance (from vessels and aircraft) during construction and operations. The duration would span from construction through the life of the project, and the extent would be the analysis area with concentrated vessel traffic between the port and lightering locations.

4.25.5.2 Humpback Whale

Construction of the sheet pile dock structure filled with gravel material (earthen causeway) would result in underwater noise from sheet pile-driving and rock laying for the causeway. Humpback whales may experience noise levels that exceed NMFS noise thresholds during sheet pile-driving (if they are present in the immediate vicinity during the sheet pile-driving), which are detailed in

Table K4.25-6. The levels of noise from sheet pile-driving are detailed above for Cook Inlet beluga whales and are expected to exceed disturbance (Level B) and injury (Level A) acoustic harassment thresholds during construction, as defined by NMFS and USFWS, by the time they reach offshore areas where humpback whales may occur. The extent of potential noise impacts to humpback whales would be localized to the immediate vicinity of the causeway. Measures to avoid and minimize noise impacts to Cook Inlet beluga whales would be determined through consultation with NMFS.

Construction noise associated with the Pile-Supported Dock Variant would have the greatest potential of inducing behavioral responses from humpback whales. Construction of a Pile-Supported Dock Variant may result in impacts from an increase in underwater noise associated with pile-driving. Underwater sound from pile-driving varies with size and type of piles, and type of hammer. Impact pile-driving results in higher peak sound levels, which have greater potential for injury and disturbance; whereas vibratory pile-driving results in lower overall sound levels, with potential for disturbance, but typically not injury. Details of the radii where humpback whales may experience harassment, if present during pile-driving, are detailed above for Cook Inlet beluga whales. Potential noise levels from pipe-pile-driving are included in Table K4.25-7. Under the Pile-Supported Dock Variant of Alternative 1, the duration of impacts to humpback whales would be a short-term exposure to noise from pile-driving during the 2 years of summer construction. The low-frequency, percussive noise produced by pile-driving would be detectable to humpback whales at a distance of several miles. The magnitude of noise from pile-driving would exceed disturbance (Level B) and injury (Level A) acoustic harassment thresholds as defined by NMFS. Underwater sound levels from pile-driving would be further analyzed in ESA consultation and MMPA consultation. The extent of potential impacts to humpback whales would be localized to the immediate vicinity of the port. Measures to avoid and minimize impacts from pile-driving activities to humpback whales would be determined through consultation with NMFS.

There are no anticipated impacts to proposed critical habitat because the habitat occurs farther offshore. All other impacts to humpback whales are anticipated to be the same as Alternative 1a. The magnitude of impacts would be disturbance (from vessels and aircraft) during construction and operations. The duration would span from construction through the life of the project, and the extent would be the analysis area, with concentrated vessel traffic between the port and lightering locations.

4.25.5.3 Fin Whale

Construction of the port site under the sheet pile dock and Pile-Supported Dock Variant have a potential to cause harassment from noise, as detailed previously for Cook Inlet beluga whale and humpback whale. Sheet- and pile-driving noise may exceed disturbance and injury thresholds, as defined by NMFS. Underwater sound levels from sheet and pile-driving vary with size, as well as the size and type of hammer, and would be further analyzed in ESA and MMPA consultation. Approximate levels of noise produced by pile-driving are provided in Appendix K4.25, Threatened and Endangered Species.

There are no anticipated impacts to habitat for fin whales, because there is no critical habitat in the analysis area, and the shallow waters around the port are unlikely to be used by fin whales. All other impacts to fin whales are anticipated to be the same as Alternative 1a. The magnitude of impacts would be disturbance (from vessels and aircraft) during construction and operations. The duration would span from construction through the life of the project, and the extent would be the analysis area, with concentrated vessel traffic between the port and lightering locations.

4.25.5.4 Blue, Sperm, Sei, Gray, and North Pacific Right Whales

Five endangered whale species have a potential to occur in the project shipping routes in the Pacific Ocean, including the Gulf of Alaska, along the Aleutian Islands, and the Bering Sea. These species do not occur in Cook Inlet, and impacts from construction of the two dock variants would not extend into areas south of Cook Inlet where these whale species may be found. The same impacts from vessels (noise, physical disturbance, and potential for injury and mortality) previously detailed under Alternative 1a have a potential to occur for blue, sperm, sei, gray, and North Pacific right whales, and are not repeated here. The main potential impacts to listed populations of these whale species is behavioral disturbance, including disturbance from underwater noise from project vessels, and a potential for injury and mortality from vessel strikes. All potential impacts would have a low magnitude; the duration would last primarily during operations, when concentrate bulk carriers are transiting the vessel routes; and the extent would encompass the vessel routes.

4.25.5.5 Steller Sea Lion

Sea lions are cautious by nature, and loud, pulsed, frequent, or unfamiliar noises, such as those caused by construction of Amakdedori port, could disrupt resting sea lions or animals foraging near the sound source (NMFS 2005a). Under the sheet pile dock and pile-supported dock variants, Steller sea lions may experience behavioral changes due to short-term exposure to underwater and airborne noise from sheet or pile-driving activities during the 2 years of summer construction. Sheet or pile-driving noise would exceed disturbance (Level B) and injury (Level A) acoustic harassment thresholds as defined by NMFS, outlined in Table K4.25-1. The range to Level B harassment levels would be similar to those detailed above, and range from 0.6 mile for sheet pile to 2.9 miles for 48-inch impulsive pile-driving activities. Underwater sound levels from sheet or pile-driving vary with size, as well as the size and type of hammer, and would be further analyzed in consultation with NMFS. Noise impacts could occur in the vicinity of the port. However, based on survey data detailed in Section 3.25, Threatened and Endangered Species, there are only a few scattered records of Steller sea lions in the general area of the port, and it does not appear to be a major use area. The major haulouts and rookeries are many miles away near the mouth of Cook Inlet. Data from ABR surveys during spring and summer 2018 in Kamishak Bay incidentally detected several Steller sea lions (ABR 2018b). These observations were south and west of Augustine Island, including reefs and shoals close to Amakdedori port. Recent data from March, May, June, and October of 2019 aerial transect surveys (conducted by ABR for northern sea otters and to document haulout locations) detected seven Steller sea lion individuals during the May survey, with several of them hauled out. These individuals were detected around the southern side of Augustine Island and around Nordyke Island (ABR 2019b).

There are no anticipated physical impacts to critical habitat for Steller sea lions, and as detailed under Alternative 1a, above, the closest that vessel traffic would come to haulouts and rookeries is approximately 5 nautical miles. There would be loss of foraging habitat in the nearshore environment from construction of the port, depending on the dock variety selected. All other impacts to Steller sea lions are anticipated to be the same as Alternative 1a. The magnitude of impacts would be minor loss of benthic marine foraging habitat and disturbance (from vessels and aircraft) during construction and operations. The duration would span from construction through the life of the project, and the extent of habitat loss would be at the port, but disturbance could extend throughout the analysis area from transiting project vessels.

4.25.5.6 Northern Sea Otter

Construction of the sheet pile dock would result in underwater noise, with USFWS disturbance thresholds detailed in Table K4.25-1 in Appendix K4.25, Threatened and Endangered Species. The Pile-Supported Dock Variant would have slightly higher anticipated levels of noise due to pile-driving activities compared with the earthen causeway/sheet pile dock. Underwater sound from pile-driving varies with size and type of piles and type of hammer. Impact pile-driving results in higher peak sound, which has greater potential for injury and disturbance; whereas vibratory pile-driving results in lower overall sound levels, with potential for disturbance, but not injury. The USFWS recognizes the 160 dB re 1 µPa rms as the Level B disturbance threshold for sea otters for both impulsive and non-impulsive noise types. Based on a recent programmatic consultation between the USACE and USFWS regarding effects to northern sea otters from activities permitted by the USACE, the USFWS recommends a monitoring radius centered on the noise source of 984 feet for in-water vibratory pile-driving, which includes sheet pile of any size (USFWS 2015). This would be the monitoring radius that would be monitored for the sheet pile dock. For the Pile-Supported Dock Variant, in-water impact pile-driving for round or H pile greater than 36 inches with sound attenuation devices would result in a 1.2-mile-radius hazard area centered on the noise source (USFWS 2015). For round or H pile greater than 36 inches without sound attenuation devices, the USFWS should be consulted. Mitigation measures to reduce impacts during pile-driving, such as shutting down when sea otters are observed in established monitoring zones, would minimize the potential for injury, and would reduce disturbance, as detailed in the biological assessment (Appendix G).

Impacts to northern sea otter critical habitat are detailed in Table 4.25-4. There would be loss of foraging habitat in the nearshore environment from construction of the port, depending on the dock variety selected. All other impacts to northern sea otters are anticipated to be the same as Alternative 1a. The magnitude of impacts would be minor loss of critical habitat encompassing benthic marine foraging habitat, and disturbance (from vessels and aircraft) during construction and operations. The duration would span from construction through the life of the project, and the extent of habitat loss would be at the port, but disturbance could extend throughout the analysis area from transiting project vessels.

4.25.5.7 Steller's Eider

Because Steller's eider occur in Kamishak Bay from fall through late winter/early spring, they are unlikely to occur around Amakdedori during the summer construction months. There is a potential for overlap in August and September, when summer construction would be wrapping up, and the first Steller's eiders arrive at Douglas River Shoals to molt. Data presented in Section 3.25, Threatened and Endangered Species, show that Steller's eiders normally do not occur farther north in Kamishak Bay, including around Amakdedori, until later in winter from December through April. Therefore, Steller's eiders are not anticipated to be present during summer construction of either dock. Impacts to Steller's eiders under this Alternative would be similar to those described under Alternative 1a. Potential noise impacts from sheet/pile-driving is anticipated to have no effect on the species. Loss of nearshore foraging habitat is detailed above in Table 4.25-4. All mitigation measures developed as part of the consultation process would be implemented. The magnitude of impacts to Steller's eiders would be minor loss of nearshore foraging habitat by construction of the port. The extent would encompass the in-water portion of the port and vary depending on the dock design selected. The duration of impacts would last for the life of the project, because the port would remain in place beyond closure to facilitate post-closure and reclamation activities.

4.25.5.8 Short-Tailed Albatross

There would be no additional potential impacts to short-tailed albatross beyond those detailed above for Alternative 1a.

4.25.6 Alternative 2—North Road and Ferry with Downstream Dams

As detailed in Chapter 2, Alternatives, Alternative 2 would involve many of the same elements as Alternative 1a and Alternative 1, but shifted north in the analysis area. The port would be at Diamond Point near the intersection of Cottonwood and Iliamna bays, the primary lightering location would be in Iniskin Bay, and the natural gas pipeline corridor and fiber-optic cable would follow a more northerly route above Augustine Island. Only the marine components of Alternative 2 and their potential impacts on TES are discussed, because no TES occur in the terrestrial portions of Alternative 2. Because the same impacts detailed above for TES (behavioral disturbance, injury and mortality, and habitat changes) also have a potential to occur under Alternative 2, only the differences are discussed below. The main differences with Alternative 2 as it relates to TES in Cook Inlet include: there is no airstrip at the port (the airstrip is farther inland at Pedro Bay, away from TES habitat); no caisson dock is being considered (only sheet pile and pile-support dock variants are considered, which is similar to Alternative 1); the port access road would be constructed partially in the intertidal zone around Diamond Point, which would increase impacts to some TES and their critical habitats, periodic dredging (potentially every 5 years) of a navigation channel at the port for vessel ingress/egress would be necessary for the life of the project; there would be no lighted navigation buoys necessary; and the primary lightering location would be in Iniskin Bay, with the alternate location west of Augustine Island (at the same location as Alternative 1a). Furthermore, there is currently a low level of established vessel activity, primarily between Homer and Williamsport, that occurs mainly during the summer months as a route for vessels heading to Bristol Bay. In addition, there is a barge that makes approximately eight trips per month between April through October from Homer to Williamsport delivering fuel and supplies (Eley 2012). Therefore, there is a low level of established vessel traffic in this area. The same vessel routes would be used by concentrate bulk carriers and supply and fuel barges, which are discussed under Alternative 1a. The only difference is that vessels would have to travel slightly farther into Cook Inlet to reach Diamond Point port and would travel on the eastern side of Augustine Island to reach the port.

The same mitigation measures detailed in Chapter 5, Mitigation, Table 5-2 would also apply to Alternative 2. Additional measures would be implemented through ESA and MMPA consultation.

Table 4.25-5 summarizes the construction and operations impacts in Cook Inlet that are anticipated under Alternative 2. Unlike Alternative 1a and Alternative 1, a short portion of the port access road that wraps around the steep rock face of Diamond Point would require fill into the intertidal zone of Iliamna Bay. Blasting of rock and fill into the intertidal zone would impact critical habitat for Cook Inlet beluga whale and northern sea otter. Maintenance dredging of a navigation channel and turning basin would be necessary to maintain adequate depths for the tugboats and barges, especially during low tides. Because the maintenance dredging would occur multiple times over the life of the project, it is considered a permanent impact to species that feed in the benthic environment (northern sea otters and Steller's eiders).

Table 4.25-5: Summary of Construction and Operations Impacts for Alternative 2

Project Component[1]	Impacts[2]
Construction	
Earthen Causeway and Wharf (Sheet Pile Dock) and Port Access Road	37.6 acres (inclusive of the causeway, wharf, and port access road) plus additional temporary impacts from a 30-foot construction buffer around the causeway, wharf, and port access road. In addition, there would be an impact of 57.7 acres to benthic marine habitat from periodic maintenance dredging at the port. These acreages represent permanent and temporary impacts to Cook Inlet beluga whale and northern sea otter critical habitat.
Pile-Support Dock Variant and Port Access Road	35.4 acres (inclusive of the piling footprints [0.15 acre], overhead dock structures [8 acres], and port access road) plus additional temporary impacts from a 30-foot construction buffer around the dock and port access road. In addition, there would be an impact of 57.7 acres to benthic marine habitat from periodic maintenance dredging at the port. These acreages represent permanent and temporary impacts to Cook Inlet beluga whale and northern sea otter critical habitat.
Lightering Locations[2]	The total spread of the anchors per lightering location is approximately 2,300 by 1,700 feet. The total substrate covered by the anchors is 0.15 acre from the combined footprints of all anchors necessary to hold the mooring buoys in place.
Lighted Navigation Buoys	None are required.
Natural Gas Pipeline (and adjacent fiber-optic cable)	The maximum corridor width from anchors placed for the pipe-lay barge may extend out to 8,202 feet, spanning the pipeline corridor (depending on the depth of Cook Inlet). On average, the pipeline corridor width would be about 1 mile wide, and include both the physical trenching footprint and the station-holding anchors for the pipe-lay barge. The pipeline would be trenched into the substrate, and result in temporary impacts to approximately 126 acres of designated Cook Inlet beluga whale critical habitat, 171 acres of designated northern sea otter critical habitat, and 496 acres of proposed humpback whale critical habitat. The primary noise source during pipeline and fiber-optic cable placement emanates from tugboats during dynamic positioning. It was determined that a 1.7-mile radius was a conservative distance for the extent of underwater noise generated by the tugboats during anchor-handling activities, which exceeds the 120-dB harassment threshold for continuous noise sources. This 1.7-mile radius would encompass all potential noise sources, including those from various dredging technologies and from anchor handling. The average width of impacts (both physical and from underwater noise) would extend approximately 4.4 miles in width along the length of the pipeline though Cook Inlet.
Aircraft Activity	No airstrip is planned at the Diamond Point Port; therefore, no noise impacts are anticipated from project aircraft in the area. There is an existing airstrip farther inland at Pedro Bay that would be used.
Operations	
Vessel Activity	Twenty-seven concentrate vessel shipments would depart the lightering locations annually. Each concentrate vessel would be moored for 4 to 5 days and require 10 lightering trips to fill each concentrate vessel. An additional 33 supply barges (inclusive of 4 fuel barges) would be required annually to supply consumables, fuel, reagent, etc. This equates to 330 annual project-related vessel trips in the analysis area. This would result in an increase of vessel traffic in Cook Inlet by 12.5 percent, and through the Aleutian Islands by 1 percent. There would also be oceanic tugboats to pull the supply barges and port-based ice-breaking tugboats to assist the bulk carrier with mooring, and to move the lightering barges.

Table 4.25-5: Summary of Construction and Operations Impacts for Alternative 2

Project Component[1]	Impacts[2]
	Vessel routes (shipping lanes) would extend north to Nikiski and south through the Gulf of Alaska to West Coast ports, and west along the southern side of the Aleutian Islands through Unimak Pass, into the Bering Sea, and out to the exclusive economic zone. The width of the vessel routes would be approximately 7.4 miles, and encompass the zone of ensonification from project-related vessels.
Port Maintenance Dredging	There would periodic maintenance dredging at the port. Although the frequency of required maintenance dredging is unknown, it could occur every 5 years for the life of the project. This would result in additional habitat impacts, turbidity, and noise impacts during dredging.
Aircraft Activity	No airstrip is planned at the Diamond Point port, and the existing airstrip at Pedro Bay that would be used infrequently.

Notes:

[1] Acreage calculations were determined based on the intersection of project components and geographic information system critical habitat layers from the US Fish and Wildlife Service and National Marine Fisheries Service (depending on the species under their purview), along with the written description of the critical habitat PCEs. The in-water portion of the port for each dock variant and the lightering locations are considered permanent impacts. The 30-foot construction buffer and trenching for the natural gas pipeline are considered temporary impacts.

[2] The primary lightering location is inside of critical habitat for Cook Inlet beluga whale and northern sea otter, but outside of proposed critical habitat for humpback whale. The alternate lightering location west of Augustine Island is outside of Cook Inlet beluga whale and northern sea otter critical habitat, but is inside proposed humpback whale critical habitat.

Similar to Alternative 1, details for the two dock varieties at Diamond Point are included in Chapter 2, Alternatives. Alternative 2 would include an earthen causeway and wharf (sheet pile dock) as the main dock with a pile-supported dock variant. The pile-supported dock variant would be similar to the one under Alternative 1. The conceptual structure would consist of 44 trestle piles and 474 dock piles, for a total of 518 piles. All piles would be 48 inches in diameter, with a 1.5-inch wall thickness. The piles would be vibrated into place and then driven to refusal with an impact hammer.

The main source of disturbance to TES and their critical habitats would be noise from sheet/pile-driving, and habitat loss. These are the only impacts discussed below per species. Critical habitat is only designated for Cook Inlet beluga whale and northern sea otter around Diamond Point. Although the other TES could forage around the port, the main impacts to TES habitat would apply to beluga whales and northern sea otters.

Behavioral disturbance to TES from vessel noise and physical presence is the same as Alternative 1a, and not repeated here. Likewise, impacts from injury and mortality from vessel collisions and entanglement, and potential impacts on food sources from habitat changes are not repeated below. Only behavioral disturbance from underwater noise and impacts to critical habitat (for species where critical habitat is present in the analysis area) are discussed below.

4.25.6.1 Cook Inlet Beluga Whale

Cook Inlet beluga whales have historically been detected infrequently in small groups in Iliamna and Iniskin bays. Because there is no airstrip adjacent to Diamond Point (the airstrip is inland at Pedro Bay), behavioral impacts to beluga whales from aircraft overflights are not anticipated. Potential impacts from underwater noise from construction of the Diamond Point port (both earthen causeway and wharf [sheet-pile dock] or pile-supported dock variants) would be the same as Alternative 1. The earthen causeway dock would result in an underwater noise Level B disturbance radius buffer of 11.3 miles. This range illustrates a maximum area of sound ensonification that could lead to harassment of beluga whales, depending on the type of sheet pile-driving during construction. This distance would require monitoring to ensure beluga whales are not present during sheet pile-driving construction activities to avoid harassment. There would be additional critical habitat lost and noise impacts from construction of the port access road along the edge of the intertidal zone between Iliamna and Cottonwood bays and Diamond Point. Construction of the port access road would include blasting and placement of material into the intertidal zone along the shore of Iliamna and Cottonwood bays. Blasting would be timed to occur primarily at low tide when the habitat is exposed; potential underwater noise impacts are reduced because construction would occur when water is farther out in the bays.

The Pile-Supported Dock Variant would result in an underwater noise disturbance radius buffer of 2.9 miles for 48-inch impulsive impact pile-driving. Pile-driving activity is a well-studied acoustic disturbance of primary concern for the impact on marine mammals, and NMFS and USFWS currently evaluate any IHA application for pile-driving in Cook Inlet with particular concern to potential impacts on beluga whales, and multiple mitigation measures are requested as part of the permitting process (Castellote et al. 2019).

The magnitude, duration, and extent of impacts from underwater noise due to anchor handling and tugboats operating dynamic positioning during pipeline installation are similar to Alternative 1a, although the pipeline length is shorter under Alternative 2, resulting in less construction time, and therefore, less disturbance expected during the activities. The lightering location under Alternative 2 is in Iniskin Bay, which is in beluga whale critical habitat, and may result in disturbance to critical feeding habitat during the fall months. Unlike Alternative 1a, periodic dredging of the port at Diamond Point would be conducted under Alternative 2. Noise from dredging activities is provided in Appendix K4.25, Threatened and Endangered Species, and in the NMFS draft biological assessment (Appendix H) for Alternative 3, but would apply to dredging at Alternative 2. Maintenance dredging of the navigation channel has the potential to temporarily increase the turbidity, impacting prey species and their detection, but any increase in turbidity is expected to last only a few hours, and dissipate naturally with tidal flow. The extent would be localized around the dredging area. The duration would be throughout the life of the project; dredging would occur initially during port construction, and then dredging would continue for the life of the project as needed, but potentially every 5 years.

In summary, the magnitude of impacts includes potential disturbance from noise and turbidity, minor loss of critical habitat, and changes to forging ability and prey from vessel presence during construction and operations, and continued maintenance dredging in critical habitat. The duration of impacts would be for the life of the project. The extent of impacts would encompass the analysis area, but primarily be restricted to the port, lightering locations, and vessel routes into and out of the analysis area from main shipping lanes in Cook Inlet.

4.25.6.2 Humpback Whale

Humpback whales have been more frequently sighted around the western side of Augustine Island near the alternative lightering location. No humpback whales have been detected in the shallow marine waters in Cottonwood, Iliamna, and Iniskin bays; therefore, the potential for vessel encounters and potential collisions around the port and primary lightering location may be lower under Alternative 2. Impacts from underwater noise from construction of the Diamond Point port (both sheet pile dock and pile-support dock variants) would be similar to those detailed above for Cook Inlet beluga whales, but are unlikely to impact humpback whales because the species has not been detected in the shallow waters where the port would be constructed. The same monitoring radii from noise impacts associated with sheet pile-driving and pile-driving (depending on the dock variety) detailed for Cook Inlet beluga whales would be monitored for humpback whales. Noise impacts from port construction are unlikely to impact humpback whales, because construction noise impacts would occur in Iliamna Bay, where humpback whales have not been documented. Impacts from underwater noise from anchor handling and tugboats operating dynamic positioning during pipeline installation are also similar between Alternative 1a and Alternative 2, although the pipeline length is shorter under Alternative 2, resulting in potentially less disturbance during activities from less construction time. The construction of the natural gas pipeline corridor would result in 496 acres (68 miles of the pipeline corridor) of temporary impacts to proposed humpback whale critical habitat (for the Mexico DPS). The greatest potential impact to humpback whales would be the increase in vessel traffic. The magnitude of impacts under Alternative 2 would be increased underwater noise (restricted mainly to Iliamna and Iniskin bays) from construction, and increased vessel traffic during construction and operations. Temporary disturbance to prey, primarily during construction of the natural gas pipeline would also be anticipated. The duration of impacts (primarily from increased vessel traffic during operations) would last for the life of the project, and extent would encompass the analysis area (especially the vessel routes south of Cook Inlet).

4.25.6.3 Fin Whale

Fin whales are considered uncommon in Cook Inlet (because it is generally outside of their range) and are unlikely to be encountered in the relatively shallow waters of Iliamna and Iniskin bays; they are more likely to be encountered in the vessel routes outside of Cook Inlet. Impacts to fin whales would be similar to those detailed under Alternative 1a. There would be no aircraft traffic disturbance associated with Alternative 2, because the airstrip is inland; but there would be dredging associated with the construction and operations of the port. The port dredging at Diamond Point would increase the turbidity of the water in Iliamna Bay during dredging activities; however, fin whales would be unlikely in the area due to the shallow water depths. Construction of the port at Diamond Point, regardless of the dock variety selected, would have a low magnitude, because fin whales have not been documented around the port and are unlikely to occur. Hazard radii for underwater noise impacts would be similar to those detailed above for Cook Inlet beluga whales. The installation of the natural gas pipeline would occur during summer months when fin whales have been detected in Cook Inlet; however, none have been detected as far north as the natural gas pipeline corridor (see Section 3.25, Threatened and Endangered Species). Vessels associated with natural gas pipeline installation would be traveling at slow speeds and are not anticipated to pose a collision hazard for fin whales. The loss of habitat from construction and dredging of the port at Diamond Point would not be expected to affect fin whales, because they have not been documented in the area and are unlikely to occur. The greatest potential impact to fin whales would be the increase in vessel traffic. The magnitude of impacts under Alternative 2 would be increased underwater noise (restricted mainly to Iliamna and Iniskin bays, which are likely outside of the range of fin whales) from construction and increased vessel traffic during construction and operations, and temporary disturbance to prey, primarily during construction of the natural gas pipeline. The duration of impacts (primarily from increased vessel traffic during operations) would last for the life of the project, and extent would encompass the analysis area (especially the vessel routes south of Cook Inlet).

4.25.6.4 Blue, Sperm, Sei, Gray, and North Pacific Right Whales

Five endangered whale species have a potential to occur in the project shipping routes in the Pacific Ocean, including the Gulf of Alaska, along the Aleutian Islands, and the Bering Sea. The North Pacific stocks of blue, sperm, and sei whales occur in the EIS analysis area along with the Western North Pacific DPS of the gray whale, and the Eastern North Pacific stock of North Pacific right whale. Because these species do not normally occur in Cook Inlet, where the majority of project-related impacts are anticipated to occur, but their ranges overlap with proposed vessel routes in the Gulf of Alaska, along the Aleutian Islands, through Unimak Pass, into the Bering Sea and out the exclusive economic zone, these species are discussed collectively herein. The same impacts from vessels (noise, physical disturbance, and potential for injury and mortality) previously detailed above for Alternative 1a have a potential to occur for blue, sperm, sei, gray, and North Pacific right whales. Because these whale species do not occur around the Diamond Point port, there are no additional impacts to these species that are specific to Alternative 2; all impacts are previously discussed under Alternative 1a.

4.25.6.5 Steller Sea Lion

Impacts to Steller sea lions from construction and operations of Alternative 2 would be similar to the impacts analyzed under Alternative 1, because an earthen causeway (sheet pile) dock and pile-supported dock variants are being considered at Diamond Point. Construction impacts would primarily be centered on underwater noise from summer construction of the port, with various monitoring radii detailed above under Cook Inlet beluga whale, depending on the dock variety. Physical impacts to Steller sea lion critical habitat are not expected, because it does not occur in the analysis area; however, project vessels would transit past haulouts and rookeries, but would remain at least 5 nautical miles away. Maintenance dredging activities are likely to cause temporary disturbance to Steller sea lion prey species after increasing turbidity in the water column, thereby displacing fish. In addition, there would be an increase in underwater noise disturbance from maintenance dredging activity for the life of the project, as discussed above. Because no airstrip is proposed near Diamond Point port, impacts from aircraft overflights are not anticipated to occur to the species. Because Steller sea lions have been detected more frequently around Iliamna and Iniskin bay (compared with Amakdedori), especially at the mouth of the bays, impacts from increased vessel activities are likely to cause a greater level of disturbance compared with Alternative 1a. The magnitude of impacts under Alternative 2 would be similar to those discussed in Alternative 1a, and include noise disturbance and changes to forging ability and prey community as a result of maintenance dredging, and a low potential for injury and mortality from vessel collision. The duration would be for the life of the project, and extent would encompass the analysis area.

4.25.6.6 Northern Sea Otter

As detailed in Section 3.25, Threatened and Endangered Species, northern sea otters occur in high densities in and around Iliamna and Iniskin bays. Impacts from underwater noise from construction of the Diamond Point port (either Earthen Causeway Variant [sheet pile dock] or Pile-Supported Dock Variant) would be similar to those detailed above for northern sea otters under Alternative 1. There would be additional critical habitat lost and noise impacts from construction of the port access road along the edge of the intertidal zone between Iliamna and Cottonwood bays and Diamond Point. Construction of the port access road would include blasting and placement of material into the intertidal zone along the shore of Iliamna and Cottonwood bays. Blasting would be timed to occur primarily at low tide when the habitat is exposed; potential underwater noise impacts would be reduced because construction would occur when water is farther out in the bays. Monitoring of areas with elevated noise would be necessary to minimize harassment during summer construction of the port and lightering locations. The magnitude and extent of impacts from underwater noise from anchor handling and tugboats operating dynamic positioning during pipeline installation would be similar to those described under Alternative 1a. The primary lightering location in Iniskin Bay is in northern sea otter critical habitat and important foraging habitat, and would result in disturbance to norther sea otters for the life of the project as vessels transit to and from concentrate vessels moored in Iniskin Bay. Maintenance dredging at the port would result in greater underwater noise and disturbance from vessels, as well as loss of benthic habitat. The operational vessel route is slightly longer under Alternative 2 than under Alternative 1a, potentially resulting in more disturbance and higher vessel collision risk. In summary, the magnitude of impacts would be disturbance and changes to forging ability and prey community in critical habitat; the duration would be for the life of the project, and extent would encompass the analysis area, primarily in Iliamna and Iniskin bays.

4.25.6.7 Steller's Eider

As detailed in Section 3.25, Threatened and Endangered Species, surveys conducted by Agler et al. (1995), Larned (2006), and ABR (2011a, 2015c) indicate that Iniskin and Iliamna bays provide overwintering habitat for several hundred Steller's eiders (generally from late November through April). Steller's eiders were found primarily in offshore waters in the middle portions of Iniskin and Iliamna bays, and occasionally in nearshore waters. Most birds occurred around a shallow shoal in the lower part of Iniskin Bay, and in the middle of the channel between Cottonwood and Iliamna bays. More specifically, Steller's eiders winter in the waters directly in front of the Diamond Point port location (and in the vessel approach lanes). In addition, eiders winter immediately adjacent to the lightering location in Iniskin Bay. Of the Steller's eiders that winter in Cook Inlet, only a fraction (i.e., less than 1 percent) is assumed to belong to the Alaska breeding federally listed population.

Impacts to Steller's eiders are anticipated to be similar to those from Alternative 1a, except impacts would be shifted north to Iliamna and Iniskin bays. These bays are narrower and may offer more suitable winter protection than exposed waters in Kamishak Bay. In addition, there are no lighted navigation buoys associated with Alternative 2; therefore, they do not pose a collision hazard for Steller's eiders. All potential impacts detailed under Alternative 1a (e.g., behavioral disturbance, habitat changes, and potential for injury and mortality) are similar for Alternative 2.

The primary lightering location at the mouth of Iniskin Bay represents an increased potential for eider collisions due to its location at the mouth of a protected bay where Steller's eiders winter. The magnitude of collision risk is likely to be higher than Alternative 1a due to the more restricted mouth of Iniskin Bay (which may funnel Steller's eiders towards the lightering location), and higher wintering density of eiders directly adjacent to the lightering location. If bulk carriers are moored at the lightering location in Iniskin Bay during periods of dense fog or low visibility and the bulk carrier's lights are illuminated, the potential for eider collision would be increased. If bulk carriers are moved to the alternate lightering location on the western side of Augustine Island, the risk of eider collision is likely lower because fewer birds have been documented wintering directly west of Augustine Island. This would reduce the risk of collisions with the bulk carriers for eiders in Iniskin Bay during stormy weather conditions. Overall, impacts to Steller's eiders from Alternative 2 are anticipated to be similar to Alternative 1a, but more eiders could be impacted because several hundred eiders are known to winter throughout Iliamna and Iniskin bays.

The magnitude and extent of impacts due to construction of a port at Diamond Point would be the loss of nearshore marine benthic foraging habitat for Steller's eiders. One port design at Diamond Point would be an earthen causeway with a sheet pile jetty structure. The acreages of habitat both permanently and temporarily removed by Alternative 2 are detailed in Table 4.25-5. Due to the need for dredging, a larger acreage of benthic habitat would be periodically disturbed for the life of the project compared to Alternative 1a, where no dredging would be necessary. Under the Pile-Supported Dock Variant, less marine habitat would be impacted, although dredging would still be necessary.

In summary, the magnitude of impacts from the project on Steller's eiders would be disturbance and changes to forging areas (including habitat loss) and the potential for injury and mortality from collisions with project vessels and the port infrastructure. The duration would last for life of the project, and extent would be limited to the footprint of the port (including the dredged area) and the lightering locations.

4.25.6.8 Short-Tailed Albatross

There would be no additional potential impacts to short-tailed albatross beyond those previously detailed above for Alternative 1a because the proposed vessel routes outside of Cook Inlet are the same for all alternatives.

4.25.7 Alternative 3—North Road Only

Although the port is shifted slightly north into Iliamna Bay and there is only one lightering location in Iniskin Bay, there are no new geographical areas potentially impacted by this alternative in the marine environment of Cook Inlet; therefore, no new information for any TES is presented. All information for this alternative is previously covered by Alternative 1a (for impacts to species from vessel noise and presence, and impacts from injury and mortality) and Alternative 2 (impacts from dredging and port construction). Compared with Alternative 2, Alternative 3 would have a caisson dock similar to Alternative 1a, and a dredged navigation channel and turning basin similar to Alternative 2. Temporary and permanent impacts associated with construction and operations are detailed above in Table 4.25-6. One important difference with Alternative 3 and the other alternatives is a reduction in the number of annual project-related vessel movements in Cook Inlet. Fewer lightering vessel trips are required to load the bulk carriers under Alternative 3 (6 trips versus 10 trips for all other alternatives); therefore, there is a reduced potential for disturbance, injury, and mortality from vessel collisions with lightering vessels. Underwater noise impacts to TES are discussed previously under Alternative 1a for the caisson dock. Maintenance dredging would be required (potentially every 5 years for the life of the project), and impacts from maintenance dredging are previously discussed under Alternative 2. There is one variant for Alternative 3 that would have a minor impact on TES. The Concentrate Pipeline Variant could potentially result in slurry water being discharged into Cook Inlet. However, as detailed in Section 4.18, Water and Sediment Quality, all water that would be discharged into Cook Inlet would meet or exceed water quality standards, and therefore no impacts to the marine environment are anticipated. In addition, under the Concentrate Pipeline Variant, construction of the concentrate pipeline and the optional return water pipeline would increase the average width of the road corridor by approximately 3 feet (PLP 2018-RFI 066), in comparison to the base case Alternative 3. This would slightly increase the width of the port access road around Diamond Point, encroaching slightly into Iliamna Bay, where critical habitat exists for Cook Inlet beluga whale and northern sea otter. All other impacts are anticipated to be the same as Alternative 2 and are not reiterated here.

The draft biological assessments for species under the purview of the USFWS and NMFS (Appendix G and Appendix H, respectively) contain the most detailed information for Alternative 3; the key impacts are briefly discussed below.

Table 4.25-6: Summary of Construction and Operations Impacts for Alternative 3

Project Component	Acres of Impacts
Construction	
Caisson Dock and other Marine Components	There would be 6 acres of permanent habitat loss from overwater structures such as the access causeway, marine jetty, and bulk loader in Iliamna Bay for the Concentrate Pipeline Variant. This would represent a permanent loss of critical habitat for Cook Inlet beluga whale and northern sea otter. There would be additional temporary impacts to adjacent habitat from a 30-foot construction buffer.
Port Access Road	Blasting of rock and fill would be placed into the intertidal zone along the shore of Iliamna Bay to create the port facilities and access road to the caisson dock. This would result in 19.1 acres of permanent habitat loss designated as critical habitat for Cook Inlet beluga whale and northern sea otter. There would be additional temporary impacts to adjacent habitat from a 30-foot construction buffer.
Navigation Channel and Turning Basin	The construction of the navigation channel and turning basin at the port would result in 75.5 acres of temporary habitat loss for Cook Inlet beluga whale, and permanent habitat loss for northern sea otter. There would be an additional temporary impacts to adjacent habitat from a 30-foot construction buffer.
Lightering Location	The total spread of the anchors per lightering location is approximately 2,300 feet by 1,700 feet. The total substrate covered by the anchors is 0.07 acre from the combined footprints of all anchors necessary to hold the mooring buoys in place. This would be a permanent loss of critical habitat for Cook Inlet beluga whale and northern sea otter.
Lighted Navigation Buoys	None are required.
Natural Gas Pipeline (and adjacent fiber-optic cable)	The maximum corridor width from anchors placed for the pipe-lay barge may extend out to 8,202 feet in diameter. The pipeline would be trenched into the substrate and result in temporary impacts to approximately 118.7 acres of designated Cook Inlet beluga whale critical habitat, 164.8 acres of designated northern sea otter critical habitat, and 496 acres of proposed humpback whale critical habitat. The primary noise source during pipeline and fiber optic cable placement emanates from tugboats during dynamic positioning. It was determined that a 1.7-mile radius was a conservative distance for the extent of underwater noise generated by the tugboats during anchor handling activities, which exceeds the 120-dB harassment threshold for continuous noise sources. This 1.7-mile radius would encompass all potential noise sources, including those from various dredging technologies and from anchor handling. The average width of impacts (both physical and from underwater noise) would extend approximately 4.4 miles in width along the length of the pipeline though Cook Inlet.
Aircraft Activity	No airstrip is planned at the Diamond Point port; therefore, no noise impacts are anticipated from project aircraft in the area. There is an existing airstrip farther inland at Pedro Bay that would be used, and no impacts to TES are anticipated from use of the airstrip.
Operations	
Vessel Activity	Twenty-seven concentrate vessel shipments would depart the lightering locations annually. Each concentrate vessel would require up to 6 lightering trips to fill each concentrate vessel (162 lightering trips annually). An additional 33 supply barges (inclusive of four fuel barges) would be required annually to supply consumables, fuel, and reagent. This equates to 222 annual project-related vessel trips in the analysis area. There would also be oceanic tugboats to pull the supply barges and port-based tugboats to assist the bulk carrier with mooring, and to move the lightering barges. Vessel routes (shipping lanes) would extend north to Nikiski and south through the Gulf of Alaska to West Coast ports, and west along the southern side of the Aleutian Islands through Unimak Pass, into the Bering Sea, and out to the exclusive economic zone. The width of the vessel routes would be approximately 7.4 miles, and encompass the zone of ensonification from project-related vessels.

Table 4.25-6: Summary of Construction and Operations Impacts for Alternative 3

Project Component	Acres of Impacts
Port Maintenance Dredging	There would periodic maintenance dredging at the port. Although the frequency of required maintenance dredging is unknown, it could occur every 5 years for the life of the project. Approximately 75.5 acres of Cook Inlet beluga whale and northern sea otter habitat would be periodically dredged. This would be considered a temporary impact to Cook Inlet beluga whale critical habitat, because they do not normally feed on benthic species, but it would be a permanent impact to northern sea otters. It would also be a permanent impact to Steller's eider foraging habitat. Maintenance dredging would generally occur during the summer months and last 3 to 4 weeks.
Aircraft Activity	No airstrip is planned at the Diamond Point port, and the existing airstrip at Pedro Bay would be used infrequently.

4.25.7.1 Cook Inlet Beluga Whale

Although most impacts to Cook inlet beluga whales are similar to Alternative 2, there would be slightly more impact to critical habitat from the natural gas pipeline corridor, port facilities (including the road), and navigation channel. The acreages of impacts are detailed above in Table 4.25-6, and although most of the habitat disturbed would be considered a temporary impact, the fill of material into Iliamna Bay from the port access road and caissons would be permanent. The amount of habitat that would be impacted would represent a small fraction of the overall habitat available for Cook Inlet beluga whales, and the species is uncommon, and has rarely been detected in recent years in Iliamna and Iniskin bays. In addition, there is a proposed vessel route to Nikiski that may be used to transport fuel via four barges annually to the port. Vessels would be traveling slowly (less than 10 knots), and are unlikely to cause injury and mortality to Cook Inlet beluga whales that may be wintering off the mouth of the Kenai River. Measures detailed in Table 5-2, and the NMFS draft biological assessment would reduce potential impacts to Cook Inlet beluga whales. Therefore, there is a low magnitude of impacts from habitat loss and potential for strike; the extent would encompass both Iliamna and Iniskin bays and shipping lanes in Cook Inlet; and the duration would be for the life of the project.

4.25.7.2 Humpback and Fin Whale

Similar to impacts detailed previously under Alternative 2, both humpback and fin whales have not been detected in Iliamna or Iniskin bays, and therefore are unlikely to be impacted by noise or habitat loss from construction of the port. Both species prefer deeper waters for feeding, and both bays are relatively shallow, with restricted entrances. Both species may be temporarily disturbed from summer feeding areas while the natural gas pipeline and fiber-optic cable is trenched through Cook Inlet; however, neither species feed on benthic fauna, and temporary noise and turbidity would only impact a few individuals if present in the vicinity during construction activities. Both species are more common south of Cook Inlet, where vessels would not be restricted to a 10-knot speed limit. Details of potential for injury and mortality were previously discussed under Alternative 1a, because the vessel routes would be the same. Measures detailed in Table 5-2 and the NMFS draft biological assessment would reduce potential impacts to humpback and fin whales. Therefore, there is a low magnitude of impacts from noise, disturbance, and potential for vessel strike in the analysis area. Some of the impacts would occur only during construction, with a low potential for vessel collision lasting for the life of the project.

4.25.7.3 Blue, Sperm, Sei, Gray, and North Pacific Right Whale

Five endangered whale species have a potential to occur in the project shipping routes in the Pacific Ocean, including the Gulf of Alaska, along the Aleutian Islands, and the Bering Sea. The same impacts from vessels (noise, physical disturbance, and potential for injury and mortality) previously detailed above for Alternative 1a have a potential to occur for blue, sperm, sei, gray, and North Pacific right whales. Because these whale species do not occur around the Diamond Point port, there are no additional impacts to these species that are specific to Alternative 3, and all impacts are previously discussed under Alternative 1a.

4.25.7.4 Steller Sea Lion

As previously detailed under Alternative 2, Steller sea lions occur in Iliamna and Iniskin bays, but there are no major haulouts or rookeries in the vicinity of the port or lightering locations. There would be a loss of habitat from construction of the port, and noise impacts would occur during construction. Steller sea lions are less common in Iliamna and Iniskin bays during summer; therefore, impacts from construction of the natural gas pipeline and fiber-optic cable installation would be less. Project vessels would transit well-established vessel routes that bypass major haulouts and rookeries by at least 5 nautical miles. Measures detailed in Table 5-2 and the NMFS draft biological assessment would reduce potential impacts to Steller sea lion. There is a low magnitude of impacts from noise during project construction and operations, along with a low potential for injury and mortality, because Steller sea lions are highly mobile and maneuverable. There would be disturbance to a small portion of available foraging habitat in Iliamna and Iniskin bays. The extent of impacts would be focused on Iliamna and Iniskin bays and the vessel routes that pass through critical habitat buffers around haulouts and rookeries. The duration of impacts would be for the life of the project, but primarily during operations, when concentrate bulk carriers are traveling through the proposed vessel routes.

4.25.7.5 Northern Sea Otter

Similar to Alternative 2, there are high densities of northern sea otters in Iliamna and Iniskin bays. There would be a permanent loss of habitat from the dock and navigation channel. Vessels would travel slowly when entering critical habitat for northern sea otters, but there would be a large increase in vessel traffic above current levels. There is a potential for above-water noise impacts during blasting to create the port access road. This would be conducted at low tide when sea otters are furthest away. All potential sources of noise that could impact northern sea otters would be monitored by PSOs. There is a potential for loss of 100.6 acres of permanent habitat that is designated as critical habitat. Measures detailed in Table 5-2 and the USFWS draft biological assessment would reduce potential impacts to northern sea otter. Overall, the magnitude of impacts would be moderate because the loss of habitat is a small percentage of the overall critical habitat, but there is a high density of sea otters in the area. The duration would last for the life of the project, and the extent would be limited to the analysis area, particularly Iliamna and Iniskin bays.

4.25.7.6 Steller's Eider

The only lightering location would be on the western side of Iniskin Bay in deep waters where Steller's eiders are less likely to forage. Based on the specific locations of wintering Steller's eiders (detailed in Section 3.25, Threatened and Endangered Species), they appear to prefer the shallower waters on the eastern side and northern end of Iniskin Bay. They would have to fly past the lightering location to access the bay, and therefore have a potential to collide with vessels moored at the lightering locations. As detailed previously, the risk would be elevated during periods of inclement weather such as low clouds and fog.

Construction of the dock and navigation channel would result in permanent loss of habitat used by Steller's eiders for foraging primarily during winter. Because the navigation channel would be periodically dredged to remove silt in material, any benthic organisms that had accumulated would also be removed. This process would cause repeated disturbance to the navigation channel, which is considered preferred foraging habitat for Steller's eider. Measures detailed in Table 5-2, Mitigation, and the USFWS draft biological assessment would reduce potential impacts to Steller's eiders. The magnitude of impacts would be loss of foraging habitat and a potential for collisions in an area with several hundred Steller's eiders during winter. However, only a small percentage of the Steller's eiders that winter in Cook Inlet are from the federally listed Alaska breeding population. The duration would last for the life of the project, and the extent would primarily be restricted to Iliamna and Iniskin bays.

4.25.7.7 Short-Tailed Albatross

There would be no additional potential impacts to short-tailed albatross beyond those previously detailed above for Alternative 1a, because the proposed vessel routes outside of Cook Inlet are the same for all alternatives.

4.25.8 Cumulative Effects

Impacts to TES would be those related to impacts considered a "take" (defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in such conduct"), which is prohibited except as incidentally authorized through consultation with USFWS and NMFS. The cumulative effects analysis area for TES includes the project footprint for all alternatives and variants, the expanded mine footprint (including road, pipeline, and port facilities), and all other reasonably foreseeable future actions (RFFAs) in the vicinity of the project that would result in potential synergistic and interactive effects. This includes the extended geographic area where direct and indirect effects to TES may occur throughout the life of the project. Past, present, and RFFAs in the cumulative impact analysis area have the potential to contribute cumulatively to impacts on TES.

Several of the RFFAs detailed in Section 4.1, Introduction to Environmental Consequences, are considered to have no potential for cumulatively impacting TES in the analysis area. These would include activities associated with exploration, development, and operation of natural resources; regional and community road, air, and marine transportation; and non-industrialized point-source activities that are unlikely to result in any appreciable impact on TES beyond a temporary basis (such as tourism, recreation, fishing, and regulated hunting). Other RFFAs removed from further consideration include those that are solely terrestrial-based (have no marine component in Cook Inlet) and outside the analysis area (e.g., Groundhog, community infrastructure projects).

4.25.8.1 Past and Present Actions

Past and present activities, such as subsistence hunting and fishing, commercial fishing, commercial shipping, research activities, and oil and gas exploration and development, have affected TES through direct injury/mortality, habitat loss and degradation (including noise impacts), and behavioral disturbance. The past and present human activities affecting Cook Inlet beluga whales include subsistence harvest, past commercial whaling, poaching or intentional harassment, and incidental mortality or injury from fisheries, vessel, and research activities (NMFS 2016b).

Past and present factors affecting humpback whales include subsistence hunting, incidental entrapment or entanglement in fishing gear, collision with ships, and disturbance or displacement caused by noise and other factors associated with shipping, recreational boating, high-speed thrill craft, whale watching, and air traffic. Introduction and/or persistence of pollutants and pathogens from waste disposal; disturbance and/or pollution from oil, gas or other mineral exploration and production; habitat degradation or loss associated with coastal development; and competition with fisheries for prey species may also impact the whales (NMFS 1991).

Populations of fin whales in the North Atlantic, North Pacific, and Southern Hemisphere have been legally protected from commercial whaling for the last 20 or more years, and this protection continues. Although the main direct threat to fin whales was addressed by the International Whaling Commission moratorium on commercial whaling, several potential threats remain. Among the current potential threats are collisions with vessels, reduced prey abundance due to overfishing and/or climate change, the possibility that illegal whaling or resumed legal whaling would cause removals at biologically unsustainable rates, and possibly, the effects of increasing anthropogenic ocean noise (NMFS 2010b).

Factors affecting Steller sea lions include killer whale (*Orcinus orca*) and shark predation, commercial harvest (prior to 1973), subsistence harvest, incidental take by fisheries, illegal shooting, entanglement in marine debris, disease and parasitism, toxic substances, disturbance, reduced prey, and climate change (NMFS 2008c).

Multiple human actions have had negative effects on the southwest Alaska stock of northern sea otters. These include mortality due to marine oil spills, take by Alaska Natives for subsistence and handicrafts, illegal intentional take, incidental take in fisheries, exposure to environmental contaminants, habitat degradation and loss, heightened risk of disease, and disturbance (USDOI, MMS 2003). The cause of the overall decline is not known with certainty, but the weight of evidence points to increased predation, with the killer whale as the most likely cause. The threats judged to be most important are predation (moderate to high importance) and oil spills (low to moderate importance) (USFWS 2013c).

When the Alaska-breeding population of the Steller's eider was listed as threatened, the factor(s) causing the decline were unknown. Factors identified as potential causes of decline in the final rule listing the population as threatened included predation, hunting, ingestion of spent lead shot in wetlands, and changes in the marine environment that could affect Steller's eider food or other resources. Since listing, other potential threats, such as exposure to oil or other contaminants near fish processing facilities in southwest Alaska have been identified, but the causes of decline and obstacles to recovery remain poorly understood (USFWS 2002). Additional confounding variables with climate change may also affect the species' ability to recover.

4.25.8.2 Reasonably Foreseeable Future Actions

The following RFFAs identified in Section 4.1, Introduction to Environmental Consequences, were carried forward in this analysis based on their potential to impact TES in the analysis area: Pebble Project expansion scenario; Cook Inlet Oil and Gas Development; Alaska Liquefied Natural Gas Project; Alaska Stand Alone Pipeline Project; and the continued development of the Diamond Point Rock Quarry.

All of these RFFAs would cause an increase in vessel traffic in Cook Inlet, which would increase the likelihood of TES being affected by behavioral disturbance and/or vessel strikes (potentially resulting in injury or mortality). For each additional project, a larger area would be potentially affected, increasing both the extent and duration of cumulative impacts.

The RFFA that would contribute the most to the cumulative impacts on TES in the analysis area is the Pebble Project expansion scenario, because it would directly affect the same species in the same location as the project and would continue those impacts for a long period of time.

The No Action Alternative would not contribute to cumulative effects on TES. The project alternatives with the RFFAs' contribution to cumulative effects on TES are summarized in Table 4.25-7. Only marine components in Cook Inlet from RFFAs (or RFFAs that have a component that could impact Cook Inlet) are discussed below, because no TES occur in the terrestrial environment in lower Cook Inlet.

Table 4.25-7: Contribution to Cumulative Effects on TES

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Pebble Project Expansion Scenario	**Port:** The Pebble Project expansion scenario that may affect TES would be the new deepwater loading facility at Iniskin Bay for concentrate shipment. In mine year 20, a new deepwater loading facility at Iniskin Bay would be constructed and would operate concurrently with the Amakdedori port (under Alternative 1a) for 78 years or longer. A water treatment facility associated with the concentrate pipeline would also be built at Iniskin Bay, but any discharge would be required to meet state water quality standards. **Magnitude:** The Pebble Project expansion scenario footprint would result in increased vessel traffic and noise throughout Kamishak Bay (but focused in Iniskin Bay), which would increase potential for behavioral disturbance and injury and mortality to TES. There would also be loss of critical habitat for Cook Inlet beluga whale and northern sea otter in Iniskin Bay through port facility construction. **Duration/Extent**: All vessel traffic in Cook Inlet associated with the project would continue for a total of 98 years, extending the duration of underwater and airborne noise, behavioral disturbance, and risk of injury or mortality from vessel collisions or spills. This would increase both the duration and extent of potential effects on all TES in the analysis area— Cook Inlet beluga whale, humpback whale, fin whale, Steller sea lion, northern sea otter, and Steller's eider—which are discussed in the following sections. The geographic extent would include both port sites (Amakdedori	**Port**: Same impact to TES compared with Alternative 1a. **Magnitude**: Same as Alternative 1a. **Duration/Extent**: Same as Alternative 1a. **Contribution**: Same as Alternative 1a.	**Port**: Because the Diamond Point port and lightering location in Iniskin Bay are adjacent to the port under the Pebble Project expansion Scenario, the cumulative noise, disturbance, and collision risk from increased vessel traffic is expected to have a greater impact on TES than having the ports farther apart at Amakdedori and Iniskin bay under Alternative 1a. Furthermore, a natural gas compressor station constructed at Diamond Point would increase ambient noise in Iliamna Bay, thereby increasing noise impacts to nearby TES. The close proximity of the two ports would compound the effects, because there would be less nearby habitat for TES to move to when disturbed by project noise and vessel traffic. **Magnitude**: There would be increased noise and vessel disturbance focused around Iliamna and Iniskin bays. This may cause some TES to avoid using heavily trafficked areas. Avoidance of areas would be cumulative in addition to critical habitat loss for Cook Inlet beluga whale and northern sea otter. There is a potential for increased vessel collisions potentially resulting in injury and mortality from concentrated project activities in these two secluded bays. **Duration/Extent**: Same duration as Alternative 1a, but the extent would be focused on Iliamna and Iniskin bays.	**Port:** Same impact to TES compared with Alternative 2. Because the only lightering location under Alternative 3 is in Iniskin Bay, impacts to all TES in that bay would be high due to elevated levels of project activities concentrated in Iniskin Bay. **Magnitude**: Same impact to TES compared with Alternative 2. **Duration/Extent**: Similar impact to TES compared with Alternative 2, with the extent primarily in Iniskin Bay. **Contribution**: Same impact to TES compared with Alternative 2.

Table 4.25-7: Contribution to Cumulative Effects on TES

<table>
<tr><th>Reasonably Foreseeable Future Actions</th><th>Alternative 1a</th><th>Alternative 1 and Variants</th><th>Alternative 2 and Variants</th><th>Alternative 3 and Variant</th></tr>
<tr><td rowspan="2"></td><td>and Iniskin bay), and marine traffic in Cook Inlet serving both ports.

Contribution: The Pebble Project expansion scenario would increase the amount of year-round ship traffic in Cook Inlet; specifically in the areas around the Amakdedori and Iniskin bay, where there are currently low levels of vessel traffic.</td><td></td><td>Contribution: Same as Alternative 1a, with impacts focused on Iliamna and Iniskin bays.</td><td></td></tr>
<tr><td colspan="4">Magnitude:

Potential future cumulative impacts to Cook Inlet beluga whale, humpback, fin, blue, sei, sperm, gray, and North Pacific right whale, Steller sea lion, northern sea otter, Steller’s eider, and short-tailed albatross from the project (regardless of alternative or variant selected) in conjunction with the Pebble Project expansion scenario would be from increased vessel traffic, behavioral disturbance, habitat loss and modification (including critical habitat for some species), and injury and mortality with the addition of the port facilities at Iniskin Bay.

Cook Inlet Beluga Whale

Iniskin Bay contains critical habitat for Cook Inlet beluga whale and construction and operations of the port would result in similar impacts to Cook Inlet beluga whales that have been analyzed herein for Amakdedori port. The acreage of critical habitat loss from construction of a port in Iniskin Bay is currently unknown. Construction of the port would cause underwater noise, which is listed as a primary potential stressor for beluga whales in the Cook Inlet Beluga Whale Recovery Plan (NMFS 2016b). Beluga whales are rare in the analysis area (which includes the port at Iniskin Bay) during the summer, so they would be unlikely during summer construction. Beluga whales that may occasionally occur in the analysis area during the winter could be affected by the increased vessel traffic through behavioral disturbance or vessel strike.

Humpback Whale

Increased vessel traffic may impact humpback whales from disturbance and potential vessel strikes. Humpback whales have not been detected in Iniskin Bay, and therefore are unlikely to be impacted by construction in Iniskin Bay. They are more likely to be encountered in deeper waters of Cook Inlet while vessels are transiting to the port at Iniskin Bay. Humpback whales occur in Cook Inlet during the summer feeding months, and therefore are most likely to be encountered during summer operations. There is potential for injury or mortality through vessel strikes. No critical habitat is proposed in Iniskin Bay for humpback whales (Mexico DPS); however, proposed critical habitat would be transited through by project vessels in Kamishak Bay and lower Cook Inlet.

Fin Whale

Impacts to fin whales would be similar to those described for humpback whales, except fin whales are rare in Cook Inlet, especially in shallow waters around Iniskin Bay. They have not been documented around Iniskin Bay and have primarily been detected near the mouth of Cook Inlet. They are unlikely to be impacted by construction noise and have a potential to experience behavioral disturbance and injury and mortality from project vessels during operations.</td></tr>
</table>

Table 4.25-7: Contribution to Cumulative Effects on TES

<table>
<tr><th>Reasonably Foreseeable Future Actions</th><th>Alternative 1a</th><th>Alternative 1 and Variants</th><th>Alternative 2 and Variants</th><th>Alternative 3 and Variant</th></tr>
<tr><td></td><td colspan="4">Blue, Sperm, Sei, Gray, and North Pacific Right Whales
Impacts would be similar to those described for humpback and fin whales, which also occur in the Gulf of Alaska and along the Aleutian Islands out to the exclusive economic zone. They are unlikely to be impacted by construction noise in Cook Inlet (because these whale species do not normally occur in Cook Inlet), but have a potential for behavioral disturbance and injury and mortality from project vessels during operations, especially from concentrate bulk carriers traveling in Shelikof Strait, or along self-edge habitats in the Gulf of Alaska, along the Aleutian Islands, and in the Bering Sea.
Steller Sea Lion
Impacts to Steller sea lion would be similar to other TES, with primary impacts related to construction noise and operational vessel traffic. However, Steller sea lions have been detected multiple times in Iniskin Bay. In particular, Steller sea lions may be drawn to spawning herring near the mouth of Iniskin Bay and may be disturbed by the construction and operations of the port in Iniskin Bay. Increased vessel traffic increases the risk of adverse interactions such as behavioral disturbance or vessel strikes. There is also the potential for increased injury and mortality from vessel strikes in the analysis area, although this potential is low, due to the species’ ability to detect vessels and maneuver out of the way.
Northern Sea Otter
Northern sea otters may experience similar impacts to other TES, but they have high densities in and around Iniskin Bay and the surrounding waters. There is critical habitat in Iniskin Bay that would be affected by the construction and operations of the port in Iniskin Bay. The acreage of critical habitat loss from construction of a port in Iniskin Bay is currently unknown. Increased vessel traffic would increase the risk of adverse interactions such as behavioral disturbance and vessel strikes.
Steller’s Eider
Wintering Steller’s eiders have been observed in Iniskin Bay, and therefore may experience injury or mortality, habitat loss, and disturbance from construction and operations of a port in the protected bay. Increased vessel traffic would increase the potential for eiders to collide with ships during the winter (late November through early April), especially during inclement weather conditions. Iniskin Bay provides wintering habitat that is relatively protected, and construction and operations of a port in the bay may cause the species to avoid using the area.
Short-tailed Albatross
Short-tailed albatross have not been reported in Cook Inlet, and the only potential impacts to the species would be a low potential for increased disturbance while resting and foraging in pelagic and self-edge waters in the Gulf of Alaska and along the Aleutian Islands from increased vessel traffic in shipping lanes. There is also a low potential for injury and mortality from vessel collisions.
Duration/Extent: The duration of construction-related noise impacts to all TES would be temporary only occurring during construction. However, impacts from vessel traffic would last for the life of the project, up to the 78-year extended mining/milling period. The extent of the impacts would be localized in the immediately vicinity of the port facilities in Iniskin Bay and throughout Kamishak Bay, depending on shipping routes.
Contribution: The likelihood of cumulative impacts is low for Cook Inlet beluga whales because they do not commonly occur in the analysis area, especially around Iniskin Bay. The likelihood of cumulative impacts is moderate for humpback, fin, blue, sei, sperm, gray, and North Pacific right whales, because they may suffer disturbance and injury or mortality from vessel operations. The likelihood of cumulative impacts is moderate for Steller sea lion and northern sea otter because they occur regularly in the analysis area. The likelihood of cumulative impacts is moderate for Steller’s eiders, because they winter in the vicinity of Iniskin Bay.</td></tr>
</table>

Table 4.25-7: Contribution to Cumulative Effects on TES

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Alaska Stand Alone Pipeline Project	**Magnitude:** Impacts to TES from this project would be increased vessel traffic (quantity unknown) in Cook Inlet and potential impacts to Cook Inlet beluga whale critical habitat. **Duration/Extent:** The duration would last for the life of the project and extent would be limited mainly to the port facilities at Point MacKenzie. Vessel traffic would likely follow existing shipping lanes in the center of Cook Inlet. Only Cook Inlet beluga whale is known to regularly occur around the port facilities at Point MacKenzie. There is a potential for vessel strikes to all TES from boats transporting supplies and LNG, but this would be limited mainly to the lower portion of Cook Inlet. **Contribution:** Vessel traffic would contribute cumulatively to behavioral avoidance, underwater noise impacts, and potential for injury and mortality, mainly to Cook Inlet beluga whales, but also to any other TES that occur in shipping lanes in Cook Inlet.			
Alaska LNG	**Magnitude:** Impacts to TES from this project would be increased vessel traffic during operations (204 to 360 port calls at Nikiski per year, potentially resulting in a 42 to 74 percent increase in large ship traffic in Cook Inlet [FERC 2019b]) in Cook Inlet and potential impacts to Cook Inlet beluga whale critical habitat. **Duration/Extent:** The duration would last for the life of the project, and extent would be limited mainly to the port facilities at Nikiski. Vessel traffic would likely follow existing shipping lanes in the center of Cook Inlet. Only Cook Inlet beluga whale is known to regularly occur around the port facilities at Nikiski. There is a potential for vessel strikes to all TES from boats transporting supplies and LNG, but this would be limited mainly to the lower portion of Cook Inlet. **Contribution:** Vessel traffic would contribute cumulatively to behavioral avoidance, underwater noise impacts, and potential for injury and mortality, mainly to Cook Inlet beluga whales, but also to any other TES that occur in shipping lanes in Cook Inlet.			
Cook Inlet Oil and Gas Lease Sales	**Magnitude**: Operations of existing offshore oil and gas production platforms in Cook Inlet have a potential to impact TES through noise, vessel and aircraft traffic, habitat impacts, and injury or mortality. **Duration/Extent**: Potential impacts are restricted to the existing offshore oil and gas platforms, and impacts are likely to occur through the operational life of each platform. Additional exploration activities have a potential to impact TES, depending on the timing, location, and type of activity. **Contribution**: Continued use of existing platforms and exploration activities has a potential to increase cumulative impacts on TES (especially Cook Inlet beluga whales), but not in the analysis area, because most activities occur farther north in Cook Inlet.			
Diamond Point Rock Quarry	**Magnitude**: The Diamond Point Rock Quarry at Cottonwood and Iliamna bays would impact critical habitat for Cook Inlet beluga whale and northern sea otter. This would include permanent loss of critical habitat, with additional impacts from underwater noise due to blasting, placement of fill in the marine environment, and manipulation of the substrate. Wintering Steller's eiders may also experience increased disturbance in	Similar to Alternative 1a.	**Magnitude:** The footprint of the Diamond Point Rock Quarry coincides with the Diamond Point port footprint under this alternative. Impacts include a loss of Cook Inlet beluga whale and northern sea otter critical habitat that would be additive to those of Alternative 2. Additional TES may be impacted through underwater noise, behavioral disturbance, and foraging	Similar to Alternative 2, except the port does not overlap with the Diamond Point Rock Quarry, because the port would be shifted north into Iliamna Bay.

Table 4.25-7: Contribution to Cumulative Effects on TES

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	wintering and foraging areas. Steller sea lions may be impacted by underwater noise, loss of foraging habitat, and vessel traffic. Depending on where quarried material is taken, there may be vessel traffic disturbance and potential for injury and mortality for TES in lower Cook Inlet. **Duration/Extent**: The duration of impacts would last for the life of the project, and the geographic extent would be limited to Cottonwood and Iliamna bays, along with shipping routes for quarried material. **Contribution:** The project would contribute to cumulative loss of habitat (including critical habitat) for several TES, as well as disturbance and potential for injury or mortality.		habitat loss, including Steller sea lion and Steller's eiders. **Duration/Extent**: The duration of impacts would last for the life of the project, and the geographic extent would be limited to Cottonwood and Iliamna bays, along with shipping routes for quarried material. **Contribution:** The project would contribute to cumulative loss of habitat (including critical habitat) for several TES, as well as disturbance and potential for injury or mortality.	
Summary of Project contribution to Cumulative Effects	Alternative 1a would contribute cumulatively to impacts to TES in Cook Inlet, when taking other past, present, and RFFAs into account. This would include an increase in vessel traffic in Kamishak Bay, an area with relatively little existing commercial vessel traffic. There would also be an increase in traffic in the Gulf of Alaska, along the Aleutian Islands, and in the Bering Sea from project vessels. There would be an increase in the potential to impact a variety of TES, with northern sea otters most likely to be impacted due to their high density in Kamishak Bay. There would be relatively little loss of critical habitat, because most projects have small in-water footprints and there is a vast amount of nearby critical habitat. There would be an increase in vessel noise, presence, disturbance, and potential for	Similar to Alternative 1a.	Alternative 2 would contribute cumulatively to impacts to TES in Cook Inlet, when taking other past, present, and RFFAs into account. This would include impacts in Iliamna and Iniskin bay, an area with relatively little existing commercial vessel traffic, but slightly more than Amakdedori due to the presence of summer traffic to Williamsport. There would be an increase in the potential to impact a variety of TES, with northern sea otters most likely to be impacted due to their high density in the area. Molting and wintering Steller's eiders may also be impacted, because several hundred use Iliamna and Iniskin bays for several months out of the year. There would be relatively little loss of critical habitat, because	Similar to Alternative 2, but with an increase in impacts concentrated in Iniskin Bay.

Table 4.25-7: Contribution to Cumulative Effects on TES

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	injury and mortality to several whale species that occur in the Gulf of Alaska, along the Aleutian Islands, and in the Bering Sea.		most projects have small in-water footprints and there is a vast amount of nearby critical habitat. There would be an increase in vessel noise, presence, disturbance, and potential for injury and mortality to several whale species that occur in the Gulf of Alaska, along the Aleutian Islands, and in the Bering Sea.	

Notes:

DPS = Distinct Population Segment
LNG = Liquefied Natural Gas
RFFAs = reasonably foreseeable future actions
TES = Threatened and Endangered Species

4.26 VEGETATION

This section provides a description of the potential environmental consequences of the project on vegetation, and rare and sensitive species, including impacts from invasive species.

4.26.1 EIS Analysis Area

The Environmental Impact Statement (EIS) analysis area for vegetation for each project component is defined below. The analysis area includes the area affected by potential direct and indirect impacts from construction and operations. The analysis area collectively includes areas for all four components (mine site, transportation corridor, ports, and natural gas pipeline) and the variants under each component, in each action alternative.

Mine Site—The mine site analysis area includes the direct disturbance footprint extended by a 330-foot buffer to account for the indirect impacts of fugitive dust deposition.

Transportation Corridor and Ports—The transportation corridor and ports analysis area includes the direct disturbance footprint extended by a 330-foot buffer to account for the indirect impacts of fugitive dust deposition. Although the direct disturbance footprints are included for the pile-supported and caisson dock designs (both of which have concrete decking), lightering areas, and mooring buoys, these features are not buffered, because they are not expected to be sources of fugitive dust (note open water is not considered part of the affected environment for vegetation).

Natural Gas Pipeline—The natural gas pipeline corridor analysis area includes the pipeline-only sections where the pipeline is not co-located with the transportation corridor. These sections of the natural gas pipeline have a maximum impact width of 91 feet through Iliamna Lake, 102 to 183 feet through Cook Inlet, and 150 feet through overland areas. The overland analysis area includes the direct disturbance footprints for access roads and material sites buffered by a 330-foot zone to account for dust impacts (note open water is not considered part of the affected environment for vegetation).

4.26.2 Analysis Methodology

Potential direct and indirect effects to vegetation and the risk of invasive species introductions were assessed according to four factors: the magnitude (intensity) of the impacts; the duration (how long the impact would last); the extent (the area of the impact); and the likelihood of the effect (the certainty that the impact would occur, should the project be permitted).

Magnitude—the magnitude of impacts is quantified by the number of acres impacted by the project.

Duration—duration considers how long an impact is expected to last, and is qualified as permanent, temporary, or long-term. The duration of direct impacts to vegetation is considered permanent where removal of—or disturbance to—vegetation would occur during construction and remain free of vegetation through closure. The duration of impacts would be considered temporary where vegetation functions would be reduced during construction, and the area would be reclaimed (meaning that vegetative functions would be restored) after the construction phase. Restoration measures would reduce the duration of temporary impacts (Chapter 5, Mitigation). The duration of indirect impacts due to the deposition of fugitive dust is considered long-term.

Extent—extent considers the geographic location of impacts in the analysis area. The extent of impacts would be limited to the watersheds where vegetation would be lost or disturbed as a result of project-related impacts or where the project would affect vegetation outside of the project area, for example, by the introduction and spread of invasive species (see Figure 4.22-4 for an overview of the Hydrologic Unit Code [HUC] 10 watersheds impacted by the project).

Likelihood—likelihood evaluates the probability of impacts. The likelihood of vegetation loss and indirect impact to vegetation due to dust deposition would be certain if the project is permitted and constructed. The likelihood of the removal of rare or sensitive plant species or rare or sensitive plant species habitat is considered low if the project was to be permitted and constructed, because there are no confirmed occurrences of rare plants in the analysis area for vegetation. Assuming implementation of the invasive species management plan (ISMP) (Owl Ridge 2019d) developed by the Applicant, the likelihood of invasive species introductions is also considered low. This analysis factor is not further discussed, because there is no difference in likelihood among the alternatives.

Scoping comments requested that the EIS analyze impacts to rare and sensitive species, the effects of fugitive dust on vegetation in the project area, and the risk for introduction of invasive species (rare or sensitive plant and invasive species are defined in Section 3.26, Vegetation).

The following sections present the impacts to vegetation (including rare and sensitive species) under each alternative for all project components and associated variants. Direct effects from vegetation removal and fugitive dust are summarized by type of vegetation affected. Project vegetation types were developed as described in Section 3.26, Vegetation. Also described in Section 3.26, the “open water” type is not considered part of the affected environment for vegetation. Therefore, the open water type was not included in vegetation impact calculations. Values are rounded to the nearest whole acre, or nearest whole percent; apparent inconsistencies in sums are the result of rounding.

4.26.3 Direct and Indirect Impacts

The project has the potential to cause the following direct and indirect impacts on vegetation:

- Direct impacts from:
  - Vegetation removal
  - Elimination of rare or sensitive plant species and habitat
- Indirect impacts from:
  - Invasive species introduction or spread
  - Fugitive dust

Project-related direct impacts to vegetation are the removal of vegetation, and the removal of rare or sensitive plant species, or rare or sensitive plant species habitat. Vegetation removal would require the clearing of existing vegetation and grading of the soil surface. Most direct impacts to vegetation would be initiated during the construction phase, and would result in the temporary or permanent loss of vegetation cover, and the functions that cover provides. Where the disturbance of vegetation does not result in the direct loss of habitat, alterations to plant community composition, structure, and functions such as soil stabilization and the attenuation of surface water flow may result. Because the mine site is designed to divert water to settling and water management ponds prior to leaving the site, the potential for increased erosion and sedimentation due to the removal of vegetation would be limited to the project components of the transportation and natural gas pipeline corridor. It is expected that best management and industry practices would minimize erosion and sedimentation along these corridors. Direct impacts related to erosion and sedimentation are evaluated in Section 4.14, Soils; and Section 4.18, Water and Sediment Quality. See Section 4.23, Wildlife Values, and Section 4.24, Fish Values, for discussion of the consequences of habitat loss and degradation for wildlife.

Temporary habitat loss areas include construction workspace associated with road and other infrastructure construction, and the natural gas pipeline corridor where it is not associated with the access road. Restoration of temporarily impacted vegetation would aim to stabilize soils through practices including terrain recontouring, spreading stockpiled topsoil, placing erosion control devices, and/or establishing temporary vegetation cover. Such practices would commence post-construction, or concurrent with construction activities, once the desired grading has been achieved; the workspace is no longer needed; or the pipeline has been installed. Restoration aims to establish a permanent vegetation cover with species densities and compositions similar to adjacent lands undisturbed by the project, with efforts being deemed complete by the successful establishment of the perennial plant cover (Owl Ridge 2019a; PLP 2019-RFI 123).

Permanent habitat loss area is the direct footprint of disturbance, including mine facilities, access and mine roads, ferry terminals, and ports. Where reclamation of permanently impacted areas would entail revegetation, growth medium would be placed, amended, seeded, and watered as necessary. Reclamation would begin concurrent with operations for project facilities as soon as practical and safe; otherwise, reclamation would be phased over 50 years post-closure. Reclamation aims to achieve 30 percent vegetative cover within 3 years, with efforts considered complete when 70 percent vegetation cover is achieved (SRK 2019d; PLP 2019-RFI 115).

Both restoration and reclamation would promote the processes of natural succession that would be expected to occur in the absence of human intervention. Succession proceeds at rates dependant on the severity and extent of disturbance, the type of vegetation disturbed, and proximity of seed sources (Fastie 1995). Typically, large-scale disturbance where the removal of vegetation and overburden leaves bare mineral soil (i.e., primary succession) would take longer to recover to pre-disturbance condition, compared to small-scale disturbance where the organic layer remains intact (i.e., secondary succession). In a scenario of primary succession, plants are often nitrogen-limited; therefore, bare mineral soil is pioneered by species capable of nitrogen fixation such as lichens, lupine (*Lupinus* spp.), mountain avens (*Dryas* spp.), and alders (*Alnus* spp.) (Tilman 1985). Under a scenario of secondary succession where plants are typically light-limited, seral[1] stages transition from those dominated by species with high growth rates and prolific seed production to slow-growing species that are better able to compete for limited resources (MacArthur and Wilson 1967). Typically, sheltered, temperate sites with nearby seed sources would recover more quickly than exposed, alpine sites where reproduction is predominantly vegetative, and topography often presents a barrier to the delivery of seed from nearby, intact communities. Restoration and reclamation are further discussed in Chapter 5, Mitigation. Pebble Limited Partnership's (PLP's) draft Restoration Plan for Temporary Impacts (Owl Ridge 2019a; PLP 2019-RFI 123) and draft Reclamation and Closure Plan (SRK 2019d; PLP 2019-RFI 115) are included in Appendix M3.0 and Appendix M4.0, respectively.

Project-related indirect impacts to vegetation would include invasive species risk and fugitive dust. The areas of these indirect impacts may overlap. Indirect impacts may occur during any phase of the project, and result in temporary or permanent loss of vegetation, or the ecological functions their communities provide.

Invasive species may be introduced to the project area during construction, operations, and closure as contaminants on materials, vehicles, vessels, and/or people. The potential impacts of invasive species are assessed qualitatively based on known or potential occurrence, invasiveness, location of infestation, and implementation of an invasive species management plan. The Invasive Species subsection discusses the known and potential occurrences of all taxa of non-native species in the analysis area.

[1] Seral refers to a plant community that is demonstrably susceptible to replacement by another community.

Drawdown of groundwater is expected at the mine site as a result of operations. Depression of the groundwater table is expected to impact area wetlands, surface waters, and vegetation. Because the severity of impact from dewatering is expected to be greater for wetlands relative to non-wetland vegetation, impacts to vegetation resources are discussed collectively in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites. Impacts to surface water are presented in Section 4.16, Surface Water Hydrology; impacts to groundwater are discussed in Section 4.17, Groundwater Hydrology.

Fugitive dust—Fugitive dust is expected to be produced from ground-disturbing actions during construction, operation, and closure of the mine, as well as from the wind or vehicle dispersion of exposed soil in the post-closure period. Fugitive dust has the potential to injure or collect on vegetation, with consequences for plant physiology, community composition, and function (Farmer et al. 1993). The potential for dust-related impacts is considered long-term.

The type of impacts experienced from mineral dust deposition on vegetation largely depends on the characteristics of the dust, the plant species affected, and the environmental conditions surrounding deposition (Doley 2006). Because particle size is strongly correlated to dispersal distance, larger, gravity-deposited particles may cause smothering adjacent to a road surface; whereas smaller, wind-blown particles may cause abrasion of plant tissue and loading of plant surfaces at greater distances (Walker and Everett 1987). For vascular plants, the physical shading of photosynthetic surfaces and blockage of stomata from dust loading cause subsequent reductions in photosynthesis, respiration, and transpiration (Spatt and Miller 1981; Thompson et al. 1984).

Research on fugitive dust in Alaska shows that the deposition rate and particle size decrease logarithmically with distance from the ground-disturbing activity (Auerbach et al. 1997; Ford and Hasselbach 2001). Because the physical and chemical effects of dust deposition have been shown to be difficult to document beyond 330 feet from the disturbing action (Walker and Everett 1987), an indirect impact area was calculated by buffering the area of direct disturbance by 330 feet, then subtracting the direct disturbance footprint to exclude vegetation directly impacted by permanent mine facilities. This area of analysis is the same applied to wetlands and other waters to evaluate indirect impacts of dust (see Figure 4.22-2), and follows methods used by recent EISs in Alaska (Ambler Road DEIS [BLM 2019b]; Donlin Gold 2018 [USACE 2018d]; Point Thompson 2012 [USACE 2012a]).

Addition of dust with a pH higher than the resident soil can initiate shifts in plant community composition from acidic to more alkaline vegetation types (Auerbauch et al. 1997). Increase in soil nutrients due to higher pH has been shown to promote the recruitment and growth of mineotrophic species such as the shrub, *Alnus viridis* (Gill et al. 2014), graminoids (Meyers-Smith et al. 2006), and ruderal mosses (*Ceratodon purpureus, Bryum* spp. and *Polytrichum juniperinum*) (Walker and Everett 1987). This increase in mineotrophic species typically occurs at the expense of acrocarpous mosses (*Hylocomium splendens*) (Hasselbach et al. 2005; Neitlich et al. 2017), lichens (DiMeglio 2019), peat mosses (*Sphagnum lenense*) (Spatt and Miller 1981), forbs and dwarf shrubs (e.g., *Empetrum nigrum, Rhododendron subarcticum*, *Cassiope tetragona, Ledum palustre,* and *Vaccinium vitis-idaea, V. uliginosum*) (Gill et al. 2014; Walker and Everett 1987).

Where dust deposition facilitates the dominance of tall shrubs (e.g., alder), several ecological feedbacks are strengthened: higher-stature vegetation acts to entrap dust and further increase soil nutrient availability, thereby further reducing the presence of acidophilous mosses and vascular plants as soil pH and shading increase. Tall shrubs acting as a windbreak may also increase the depth and lateral extent of snow accumulation, insulating the ground and potentially leading to higher ground temperatures beyond areas immediately adjacent to the road (Gill et al. 2014).

The deposition of dust with color different from the natural leaf or soil surfaces can cause an albedo-induced change in temperature, affecting the rates of cellular and pedogenic processes. This is generally the case with dust deposition on snow, which has been shown to accelerate melt, thereby encouraging the early green-up of the underlying vegetation (Auerbach et al. 1997; Walker and Everett 1987). Although analysis area soils are acidic, road materials would be locally sourced, which reduces the potential for pH to differ drastically from that of native soils. Exceptions would include the deposition of light-colored and potentially higher pH mineral road dust to darker and more acidic organic soils.

With respect to the influence of environmental conditions on dust deposition, dust impacts may be directed by plant architecture, precipitation, and wind (Auerbach et al. 1997; Doley 2006). Plant susceptibility to dust loading is increased by a mat or prostrate growth form; lack of a protective leaf cuticle; narrow leaves and intricate branching; and non-deciduous leaves, which, when not covered by snow, are able to intercept dust outside of the growing season (Walker and Everett 1987). Alternatively, wind and precipitation would decrease the amount of dust retained on plant surfaces. In the analysis area, dwarf shrub and evergreen shrub and forests would be expected to be more susceptible to the adverse effects of dust deposition.

Dust-induced changes in plant community composition would likely vary by vegetation type. Dry prostrate shrub and aquatic graminoid tundra show little effect beyond smothering adjacent to the roadside; however, moist and wet graminoid tundra show an increase in mineotrophic species at the expense of acidophilous species, with lichen- and *Sphagnum*-dominated communities being the most sensitive to dust deposition (Farmer 1993). Lichens are extremely slow-growing, and take decades to over a century to recover from disturbance (Joly et al. 2010). Following fire, lichen communities transition to graminoid dominance. These communities remain low in lichen cover for over 55 years, with full recovery estimated to take as long as 160 years (Black and Bliss 1978). The sensitivity of lichen-rich communities to dust deposition and disturbance in general is important for caribou (*Rangifer tarandus granti*), which have been shown to derive much of their winter diet from reindeer lichens in the *Cladonia* genus (e.g., *Cladonia rangiferina, C. arbuscula, C. mitis,* and *C. stellaris*) (Jolly et al. 2010). Impacts to caribou due to fugitive dust deposition are discussed in 4.23, Wildlife Values; the sensitivity of peatlands to dust deposition is discussed in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.

PLP developed a conceptual Fugitive Dust Control Plan that identifies project design features and best management practices (BMPs) to minimize fugitive dust emissions (PLP 2019-RFI 134). Among other measures, the plan would enforce separation of mine site and access road traffic to minimize cross-contamination of vehicles, and would implement the use of sealed containers (i.e., containerized bulk-handling technology) for the transport of concentrate. Wet mill processes, the watering of haul roads, use of wetting material, washing of concentrate containers, and covering and/or revegetation of stockpiled soil would also be used as controls on fugitive dust generation and deposition. Although these measures would be expected to minimize fugitive dust emissions, the deposition of dust on vegetation would still be expected. Fugitive dust at the mine site is expected to be derived from both concentrate and road material, whereas dust deposition in the transportation corridor is expected to be road material dust only.

Specific to the Pebble Project, a dust dispersion model was developed to predict the worst-case scenario of air quality impacts of particulate matter at the mine site (PLP 2018-RFI 009a). Maximum annual modeled deposition of dust with an aerodynamic diameter less than or equal to 10 microns in diameter (PM_{10}) was 1.5 grams per square meter per year (grams/m^2/year) due to construction; maximum values as high as 30 grams/m^2/year were reported within the mine site ambient air quality boundary. The influence of prevailing northwest-southeast winds is clearly shown in the orientation of the deposition-rate isopleths (see Figure 4.22-3 and Figure 4.14-1).

Additional modeling evaluated concentrations of hazardous air pollutant (HAP) metals carried by fugitive dust for incremental increase over the 20-year operations period at the mine site. Only copper (6 percent) and antimony (3 percent) showed increases in concentration over 1 percent at the end of operations. Even with these increases, modeled concentrations of HAP metals are considered insufficient to produce adverse impacts on human health (Section 4.10, Health and Safety, and Section 4.14, Soils). Although the potential for adverse impacts to vegetation is presumed to be low, deposition of metal-contaminated dust at the mine site would largely affect dwarf shrub communities, which have low capacity to sequester metals; and due to a characteristically significant lichen component, would be more susceptible to the uptake of metals.

Although a few metals are essential to plant metabolism in trace amounts, including copper, manganese, cobalt, zinc, and chromium, most are toxic in bioavailable forms at high levels (Nagajyoti et al. 2010; Yurela 2005). Plants growing in metal-polluted sites exhibit altered metabolism, growth reduction, and lower production of biomass (Nagajyoti et al. 2010). Select vascular species are adapted to sequester or exclude heavy metals or avoid uptake from surface soils via a deep root system, and can survive longer in contaminated soils (Nagajyoti et al. 2010). However, mosses and lichens, which lack vascular transport mechanisms and therefore absorb water and nutrients through their thalli and leaf surfaces, are highly susceptible to airborne pollutants (DeMeglio 2019; Hasselbach et al. 2005; Neitlich et al. 2017). Metal concentrations in moss and lichen have been shown to exceed baseline levels up to 25 miles from a gravel mine access road in arctic Alaska (Red Dog haul road; Hasselbach et al. 2005; Neitlich et al. 2017). The dispersal and toxicity of metal-contaminated dust is expected to be considerably less than that documented along the Red Dog haul road due to PLP's proposed mitigation, which would reduce the generation of metal-contaminated dust, and restrict the deposition of metal-contaminated dust to the mine site. At the plant community level, decreases in biomass and species richness are common effects of metal toxicity (DeMeglio 2019; Ernst 1989). Dust deposition is further discussed in Section 4.14, Soils; indirect impacts to wetlands are discussed in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.

4.26.4 Summary of Key Issues

Depending on the alternative, the magnitude and extent of direct permanent impacts from project construction, operations, and closure would be the removal of between 9,482 (Alternative 1) and 10,081 (Alternative 3) acres of vegetation[2]. Direct temporary impacts to vegetation range from 671 (Alternative 1) to 1,240 (Alternative 2) acres. The indirect impacts related to the potential deposition of dust range from 8,236 (Alternative 2) to 9,915 (Alternative 3) acres of vegetation. Table 4.26-1 summarizes the direct and indirect impacts to vegetation from the removal of vegetation and the potential deposition of fugitive dust, respectively, across all alternatives. Because there are no known or probable locations of rare or sensitive plant species in the analysis area, the direct impact of potential loss of rare or sensitive species habitat is not further discussed among action alternatives. The indirect impacts related to the potential introduction and spread of invasive species are discussed under Invasive Species. However, because there are no confirmed occurrences of invasive species in the analysis area and the probability of introduction is difficult to predict, impacts are not quantified among the alternatives.

[2] Totals assume base case scenario without the inclusion of variants.

Table 4.26-1: Summary of Vegetation Key Impacts

Variant	Impact	Alternative 1a	Alternative 1	Alternative 2	Alternative 3
All Project Components (Acres)					
Base Case	Permanent	9,504	9,482	9,637	10,018
	Temporary	822	671	1,241	777
	Indirect	9,159	9,295	8,236	9,915
Mine Site (Acres)					
Base Case	Permanent	8,292	8,292	8,399	8,292
	Temporary	1	1	1	1
	Indirect	3,022	3,022	3,012	3,021
Summer-Only Ferry Operations Variant	Permanent	--	8,325 [+33]	8,432 [+33]	--
	Temporary	--	1	1	--
	Indirect	--	3,007 [-15]	2,997 [-15]	--
Concentrate Pipeline Variant	Permanent	--	--	--	8,293 [+1]
	Temporary	--	--	--	1
	Indirect	--	--	--	3,020 [-2]
Transportation (Acres)					
Base Case	Permanent	1,188	1,165	896	1,681
	Temporary	594	602	428	648
	Indirect	6,053	6,189	4,424	6,799
Summer-Only Ferry Operations Variant	Permanent	--	--	918 [+22]	--
	Temporary	--	--	428	--
	Indirect	--	--	4,426 [+2]	--
Kokhanok East Ferry Terminal Variant	Permanent	--	1,20	--	--
	Temporary	--	556	--	--
	Indirect	--	5,754	--	--
Newhalen River North Crossing Variant	Permanent	--	--	916 [+20]	--
	Temporary	--	--	427 [-1]	--
	Indirect	--	--	4,416 [-8]	--
Port (Acres)					
Base Case	Permanent	21	22	42	32
	Temporary	7	7	9	4
	Indirect	84	84	85	35
Summer-Only Ferry Operations Variant	Permanent	--	49 [+27]	--	--
	Temporary	--	8 [+1]	--	--
	Indirect	--	83 [-1]	--	--
Pile-Supported Dock Variant	Permanent	--	21 [-1]	--	--
	Temporary	--	7	--	--
	Indirect	--	84	--	--
Natural Gas Pipeline (Acres)					
Base Case	Permanent	2	2	300	13
	Temporary	220	62	803	125
	Indirect	--	--	715	60
Kokhanok East Ferry Terminal Variant	Permanent	--	2	--	--
	Temporary	--	86 [+24]	--	--
	Indirect	--	--	--	--

4.26.5 No Action Alternative

The No Action Alternative is intended to be used as a baseline to facilitate the comparison of impacts between the action alternatives. Impacts from the proposed Applicant's Preferred Alternative (beneficial or adverse) would not occur under the No Action Alternative.

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

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

4.26.6 Alternative 1a

The total direct impact under Alternative 1a would be the removal of 9,504 acres of vegetation, with temporary impacts to an additional 822 acres expected. Regarding indirect impacts, 9,159 acres of vegetation could be exposed to dust deposition. No variants are evaluated under Alternative 1a.

4.26.6.1 Mine Site

Alternative 1a would include development at the mine site with centerline construction for the bulk tailings storage facility (TSF) north embankment.

Vegetation Removal

Under Alternative 1a, the magnitude and extent of direct impacts during construction of the mine site would be the clearing, grading, and removal of 8,292 acres of vegetation across the Headwaters Koktuli River and Upper Talarik Creek (UTC) watersheds (Table 4.26-2). Direct permanent impacts to vegetation at the mine site represent 5 percent and less than 1 percent of vegetation mapped for the Headwaters Koktuli River and UTC watersheds, evaluated at the HUC 10 scale. Dwarf shrub represents 55 percent of the area of direct permanent impact, with open low shrub subdominant at 16 percent. Closed tall shrub comprises an additional 10 percent of the area of direct permanent impact. Direct temporary impacts would occur for 0.6 acre of dwarf to low shrub across the two watersheds. The majority (100 percent, as rounded) of all direct impacts would occur in the Headwaters Koktuli River watershed. The duration of most direct impacts to vegetation at the mine site are considered permanent, because features would remain in use through operations and into closure. For example, all road material sites would be stabilized and progressively reclaimed, but would remain active to support ongoing mine access road maintenance requirements through operations; mine laydown areas would be retained for use through operations; and all construction roads would continue to serve as site access roads. Less than 1 acre of direct impacts associated with excavation at each of the effluent discharge locations is considered temporary.

Table 4.26-2: Alternative 1a—Mine Site Permanent Impact Area

Vegetation Type	Headwaters Koktuli River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
			Acres	Percent Area
Dry to Moist Herbaceous	308	<1	308	4
Wet Herbaceous	477	1	478	6
Dwarf Shrub	4,542	12	4,553	55
Open Low Shrub	1,352	3	1,355	16
Open Tall Shrub	272	<1	272	3
Closed Low Shrub	162	--	162	2
Closed Tall Shrub	856	1	857	10
Other	307	<1	307	4
Mine Site Permanent Impact Area	**8,275**	**17**	**8,292**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Fugitive Dust

Fugitive dust would be generated during construction and operation of the mine. At the mine site, dust would be generated by ground-disturbing activities related to excavation, fill, road maintenance, and vehicle travel, as well as mining activities such as the removal, transport, and processing of ore. Wind would also be expected to generate dust from bare soil at the mine site.

During construction and operation of Alternative 1a, the magnitude and extent of indirect impacts would be the potential deposition of dust over 3,022 acres of vegetation across the Headwaters Koktuli River and UTC watersheds (Table 4.26-3). The dwarf shrub vegetation type comprises 62 percent of this area; open low shrub is subdominant at 12 percent. The majority (97 percent) of impacts would occur in the Headwaters Koktuli River watershed. The duration of these potential impacts would be considered long-term.

Table 4.26-3: Alternative 1a—Mine Site Fugitive Dust Impacts

Vegetation Type	Headwaters Koktuli River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
			Acres	Percent Area
Dry to Moist Herbaceous	120	1	121	4
Wet Herbaceous	117	10	127	4
Dwarf Shrub	1,838	41	1,879	62
Open Low Shrub	353	21	374	12
Open Tall Shrub	105	3	108	4
Closed Low Shrub	22	<1	22	1
Closed Tall Shrub	210	5	215	7
Other	175	<1	175	6
Mine Site Indirect Impact Area	**2,940**	**82**	**3,022**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

4.26.6.2 Transportation Corridor

Alternative 1a would include a transportation corridor with a mine access road to the Eagle Bay ferry terminal, a south crossing of the Newhalen River, a ferry crossing of Iliamna Lake to the south ferry terminal west of Kokhanok, and a port access road to the western side of Cook Inlet.

Vegetation Removal

Construction activities in the transportation corridor would require clearing, grading, and removal of vegetation along access roads, ferry terminals, laydown areas, and material sites. Segments of the natural gas pipeline adjacent to access roads are addressed in this section.

The magnitude, duration, and extent of impacts would be the permanent removal of 1,188 acres (Table 4.26-4), with temporary impacts to 594 acres of vegetation across seven watersheds (Table 4.26-5). The dwarf shrub vegetation type comprises 48 percent of the area of permanent impact, with open/closed forest (21 percent), and open tall shrub (11 percent) subdominant. Temporary impacts to vegetation would also be highest for dwarf shrub (44 percent), open/closed forest (25 percent), and open tall shrub (10 percent).

Table 4.26-4: Alternative 1a—Transportation Corridor Permanent Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay (Acres)	Gibraltar Lake (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Newhalen River (Acres)	Paint River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
								Acres	Percent Area
Dry to Moist Herbaceous	4	--	1	2	1	--	8	14	1
Wet Herbaceous	5	1	<1	4	-	--	1	11	1
Dwarf Shrub	68	91	12	163	87	--	151	571	48
Open Low Shrub	13	4	<1	14	27	--	30	87	7
Open Tall Shrub	57	20	1	41	2	<1	4	125	11
Closed Low Shrub	<1	<1	<1	2	1	--	1	5	<1
Closed Tall Shrub	27	13	1	38	1	--	25	104	9
Open/Closed Forest	--	10	--	110	133	--	<1	253	21
Other	4	3	--	4	1	--	5	17	1
Transportation Corridor Permanent Impact Area	**179**	**141**	**14**	**377**	**252**	**<1**	**225**	**1,188**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Table 4.26-5: Alternative 1a—Transportation Corridor Temporary Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay (Acres)	Gibraltar Lake (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Newhalen River (Acres)	Paint River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
								Acres	Percent Area
Dry to Moist Herbaceous	3	<1	1	1	<1	--	3	8	1
Wet Herbaceous	4	1	<1	3	<1	--	1	8	1
Dwarf Shrub	30	53	6	77	37	<1	58	262	44
Open Low Shrub	10	3	<1	8	11	--	12	44	7
Open Tall Shrub	25	8	<1	21	1	<1	2	57	10
Closed Low Shrub	<1	<!	<1	1	<1	--	1	2	<1
Closed Tall Shrub	13	8	<1	19	1	--	14	55	9
Open/Closed Forest	--	9	---	57	82	--	0	148	25
Other	3	1	--	2	1	--	2	8	1
Transportation Corridor Temporary Impact Area	**88**	**83**	**7**	**189**	**133**	**<1**	**94**	**594**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Fugitive Dust

Development and operations of the transportation corridor would generate less dust compared to the mine site, although dust deposition would occur over a larger geographic area. Although the transportation corridor crosses seven watersheds, dust generation is expected to be lower because the dust-producing activities would be less frequent (vehicles passing rather than ongoing movement of materials at the mine site), and the unvegetated area of the road is much smaller than the mine site.

During operations, daily transportation of materials (concentrate, fuel, reagents, and consumables) would require multiple truck round-trips per day. Section 4.12, Transportation and Navigation, describes the number of trips and the type and number of vehicles expected to use the access roads. Dust would likely be generated during gravel placement, gravel compaction activities, and from vehicular traffic and equipment operation on gravel roads.

In terms of magnitude and extent of indirect impacts, a total of 6,053 acres of vegetation would be exposed to the potential deposition of dust across seven watersheds (Table 4.26-6). The duration of these potential impacts would be considered long-term. The dwarf shrub vegetation type comprises 41 percent of the area of indirect impact; open/closed forest is subdominant at 24 percent. Closed and open tall shrub each comprise an additional 10 percent.

Table 4.26-6: Alternative 1a—Transportation Corridor Fugitive Dust Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay (Acres)	Gibraltar Lake (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Newhalen River (Acres)	Paint River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
								Acres	Percent Area
Dry to Moist Herbaceous	32	2	5	8	5	--	39	91	1
Wet Herbaceous	48	23	<1	42	11	<1	17	140	2
Dwarf Shrub	291	479	54	755	365	1	544	2,489	41
Open Low Shrub	96	45	3	103	123	--	146	515	9
Open Tall Shrub	259	86	2	234	16	1	32	630	10
Closed Low Shrub	2	2	<1	10	3	--	11	29	<1
Closed Tall Shrub	137	91	5	185	14	--	155	586	10
Open/Closed Forest	--	91	--	571	811	--	4	1,478	24
Other	34	8	<1	23	5	--	25	95	2
Transportation Corridor Indirect Impact Area	**900**	**828**	**69**	**1,931**	**1,352**	**2**	**971**	**6,053**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

4.26.6.3 Amakdedori Port

Alternative 1a would include construction of a caisson dock at Amakdedori on Kamishak Bay. Due to sufficient water depths, dredging would not be required at this port location. The port would be supported by a permanent airstrip used primarily for construction, but retained for emergency access. Other shore-based infrastructure would include facilities for the receipt and storage of containers for concentrate and freight, fuel storage and transfer, power generation and distribution, maintenance, employee accommodation, and offices.

Vegetation Removal

Construction of the port would require clearing, grading, and removal of vegetation in areas along the access road, and where the shore-based facilities would be located, such as the airstrip and facilities for receipt and storage of containers, fuel storage and transfer, power generation and distribution, maintenance, and employee accommodation.

All temporary construction facilities would be removed after construction, and the sites would be reclaimed, unless being used for permanent facilities. The Amakdedori port facilities would be removed and reclaimed after closure activities are completed, except for those required to support shallow draft tug and barge access to the dock for the transfer of bulk supplies.

Under Alternative 1a, 21 acres of vegetation would be permanently impacted, with temporary impacts to an additional 7 acres; impacts would be restricted to the Amakdedori Creek-Frontal Kamishak Bay watershed (Table 4.26-7). The dwarf shrub vegetation type comprises 74 and 68 percent of the areas of permanent and temporary impacts, respectively; with sparse to partially vegetated land (i.e., other) covering an additional 20 and 21 percent of the areas of permanent and temporary impact, respectively.

Table 4.26-7: Alternative 1a—Amakdedori Port Permanent and Temporary Impact Areas

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay			
	Permanent Impact		Temporary Impact	
	Acres	Percent Area	Acres	Percent Area
Dry to Moist Herbaceous	1	5	1	10
Dwarf Shrub	16	74	5	68
Open Tall Shrub	<1	<1	<1	<1
Closed Low Shrub	<1	<1	<1	<1
Closed Tall Shrub	<1	<1	<1	<1
Other	4	20	2	21
Amakdedori Port Impact Area	**21**	**100**	**7**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Fugitive Dust

The production of fugitive dust at the port would mostly result from construction of the terminal, with dust emissions during the period of operations expected to be limited. Onshore port facilities would be removed during closure, except for necessary infrastructure to support shallow-draft tug and barge access to the dock.

During construction, the magnitude and extent of vegetation that would potentially be affected by dust deposition at the Amakdedori port is 84 acres; the entire area of impact is in the Amakdedori Creek-Frontal Kamishak Bay watershed (Table 4.26-8). The duration of these potential impacts would be considered long-term. The dwarf shrub vegetation type comprises 63 percent of the impacted area, with sparse to partially vegetated land (i.e., other), and the dry to moist herbaceous vegetation type covering an additional 14 and 11 percent of the area, respectively.

Table 4.26-8: Alternative 1a—Amakdedori Port Fugitive Dust Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay	
	Acres	Percent Area
Dry to Moist Herbaceous	9	11
Wet Herbaceous	1	1
Dwarf Shrub	53	63
Open Low Shrub	1	1
Open Tall Shrub	2	3
Closed Low Shrub	1	1
Closed Tall Shrub	4	5
Other	12	14
Amakdedori Port Indirect Impact Area	**84**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

4.26.6.4 Natural Gas Pipeline Corridor

Alternative 1a would include a natural gas pipeline crossing Cook Inlet from the Kenai Peninsula to the Amakdedori port, along the port access road to Iliamna Lake, across the lake to Newhalen, overland to connect to the mine access road east of the Newhalen River crossing, and along the mine access road to the mine site.

Vegetation Removal

Construction of the natural gas pipeline corridor would require clearing, grading, and removal of vegetation; the right-of-way would be maintained through the life of the project. This natural gas pipeline corridor impact area includes the pipeline-only sections of the natural gas pipeline that are not co-located with access roads.

Construction of the compressor station on the Kenai Peninsula would require the removal of 2 acres of open/closed forest in Stariski Creek-Frontal Cook Inlet watershed; this loss is the only permanent impact to vegetation associated with installation of the natural gas pipeline under Alternative 1a. Temporary impacts of natural gas pipeline installation would affect 220 acres of vegetation across six watersheds (Table 4.26-9). The open/closed forest vegetation type comprises 39 percent of the area of temporary impact, with dwarf shrub (25 percent) and open low shrub (21 percent) subdominant.

Table 4.26-9: Alternative 1a—Natural Gas Pipeline Temporary Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Newhalen River (Acres)	Stariski Creek-Frontal Cook Inlet (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
							Acres	Percent Area
Dry to Moist Herbaceous	2	1	<1	--	<1	1	5	2
Wet Herbaceous	--	--	2	<1	--	--	2	1
Dwarf Shrub	7	4	24	7	--	13	54	25
Open Low Shrub	--	--	40	3	--	4	46	21
Open Tall Shrub	<1	--	8	<1	--	2	10	5
Closed Low Shrub	--	--	1	--	--	-	1	1
Closed Tall Shrub	<1	--	4	--	--	3	8	4
Open/Closed Forest	--	--	53	33	<1	--	87	39
Other	1	--	4	<1	<1	<1	6	3
Natural Gas Pipeline Temporary Impact Area	**10**	**5**	**138**	**43**	**1**	**23**	**220**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Fugitive Dust

Although fugitive dust would be generated during installation of the pipeline-only segments of the natural gas pipeline, dust generation during operation is expected to be minimal because these sections would not be regularly accessed. Subsequent indirect impacts to vegetation from fugitive dust would likely be limited, and are analyzed in the transportation corridor for Alternative 1a.

4.26.7 Alternative 1

The total direct permanent impact under the Alternative 1 base case would be the removal of 9,482 acres of vegetation, with temporary impacts to an additional 671 acres expected. Regarding indirect impacts, 9,295 acres of vegetation would be exposed to the potential deposition of dust. Three variants are considered under Alternative 1: the Summer-Only Ferry Operations Variant, the Kokhanok East Ferry Terminal Variant, and the Pile-Supported Dock Variant. The Summer-Only Ferry Operations Variant would restrict operation of the ferry across Iliamna Lake to the open-water season; the Kokhanok East Ferry Terminal Variant considers an alternate south ferry terminal site east of Kokhanok; and the Pile-Supported Dock Variant would use an alternate pile-supported dock design at Amakdedori port. Change in the total acres of direct and indirect impacts due to the incorporation of variants are summarized in Table 4.26-1, and further discussed below.

4.26.7.1 Mine Site

The mine site footprint under Alternative 1 is the same as Alternative 1a, the direct and indirect impacts of which are summarized under Alternative 1a.

Vegetation Removal

Summer-Only Ferry Operations Variant

This variant would restrict operation of the ferry across Iliamna Lake to the open-water season. Instead of daily transportation to the Amakdedori port, concentrate would be stored in a container-based system that would be stockpiled at the mine site during the period when the lake is frozen. The containers would be stored in a laydown area at the mine site, requiring relocation of the sewage tank pad.

Expansion of container storage at the mine site would increase the magnitude of permanent impacts to vegetation by 33 acres (Table 4.26-10). The area of permanent impact at the mine site accounting for the expanded container storage yard is dominated by dwarf shrub (55 percent), with the open low and closed tall shrub types representing an additional 16 and 10 percent, respectively. The duration and extent of permanent impacts under the Summer-Only Ferry Operations Variant would not change from the Alternative 1 base case.

Table 4.26-10: Alternative 1—Mine Site Summer-Only Ferry Operations Variant Permanent Impact Area

Vegetation Type	Headwaters Koktuli River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
			Acres	Percent Area
Dry to Moist Herbaceous	311	<1	311	4
Wet Herbaceous	476	1	477	6
Dwarf Shrub	4,569	12	4,581	55
Open Low Shrub	1,355	3	1,358	16
Open Tall Shrub	272	<1	272	3
Closed Low Shrub	162	--	162	2
Closed Tall Shrub	856	1	857	10
Other	308	<1	308	4
Mine Site Permanent Impact Area	**8,309**	**17**	**8,325**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Other Variants

There would be no change to the magnitude, duration, or extent of direct impacts to vegetation at the mine site under the Kokhanok East Ferry Terminal or Pile-Supported Dock variants.

Fugitive Dust

Summer-Only Ferry Operations Variant

Due to a more compact configuration of mine site facilities under adoption of the Summer-Only Ferry Operations Variant, the area of vegetation exposed to the potential deposition of fugitive dust would be decreased by 15 acres (Table 4.26-11). The area of indirect impact at the mine site accounting for the expanded container storage yard is dominated by dwarf shrub (62 percent), with the open low shrub type subdominant at 12 percent. The duration and extent of dust deposition under the Summer-Only Ferry Operations Variant would not change from the Alternative 1 base case.

Table 4.26-11: Alternative 1—Mine Site Summer-Only Ferry Operations Variant Fugitive Dust Impact Area

Vegetation Type	Headwaters Koktuli River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
			Acres	Percent Area
Dry to Moist Herbaceous	119	1	121	4
Wet Herbaceous	118	10	128	4
Dwarf Shrub	1,826	41	1,867	62
Open Low Shrub	350	21	372	12
Open Tall Shrub	105	3	108	4
Closed Low Shrub	22	<1	22	1
Closed Tall Shrub	210	5	215	7
Other	174	<1	174	6
Mine Site Indirect Impact Area	**2,925**	**82**	**3,007**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Other Variants

There would be no change to the magnitude, duration, or extent of indirect impacts to vegetation at the mine site under the Kokhanok East Ferry Terminal or Pile-Supported Dock variants.

4.26.7.2 Transportation Corridor

The transportation corridor footprint under Alternative 1 would include a mine access road in the UTC watershed to a north ferry terminal southwest of Newhalen, and a crossing of Iliamna Lake to the south ferry terminal west of Kokhanok, from where the alignment would rejoin Alternative 1a.

Vegetation Removal

Construction activities in the transportation corridor would require clearing, grading, and removal of vegetation along access roads, ferry terminals, laydown areas, and material sites. Segments of the natural gas pipeline adjacent to access roads are addressed in this section.

The magnitude, duration, and extent of impacts would be the permanent removal of 1,165 acres (Table 4.26-12), with temporary impacts to 602 acres of vegetation across seven watersheds (Table 4.26-13). The dwarf shrub vegetation type comprises 55 percent of the area of permanent impact with open tall shrub and closed tall shrub (23 percent collectively), and open/closed forest (10 percent) subdominant. Temporary impacts to vegetation would also be highest for dwarf shrub (54 percent), with open tall shrub, closed tall shrub, and open/closed forest each representing an additional 11 percent of the impact area.

Table 4.26-12: Alternative 1—Transportation Corridor Permanent Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay (Acres)	Gibraltar Lake (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Newhalen River (Acres)	Paint River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
								Acres	Percent Area
Dry to Moist Herbaceous	4	--	1	1	--	--	9	15	1
Wet Herbaceous	5	1	<1	5	<1	--	1	13	1
Dwarf Shrub	68	91	12	215	1	--	254	642	55
Open Low Shrub	13	4	<1	25	4	--	33	79	7
Open Tall Shrub	57	20	1	47	11	<1	7	143	12
Closed Low Shrub	<1	<1	<1	3	--	--	2	5	<1
Closed Tall Shrub	27	13	1	39	1	--	49	128	11
Open/Closed Forest	--	10	--	55	35	--	16	116	10
Other	4	3	--	5	--	--	12	24	2
Transportation Corridor Permanent Impact Area	**179**	**141**	**14**	**395**	**52**	**<1**	**383**	**1,165**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Table 4.26-13: Alternative 1—Transportation Corridor Temporary Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay (Acres)	Gibraltar Lake (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Newhalen River (Acres)	Paint River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
								Acres	Percent Area
Dry to Moist Herbaceous	3	<1	1	1	--	--	5	9	2
Wet Herbaceous	4	1	<1	3	<1	--	1	9	1
Dwarf Shrub	30	53	6	96	<1	<1	139	325	54
Open Low Shrub	10	3	<1	11	3	--	18	44	7
Open Tall Shrub	25	8	<1	24	7	<1	4	68	11
Closed Low Shrub	<1	<1	<1	1	--	--	2	4	1
Closed Tall Shrub	13	8	<1	19	<1	--	27	68	11
Open/Closed Forest	--	9	--	27	16	--	12	64	11
Other	3	1	--	3	--	--	5	11	2
Transportation Corridor Temporary Impact Area	**88**	**83**	**7**	**184**	**26**	**<1**	**213**	**602**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Summer-Only Ferry Operations Variant

With ferry operations limited to the open water season only, there would be increased truck traffic along the transportation corridor during the operating months to handle the movement of the full year of concentrate production, fuel, and consumables. The areas of permanent and temporary impact, however, would be the same as the Alternative 1 base case.

Kokhanok East Ferry Terminal Variant

This variant would increase the magnitude of direct permanent impacts on vegetation by 35 acres and reduce the temporary impacts by 46 acres. Similar to the Alternative 1 base case, the areas of permanent and temporary impact are dominated by dwarf shrub vegetation with open/closed forest and tall shrub types subdominant (Table 4.26-14 and Table 4.26-15). The duration and extent of direct impacts would not change from the Alternative 1 base case.

Table 4.26-14: Alternative 1—Transportation Corridor Kokhanok East Ferry Terminal Variant Permanent Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay (Acres)	Gibraltar Lake (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Newhalen River (Acres)	Paint River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
								Acres	Percent Area
Closed Low Shrub	<1	<1	<1	6	--	--	2	8	1
Closed Tall Shrub	27	10	1	44	1	--	49	131	11
Dry to Moist Herbaceous	4	--	1	4	--	--	9	17	1
Dwarf Shrub	68	18	12	168	1	--	254	521	43
Open Low Shrub	13	1	<1	33	4	--	33	84	7
Open Tall Shrub	57	13	1	52	11	<1	7	140	12
Open/Closed Forest	--	--	--	191	35	--	16	242	20
Other	4	2	--	24	--	--	12	43	4
Wet Herbaceous	5	1	<1	5	<1	--	1	12	1
Transportation Corridor Permanent Impact Area	**179**	**45**	**14**	**527**	**52**	**<1**	**383**	**1,200**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Table 4.26-15: Alternative 1—Transportation Corridor Kokhanok East Ferry Terminal Variant Temporary Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay (Acres)	Gibraltar Lake (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Newhalen River (Acres)	Paint River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
								Acres	Percent Area
Dry to Moist Herbaceous	3	<1	1	1	--	--	5	10	2
Wet Herbaceous	4	<1	<1	3	<1	--	1	8	2
Dwarf Shrub	30	8	6	65	<1	<1	139	249	45
Open Low Shrub	10	1	<1	11	3	-	18	42	8
Open Tall Shrub	25	4	<1	20	7	<1	4	61	11
Closed Low Shrub	<1	<1	<1	2	--	--	2	4	1
Closed Tall Shrub	13	7	<1	19	<1	--	27	66	12
Open/Closed Forest	--	--	--	76	16	--	12	103	19
Other	3	<1	--	5	--	--	5	13	2
Transportation Corridor Temporary Impact Area	**88**	**20**	**7**	**200**	**26**	**<1**	**213**	**556**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Pile-Supported Dock Variant

There would be no change to the magnitude, duration, or extent of direct impacts to vegetation in the transportation corridor under the Pile-Supported Dock Variant.

Fugitive Dust

Under Alternative 1, a total of 6,189 acres of vegetation across seven watersheds would potentially be impacted by dust in the transportation corridor. The duration of these potential impacts would be considered long-term. The dwarf shrub vegetation type comprises 51 percent of the area of impact, with closed and open tall shrub representing an additional 12 percent each, and open/closed forest contributing an additional 11 percent (Table 4.26-16).

Table 4.26-16: Alternative 1—Transportation Corridor Fugitive Dust Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay (Acres)	Gibraltar Lake (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Newhalen River (Acres)	Paint River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
								Acres	Percent Area
Dry to Moist Herbaceous	32	2	5	9	--	--	60	107	2
Wet Herbaceous	48	23	<1	38	<1	<1	26	135	2
Dwarf Shrub	291	479	54	968	5	1	1,339	3,137	51
Open Low Shrub	96	45	3	138	31	--	202	515	8
Open Tall Shrub	259	86	2	261	68	1	57	734	12
Closed Low Shrub	2	2	<1	13	--	--	22	40	1
Closed Tall Shrub	137	91	5	191	7	--	295	726	12
Open/Closed Forest	--	91	--	270	169	--	135	666	11
Other	34	8	<1	31	1	--	56	130	2
Transportation Corridor Indirect Impact Area	**900**	**828**	**69**	**1,918**	**282**	**2**	**2,192**	**6,189**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Summer-Only Ferry Operations Variant

With ferry operations limited to the open water season only, there would be increased truck traffic along the transportation corridor during the operating months to handle the movement of the full year of concentrate production, fuel, and consumables. This extra activity would be expected to increase the deposition of fugitive dust along the transportation corridor without change to the magnitude, duration, or extent of indirect impact.

Kokhanok East Ferry Terminal Variant

Adoption of the East Ferry Terminal Variant would decrease the magnitude of fugitive dust impacts along the transportation corridor by 435 acres (from 6,189 to 5,754 acres). Similar to the Alternative 1 base case, dwarf shrub (42 percent) dominates this reduced area of indirect impact, with open/closed forest (19 percent) and closed (12 percent) and open tall shrub (11 percent) types subdominant (Table 4.26-17). The duration and extent of indirect impacts would not change from the Alternative 1 base case.

Table 4.26-17: Alternative 1—Transportation Corridor Kokhanok East Ferry Terminal Variant Fugitive Dust Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay (Acres)	Gibraltar Lake (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Newhalen River (Acres)	Paint River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
								Acres	Percent Area
Dry to Moist Herbaceous	32	<1	5	12	--	--	60	109	2
Wet Herbaceous	48	2	<1	53	<1	<1	26	130	2
Dwarf Shrub	291	72	54	671	5	1	1,339	2,433	42
Open Low Shrub	96	13	3	142	31	--	202	486	8
Open Tall Shrub	259	43	2	209	68	1	57	640	11
Closed Low Shrub	2	1	<1	19	--	--	22	45	1
Closed Tall Shrub	137	73	5	178	7	--	295	695	12
Open/Closed Forest	--	--	--	772	169	--	135	1,077	19
Other	34	6	<1	44	1	--	56	141	2
Transportation Corridor Indirect Impact Area	**900**	**210**	**69**	**2,100**	**282**	**2**	**2,192**	**5,754**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Pile-Supported Dock Variant

There would be no change to the magnitude, duration, or extent of indirect impacts to vegetation in the transportation corridor under the Pile-Supported Dock Variant.

4.26.7.3 Amakdedori Port

Alternative 1 would include a port at Amakdedori on Kamishak Bay with an earthen fill causeway and sheet pile dock design. On-shore facilities, temporary facilities, and the reclamation and closure of the site would be the same as Alternative 1a.

Vegetation Removal

The onshore configuration of the earthen fill causeway and sheet pile dock design would require the removal of an additional 1 acre of sparse or partially vegetated land (i.e., 'other') relative to the impacts of the caisson dock proposed under Alternative 1a. The duration and extent of all impacts and the magnitude of temporary and fugitive dust impacts would remain unchanged from Alternative 1a; Table 4.26-7 and Table 4.26-8 summarize the vegetation types impacted.

Summer-Only Ferry Operations Variant

Under the Summer-Only Ferry Operations Variant, concentrate containers would be stockpiled at Amakdedori port, requiring increased storage capacity. The larger container storage yard would increase the magnitude of direct permanent impacts on vegetation at Amakdedori port by 27 acres (from 22 to 49 acres), and would increase direct temporary impacts by 1 acre (from 7 to 8 acres). The dwarf shrub vegetation type comprises 79 and 73 percent of this area of permanent and temporary impacts, respectively; sparse or partially vegetated land (i.e., 'other') represents an additional 10 and 19 percent cover of permanent and temporary impacts, respectively (Table 4.26-18). There would be no change in duration or extent of direct impacts from the Alternative 1 base case.

Table 4.26-18: Alternative 1—Amakdedori Port Summer-Only Ferry Operations Variant Permanent and Temporary Impact Areas

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay			
	Permanent Impact		Temporary Impact	
	Acres	Percent Area	Acres	Percent Area
Dry to Moist Herbaceous	1	2	1	13
Wet Herbaceous	<1	1	<1	1
Dwarf Shrub	39	79	5	73
Open Low Shrub	<1	<1	<1	<1
Open Tall Shrub	1	1	<1	<1
Closed Low Shrub	3	5	<1	1
Closed Tall Shrub	1	2	<1	5
Other	5	10	1	19
Amakdedori Port Impact Area	**49**	**100**	**8**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Other Variants

There would be no change to the magnitude, duration, or extent of direct impacts to vegetation at the Amakdedori port under the Kokhanok East Ferry Terminal or Pile-Supported Dock variants.

Fugitive Dust

Fugitive dust would be generated from construction of the terminal, and from the earthen fill causeway during operations. The magnitude and extent of vegetation that would potentially be affected by dust deposition is 84 acres in the Amakdedori Creek-Frontal Kamishak Bay watershed. Dwarf shrub comprises 64 percent of the area of indirect impact (Table 4.26-19). Potential impacts due to dust are considered an indirect but long-term consequence of development.

Table 4.26-19: Alternative 1—Amakdedori Port Fugitive Dust Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay	
	Acres	Percent Area
Dry to Moist Herbaceous	9	11
Wet Herbaceous	1	1
Dwarf Shrub	53	64
Open Low Shrub	1	1
Open Tall Shrub	2	3
Closed Low Shrub	1	1
Closed Tall Shrub	4	5
Other	12	14
Amakdedori Port Indirect Impact Area	**84**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Summer-Only Ferry Operations Variant

Adoption of the Summer-Only Ferry Operations Variant would decrease the magnitude of vegetation potentially affected by dust deposition by 1 acre relative to the Alternative 1 base case. There would be no change to the duration and extent of indirect impacts relative to the Alternative 1 base case.

Other Variants

There would be no change to the magnitude, duration, or extent of indirect impacts to vegetation at the Amakdedori port under the Kokhanok East Ferry Terminal or Pile-Supported Dock variants.

4.26.7.4 Natural Gas Pipeline Corridor

The natural gas pipeline corridor footprint under Alternative 1 follows the alignment presented under Alternative 1a from the Kenai Peninsula to the south ferry terminal at Iliamna Lake. From here, it diverges from Alternative 1a across Iliamna Lake to the north ferry terminal southwest of Newhalen, and then along the mine access road to the mine site. Impacts evaluated here are for the pipeline-only sections of the natural gas pipeline that do not fall within the transportation corridor.

Vegetation Removal

Construction of the compressor station on the Kenai Peninsula would require the removal of 2 acres of open/closed forest in Stariski Creek-Frontal Cook Inlet watershed; this loss is the only permanent impact to vegetation associated with installation of the natural gas pipeline under Alternative 1. Temporary impacts of natural gas pipeline installation would affect 62 acres of vegetation across five watersheds. The dwarf shrub vegetation type comprises 62 percent of the area of temporary impact (Table 4.26-20).

Table 4.26-20: Alternative 1—Natural Gas Pipeline Corridor Temporary Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Stariski Creek-Frontal Cook Inlet (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
						Acres	Percent Area
Dry to Moist Herbaceous	2	1	--	<1	1	5	8
Wet Herbaceous	--	--	2	--	--	2	3
Dwarf Shrub	7	4	15	--	13	38	62
Open Low Shrub	--	--	2	--	4	6	9
Open Tall Shrub	<1	--	--	--	2	2	3
Closed Tall Shrub	<1	--	1	--	3	4	7
Open/Closed Forest	--	--	3	<1	--	4	6
Other	1	--	<1	<1	<1	2	3
Natural Gas Pipeline Corridor Temporary Impact Area	**10**	**5**	**23**	**1**	**23**	**62**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Kokhanok East Ferry Terminal Variant

Adoption of the Kokhanok East Ferry Terminal Variant would increase the magnitude of temporary impacts associated with installation of the natural gas pipeline by 24 acres; the magnitude of permanent impacts would not change from the Alternative 1 base case. Under the Kokhanok East Ferry Terminal Variant, the area of temporary impact is dominated by dwarf shrub (38 percent) with open/closed forest (20 percent) subdominant (Table 4.26-21). The duration and extent of direct impacts to vegetation would remain the same as the Alternative 1 base case.

Table 4.26-21: Alternative 1—Natural Gas Pipeline Corridor Kokhanok East Ferry Terminal Variant Temporary Impact Area

Vegetation Type	Amakdedori Creek-Frontal Kamishak Bay (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Stariski Creek-Frontal Cook Inlet (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
						Acres	Percent Area
Dry to Moist Herbaceous	2	1	2	<1	1	6	7
Wet Herbaceous	--	--	2	--	--	2	2
Dwarf Shrub	7	4	10	--	13	33	38
Open Low Shrub	--	--	3	--	4	7	8
Open Tall Shrub	<1	--	1	--	2	3	4
Closed Low Shrub	--	--	4	--	--	4	4
Closed Tall Shrub	<1	--	3	--	3	7	8
Open/Closed Forest	--	--	17	<1	--	17	20
Other	1	--	6	<1	<1	8	9
Natural Gas Pipeline Corridor Temporary Impact Area	**10**	**5**	**47**	**1**	**23**	**86**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a.

Other Variants

There would be no change to the magnitude, duration, or extent of direct impacts to vegetation in the natural gas pipeline corridor under the Summer-Only Ferry Operations or Pile-Supported Dock variants.

Fugitive Dust

Fugitive dust would be generated during construction of the pipeline-only segments of the natural gas pipeline; dust generation during operation is expected to be minimal because these sections would not be regularly accessed. Subsequent indirect impacts to vegetation from fugitive dust would likely be limited, and are analyzed in the transportation corridor for Alternative 1. There would be no change to the magnitude, duration, or extent of indirect impacts to vegetation in the natural gas pipeline corridor under the Summer-Only Ferry Operations Variant, Kokhanok East Ferry Terminal Variant, or Pile-Supported Dock Variant.

4.26.8 Alternative 2—North Road and Ferry with Downstream Dams

The total direct permanent impact under the Alternative 2 base case would be the removal of 9,637 acres of vegetation, with temporary impacts to an additional 1,241 acres expected. Regarding indirect impacts, 8,236 acres of vegetation would be exposed to the potential deposition of dust. Three variants are evaluated under Alternative 2: the Summer-Only Ferry Operations Variant, the Newhalen River North Crossing Variant, and the Pile-Supported Dock Variant. The Summer-Only Ferry Operations and Pile-Supported Dock variants are described under Alternative 1. The Newhalen River North Crossing Variant evaluates a crossing of the Newhalen River north of the location proposed under Alternative 1a; change in the total acres of direct and indirect impacts due to the incorporation of variants are summarized in Table 4.26-1 and further discussed below.

4.26.8.1 Mine Site

Mining methods and facilities would remain the same as those under Alternative 1a; however, Alternative 2 would use an alternative method for construction of the bulk TSF north embankment that would increase the footprint of direct permanent disturbance.

Vegetation Removal

Under Alternative 2, the magnitude and extent of direct permanent impacts during construction of the mine site would be the clearing, grading, and removal of 8,399 acres of vegetation across the Headwaters Koktuli River and UTC watersheds (Table 4.26-22). Direct permanent impacts to vegetation at the mine site represent 5 and less than 1 percent of vegetation mapped for the Headwaters Koktuli River and UTC watersheds, respectively, evaluated at the HUC 10 scale. Dwarf shrub represents 55 percent of the area of direct permanent impact, with open low shrub subdominant at 16 percent. Closed tall shrub comprises an additional 10 percent of the area of direct impact. The majority (100 percent, as rounded) of all direct impacts would occur in the Headwaters Koktuli River watershed. The duration of most direct impacts to vegetation at the mine site are considered permanent, because features would remain in use through operations and into closure. For example, all road material sites would be stabilized and progressively reclaimed, but would remain active to support ongoing mine access road maintenance requirements through operations; mine laydown areas would be retained for use through operations; and all construction roads would continue to serve as site access roads. Less than 1 acre of direct impacts associated with excavation at each of the effluent discharge locations is considered temporary.

Table 4.26-22: Alternative 2—Mine Site Permanent Impact Area

Vegetation Type	Headwaters Koktuli River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
			Acres	Percent Area
Dry to Moist Herbaceous	319	<1	319	4
Wet Herbaceous	479	1	479	6
Dwarf Shrub	4,603	12	4,615	55
Open Low Shrub	1,363	3	1,366	16
Open Tall Shrub	273	<1	273	3
Closed Low Shrub	164	--	164	2
Closed Tall Shrub	856	1	857	10
Other	325	<1	325	4
Mine Site Permanent Impact Area	**8,382**	**17**	**8,399**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Summer-Only Ferry Operations Variant

Under this variant, the magnitude of vegetation removal impacts during construction of the mine site would increase by 33 acres. The distribution of impacts among vegetation types, as well as the duration and extent of those impacts, would be the same as the Alternative 2 base case (Table 4.26-23).

Table 4.26-23: Alternative 2—Mine Site Summer-Only Ferry Operations Variant Permanent Impact Area

Vegetation Type	Headwaters Koktuli River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
			Acres	Percent Area
Dry to Moist Herbaceous	322	<1	322	4
Wet Herbaceous	478	1	479	6
Dwarf Shrub	4,630	12	4,642	55
Open Low Shrub	1,366	3	1,369	16
Open Tall Shrub	273	<1	274	3
Closed Low Shrub	163	--	163	2
Closed Tall Shrub	856	1	857	10
Other	326	<1	326	4
Mine Site Permanent Impact Area	**8,415**	**17**	**8,432**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Other Variants

There would be no change to the magnitude, duration, or extent of direct permanent impacts to vegetation at the mine site under the Newhalen River North Crossing or the Pile-Supported Dock variants.

Fugitive Dust

During construction and operations, the magnitude and extent of indirect impacts at the mine site would be the potential deposition of dust over 3,012 acres of vegetation across two watersheds. The dwarf shrub vegetation type comprises 62 percent of this area of indirect impact; open low shrub represents an additional 12 percent (Table 4.26-24). The duration of potential impacts due to dust deposition would be considered long-term.

Table 4.26-24: Alternative 2—Mine Site Fugitive Dust Impact Area

Vegetation Type	Headwaters Koktuli River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
			Acres	Percent Area
Dry to Moist Herbaceous	125	1	127	4
Wet Herbaceous	116	10	126	4
Dwarf Shrub	1,830	41	1,871	62
Open Low Shrub	349	21	370	12
Open Tall Shrub	103	3	106	4
Closed Low Shrub	20	<1	20	1
Closed Tall Shrub	210	5	215	7
Other	176	<1	176	6
Mine Site Indirect Impact Area	**2,930**	**82**	**3,012**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Summer-Only Ferry Operations Variant

Due to a more compact configuration of mine site facilities under adoption of the Summer-Only Ferry Operations Variant, the area of vegetation exposed to the potential deposition of fugitive dust is decreased by 15 acres (Table 4.26-25). The area of indirect impact at the mine site accounting for the expanded container storage yard is dominated by dwarf shrub (62 percent) with the open low shrub type subdominant at 12 percent. The extent and duration of dust deposition under the Summer-Only Ferry Operations Variant would not change from the Alternative 2 base case.

Table 4.26-25: Alternative 2—Mine Site Summer-Only Ferry Operations Variant Fugitive Dust Impact Area

Vegetation Type	Headwaters Koktuli River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
			Acres	Percent Area
Dry to Moist Herbaceous	125	1	126	4
Wet Herbaceous	117	10	127	4
Dwarf Shrub	1,819	41	1,859	62
Open Low Shrub	346	21	368	12
Open Tall Shrub	103	3	106	4
Closed Low Shrub	20	0	20	1
Closed Tall Shrub	210	5	215	7
Other	175	0	175	6
Mine Site Indirect Impact Area	**2,915**	**82**	**2,997**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Other Variants

There would be no change to the magnitude, duration, or extent of indirect impacts to vegetation at the mine site under the Newhalen River North Crossing or Pile-Supported Dock variants.

4.26.8.2 Transportation Corridor

The transportation corridor footprint under Alternative 2 follows the alignment presented under Alternative 1a from the mine site to the Eagle Bay ferry terminal. From the Eagle Bay ferry terminal, it diverges from Alternative 1a with a ferry crossing of Iliamna Lake to a ferry terminal near Pile Bay, and continues along a port access road to the Diamond Point port.

Vegetation Removal

Construction activities in the transportation corridor would require clearing, grading, and removal of vegetation along access roads, ferry terminals, laydown areas, and material sites. Segments of the natural gas pipeline adjacent to access roads are addressed in this section.

The magnitude and extent of direct permanent impacts would be the removal of 896 acres of vegetation across six watersheds (Table 4.26-26). In this area of permanent impact, the open/closed forest (34 percent) is the dominant vegetation type, with subdominant dwarf shrub (31 percent); closed tall shrub and open low shrub represent an additional 11 and 10 percent, respectively. The magnitude and extent of temporary impacts to vegetation would be the disturbance of 428 acres of vegetation across the same six watersheds (Table 4.26-27). Similar to the distribution of permanent impacts among vegetation types, temporary impacts would be highest for open/closed forest (41 percent), with dwarf shrub (26 percent), closed tall shrub (11 percent), and open low shrub (9 percent) impacted to a lesser degree.

Table 4.26-26: Alternative 2—Transportation Corridor Permanent Impact Area

Vegetation Type	Chinitna River-Frontal Cook Inlet (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Iliamna River (Acres)	Newhalen River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
							Acres	Percent Area
Dry to Moist Herbaceous	1	1	1	15	1	8	26	3
Wet Herbaceous	--	<1	<1	3	--	1	4	<1
Dwarf Shrub	<1	12	19	9	87	151	277	31
Open Low Shrub	9	<1	6	15	27	30	86	10
Open Tall Shrub	20	1	<1	15	2	4	41	5
Closed Low Shrub	--	<1	--	8	1	1	10	1
Closed Tall Shrub	31	1	4	39	1	25	102	11
Open/Closed Forest	--	--	110	59	133	<1	302	34
Other	20	--	<1	20	1	5	46	5
Transportation Corridor Permanent Impact Area	**82**	**14**	**141**	**181**	**252**	**225**	**896**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Table 4.26-27: Alternative 2—Transportation Corridor Temporary Impact Area

Vegetation Type	Chinitna River-Frontal Cook Inlet (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Iliamna River (Acres)	Newhalen River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
							Acres	Percent Area
Dry to Moist Herbaceous	1	1	1	5	<1	3	11	3
Wet Herbaceous	--	<1	<1	3	<1	1	4	1
Dwarf Shrub	<1	6	7	4	37	58	113	26
Open Low Shrub	4	<1	2	7	11	12	37	9
Open Tall Shrub	12	<1	<1	6	1	2	22	5
Closed Low Shrub	--	<1	--	1	<1	1	3	1
Closed Tall Shrub	14	<1	2	17	1	14	48	11
Open/Closed Forest	--	--	57	38	82	<1	178	41
Other	9	--	<1	3	1	2	14	3
Transportation Corridor Temporary Impact Area	**40**	**7**	**70**	**84**	**133**	**94**	**428**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Summer-Only Ferry Operations Variant

This variant would increase truck traffic along the transportation corridor during the months of ferry operation to accommodate the movement of a full year of concentrate production, fuel, and consumables. To support year-round shipping of concentrate from Diamond Point port, concentrate containers would be stored at a laydown area along the Williamsport-Pile Bay Road, thereby increasing the magnitude of permanent impacts to vegetation by 22 acres. Construction of the laydown area would result in the permanent loss of 11 acres of sparse to partially vegetated (i.e., other) land and 11 acres of tall shrub types; the percent distribution of permanent impact among vegetation types would be the same as that presented in Table 4.26-26 for the Alternative 2 base case. The magnitude of temporary impacts and extent of direct impacts in the transportation corridor under the Summer-Only Ferry Operations Variant would remain unchanged from the Alternative 2 base case.

Newhalen River North Crossing Variant

In terms of magnitude, the Newhalen River North Crossing Variant would increase permanent impacts to vegetation by 20 acres, and decrease temporary impacts by 1 acre. Specifically, rerouting of the transportation corridor through this alternate bridge location would result in the loss of 19 acres of open/closed forest and 1 acre of dwarf shrub, yet would reduce the temporary impacts to open/closed forest by 1 acre. The percent distribution of permanent and temporary impacts among vegetation types would be the same as those shown in Table 4.26-26 and Table 4.26-27, respectively, for the Alternative 2 base case. The duration and extent of direct impacts in the transportation corridor under the Newhalen River North Crossing Variant would remain unchanged from the Alternative 2 base case.

Pile-Supported Dock Variant

There would be no change to the magnitude, duration, or extent of direct impacts to vegetation in the transportation corridor under the Pile-Supported Dock Variant.

Fugitive Dust

Under Alternative 2, the magnitude and extent of vegetation that would potentially be impacted by dust deposition in the transportation corridor would be 4,424 acres across six watersheds (Table 4.26-28). The duration of these potential impacts would be considered long-term. The open/closed forest vegetation type comprises 41 percent of this area of indirect impact; dwarf shrub is subdominant at 24 percent. Closed tall shrub represents an additional 12 percent cover.

Table 4.26-28: Alternative 2—Transportation Corridor Fugitive Dust Impact Area

Vegetation Type	Chinitna River-Frontal Cook Inlet (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Iliamna River (Acres)	Newhalen River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
							Acres	Percent Area
Dry to Moist Herbaceous	7	5	5	63	5	39	123	3
Wet Herbaceous	2	<1	8	41	11	17	79	2
Dwarf Shrub	1	54	73	38	365	544	1,076	24
Open Low Shrub	37	3	30	78	123	146	417	9
Open Tall Shrub	113	2	1	52	16	32	216	5
Closed Low Shrub	--	<1	<1	17	3	11	31	1
Closed Tall Shrub	180	5	20	179	14	155	552	12
Open/Closed Forest	--	--	584	407	811	4	1,806	41
Other	74	<1	1	19	5	25	124	3
Transportation Corridor Indirect Impact Area	**414**	**69**	**723**	**894**	**1,352**	**971**	**4,424**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Summer-Only Ferry Operations Variant

Construction of a container storage yard to support year-round shipping from the Diamond Point port would increase the magnitude of indirect impacts to vegetation. The area exposed to the potential deposition of fugitive dust would be expanded to include 2 acres of closed tall shrub. The distribution of fugitive dust impacts among vegetation types in the transportation corridor would be the same as that presented in Table 4.26-28 for the Alternative 2 base case. The extent and duration of indirect impact in the transportation corridor would also remain unchanged from the Alternative 2 base case.

Newhalen River North Crossing Variant

Rerouting of the transportation corridor through this alternate bridge location would decrease the magnitude of indirect impacts due to the deposition of fugitive dust by 8 acres. This decrease is distributed among several vegetation types, and is not large enough to change the percent areas of impact presented for the transportation corridor in Table 4.26-28 for the Alternative 2 base case. The extent and duration of indirect impacts in the transportation corridor would also remain unchanged from the Alternative 2 base case.

Pile-Supported Dock Variant

There would be no change to the magnitude, duration, or extent of indirect impacts to vegetation in the transportation corridor under the Pile-Supported Dock Variant.

4.26.8.3 Diamond Point Port

Alternative 2 would include a dock with an earthen fill causeway and sheet pile jetty design placed at Diamond Point, at the juncture of Iliamna and Cottonwood bays. Due to the shallow approach to Diamond Point, dredging would be required at this port location. Dredged material would be stored in two bermed facilities, from which runoff water would be channeled into a sedimentation pond before discharge to Iliamna Bay. Incidental leakage from this storage facility could kill or damage salinity intolerant vegetation. An airstrip would not be constructed at the Diamond Point port. Temporary facilities and reclamation and closure of the site would be the same as Alternative 1a, but would occur at Diamond Point.

Vegetation Removal

Under Alternative 2, 42 acres of vegetation would be permanently impacted, with temporary impacts to an additional 9 acres; impacts would be restricted to the Chinitna River-Frontal Cook Inlet watershed (Table 4.26-29). The open and closed tall shrub vegetation types combined comprise 64 and 67 percent of the areas of permanent and temporary impact, respectively, with dry to moist herbaceous vegetation covering an additional 29 and 18 percent of the areas of permanent and temporary impact, respectively.

Table 4.26-29: Alternative 2—Diamond Point Port Permanent and Temporary Impact Areas

Vegetation Type	Chinitna River-Frontal Cook Inlet			
	Permanent Impact		Temporary Impact	
	Acres	Percent Area	Acres	Percent Area
Dry to Moist Herbaceous	12	29	2	18
Open Tall Shrub	6	14	2	21
Closed Tall Shrub	21	50	4	46
Other	3	7	1	15
Diamond Point Port Impact Area	**42**	**100**	**9**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Variants

There would be no change to the magnitude, duration, or extent of direct impacts to vegetation at the Diamond Point port under the Summer-Only Ferry Operations Variant, Newhalen River North Crossing Variant, or Pile-Supported Dock Variant.

Fugitive Dust

Under Alternative 2, 85 acres of vegetation would be exposed to the potential deposition of fugitive dust (Table 4.26-30). This indirect impact would be considered long-term, and would be restricted to the Chinitna River-Frontal Cook Inlet watershed. Collectively, the closed and open tall shrub vegetation types comprise 66 percent of the area of indirect impact. The dry to moist herbaceous and sparse to partially vegetated (i.e., other) vegetation types represent an additional 18 and 15 percent each, respectively.

Table 4.26-30: Alternative 2—Diamond Point Port Fugitive Dust Impact Area

Vegetation Type	Chinitna River-Frontal Cook Inlet	
	Acres	Percent Area
Dry to Moist Herbaceous	15	18
Wet Herbaceous	1	2
Open Tall Shrub	27	32
Closed Tall Shrub	29	34
Other	12	15
Diamond Point Port Indirect Impact Area	**85**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Variants

There would be no change to the magnitude, duration, or extent of indirect impacts to vegetation at the Diamond Point port under the Summer-Only Ferry Operations Variant, Newhalen River North Crossing Variant, or Pile-Supported Dock Variant.

4.26.8.4 Natural Gas Pipeline Corridor

Under Alternative 2, the natural gas pipeline corridor would cross Cook Inlet to Ursus Cove; continue northward to Diamond Point port; and then follow the port and mine access roads to the mine site. Impacts evaluated here are for the pipeline-only sections of the natural gas pipeline that are not co-located with access roads. Three temporary access roads would be built to install these pipeline-only sections of the pipeline. These access roads would be reclaimed after pipeline installation.

Vegetation Removal

Under Alternative 2, the magnitude and extent of permanent impacts to vegetation would be 300 acres across five watersheds (Table 4.26-31); 93 percent of the vegetation permanently lost would be open/closed forest. Temporary impacts of natural gas pipeline installation would affect 803 acres of vegetation across eight watersheds. Similar to permanent impacts, the area of temporary impact is dominated by open/closed forest (77 percent; Table 4.26-32).

Table 4.26-31: Alternative 2—Natural Gas Pipeline Corridor Permanent Impact Area

Vegetation Type	Chekok Creek (Acres)	Chinitna River-Frontal Cook Inlet (Acres)	Iliamna Lake (Acres)	Pile River (Acres)	Stariski Creek-Frontal Cook Inlet (Acres)	Combined Watershed	
						Acres	Percent Area
Dry to Moist Herbaceous	--	3	--	--	<1	3	1
Wet Herbaceous	--	-	<1	--	--	<1	<1
Dwarf Shrub	--	<1	9	--	--	9	3
Open Low Shrub	1	1	1	--	--	2	1
Open Tall Shrub	--	5	--	--	--	5	2
Closed Low Shrub	--	--	--	--	<1	<1	<1
Closed Tall Shrub	--	2	--	<1	-	2	1
Open/Closed Forest	40	--	185	52	2	278	93
Other	<1	--	<1	--	<1	<1	<1
Natural Gas Pipeline Corridor Permanent Impact Area	**41**	**11**	**194**	**52**	**2**	**300**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Table 4.26-32: Alternative 2—Natural Gas Pipeline Corridor Temporary Impact Area

Vegetation Type	Chekok Creek (Acres)	Chinitna River-Frontal Cook Inlet (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Iliamna River (Acres)	Pile River (Acres)	Stariski Creek-Frontal Cook Inlet (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
									Acres	Percent Area
Dry to Moist Herbaceous	--	16	1	1	<1	--	<1	1	20	3
Wet Herbaceous	--	<1	--	2	<1	<1	--	--	3	<1
Dwarf Shrub	--	7	4	3	--	--	--	13	27	3
Open Low Shrub	1	12	--	11	<1	<1	--	4	27	3
Open Tall Shrub	<1	31	--	4	<1	1	--	2	37	5
Closed Low Shrub	--	1	--	<1	--	--	--	--	1	<1
Closed Tall Shrub	<1	27	--	28	1	<1	--	3	59	7
Open/Closed Forest	25	<1	--	499	49	49	<1	--	622	77
Other	<1	3	--	3	--	--	<1	<1	7	1
Natural Gas Pipeline Corridor Temporary Impact Area	**27**	**97**	**5**	**550**	**50**	**50**	**1**	**23**	**803**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Variants

There would be no change to the magnitude, duration, or extent of direct impacts to vegetation in the natural gas pipeline corridor under the Summer-Only Ferry Operations Variant, Newhalen River North Crossing Variant, or Pile-Supported Dock Variant.

Fugitive Dust

Under Alternative 2, installation of the natural gas pipeline would expose 715 acres of vegetation across four watersheds to the potential deposition of fugitive dust (Table 4.26-33). The duration of these potential impacts would be considered long-term. The open/closed forest vegetation type comprises 85 percent of this area of indirect impact.

Table 4.26-33: Alternative 2—Natural Gas Pipeline Corridor Fugitive Dust Impact Area

Vegetation Type	Chekok Creek (Acres)	Chinitna River-Frontal Cook Inlet (Acres)	Iliamna Lake (Acres)	Pile River (Acres)	Combined Watershed	
					Acres	Percent Area
Dry to Moist Herbaceous	--	11	<1	--	11	1
Wet Herbaceous	--	<1	7	5	13	2
Dwarf Shrub	--	3	4	--	7	1
Open Low Shrub	2	10	11	2	25	3
Open Tall Shrub	<1	15	3	1	20	3
Closed Low Shrub	--	2	--	--	2	<1
Closed Tall Shrub	--	13	7	1	21	3
Open/Closed Forest	47	<1	405	152	605	85
Other	--	6	6	<1	12	2
Natural Gas Pipeline Corridor Indirect Impact Area	**49**	**60**	**443**	**162**	**715**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Variants

There would be no change to the magnitude, duration, or extent of indirect impacts to vegetation in the natural gas pipeline corridor under the Summer-Only Ferry Operations Variant, Newhalen River North Crossing Variant, or Pile-Supported Dock Variant.

4.26.9 Alternative 3—North Road Only

The total direct permanent impact under the Alternative 3 base case would be the removal of 10,018 acres of vegetation, with temporary impacts to an additional 777 acres expected. Regarding indirect impacts, 9,915 acres of vegetation would be exposed to the potential deposition of dust. The Concentrate Pipeline Variant, which would deliver concentrate to a port location north of Diamond Point port, with an option to construct an additional pipeline to return filtrate to the mine site, is the only variant considered under Alternative 3; change in the total acres of direct and indirect impacts due to the incorporation of variants are summarized in Table 4.26-1 and further discussed below.

4.26.9.1 Mine Site

The mine site footprint under Alternative 3 is the same as Alternative 1a, the direct and indirect impacts of which are summarized under Alternative 1a.

Vegetation Removal

Concentrate Pipeline Variant

With adoption of the Concentrate Pipeline Variant, an additional 1 acre of vegetation, dominated by the dwarf shrub type, would be permanently impacted for the construction of a pump house at the mine site.

Fugitive Dust

Concentrate Pipeline Variant

Due to a more compact configuration of mine site facilities under adoption of the Concentrate Pipeline Variant, the area of vegetation exposed to the potential deposition of fugitive dust is decreased by 2 acres. The duration and extent of indirect impacts to vegetation at the mine site under the Concentrate Pipeline Variant would remain the same as the Alternative 3 base case.

4.26.9.2 Transportation Corridor

The Alternative 3 transportation corridor has a north access road from the mine site with a southern crossing of the Newhalen River; from there, it continues to a port location north of Diamond Point on Iliamna Bay.

Vegetation Removal

Construction activities in the transportation corridor would require clearing, grading, and removal of vegetation along access roads, ferry terminals, laydown areas, and water extraction and material sites. Segments of the natural gas pipeline co-located with access roads are addressed in this section.

The magnitude and extent of permanent impacts would be the removal of 1,681 acres of vegetation across eight watersheds (Table 4.26-34). In this area of permanent impact, the open/closed forest (58 percent) is the dominant vegetation type, with dwarf shrub (20 percent) subdominant. The magnitude and extent of temporary impacts to vegetation would be the disturbance of 648 acres of vegetation, also across eight watersheds (Table 4.26-35). Similar to the distribution of permanent impacts among vegetation types, temporary impacts would be highest for open/closed forest (60 percent), with dwarf shrub (16 percent) subdominant.

Table 4.26-34: Alternative 3—Transportation Corridor Permanent Impact Area

Vegetation Type	Chekok Creek (Acres)	Chinitna River-Frontal Cook Inlet (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Iliamna River (Acres)	Newhalen River (Acres)	Pile River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
									Acres	Percent Area
Dry to Moist Herbaceous	--	1	1	2	15	1	--	8	28	2
Wet Herbaceous	--	--	<1	<1	2	<1	<1	2	4	<1
Dwarf Shrub	--	<1	12	21	9	114	--	186	342	20
Open Low Shrub	1	9	<1	11	16	33	--	39	111	7
Open Tall Shrub	<1	18	1	3	15	2	<1	5	45	3
Closed Low Shrub	--	--	<1	<1	5	2	--	1	8	<1
Closed Tall Shrub	<1	32	1	22	38	2	<1	32	128	8
Open/Closed Forest	62	--	--	595	61	177	75	1	971	58
Other	<1	19	--	3	12	3	--	6	44	3
Transportation Corridor Permanent Impact Area	**65**	**81**	**14**	**657**	**173**	**334**	**76**	**281**	**1,681**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Table 4.26-35: Alternative 3—Transportation Corridor Temporary Impact Area

Vegetation Type	Chekok Creek (Acres)	Chinitna River-Frontal Cook Inlet (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Iliamna River (Acres)	Newhalen River (Acres)	Pile River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
									Acres	Percent Area
Dry to Moist Herbaceous	--	1	1	1		<1	--	3	12	2
Wet Herbaceous	--	--	<1	1	2	<1	<1	1	4	1
Dwarf Shrub	--	<1	6	2	4	37	--	57	106	16
Open Low Shrub	<1	4	<1	5	7	11	--	12	40	6
Open Tall Shrub	<1	11	<1	2	6	1	<1	2	22	3
Closed Low Shrub	--	--	<1	<1	1	<1	--	1	3	<1
Closed Tall Shrub	<1	14	<1	14	17	1	<1	13	60	9
Open/Closed Forest	13	--	--	238	40	82	15	<1	388	60
Other	<1	6	--	1	3	1	--	2	13	2
Transportation Corridor Temporary Impact Area	**14**	**37**	**7**	**264**	**85**	**134**	**16**	**92**	**648**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Concentrate Pipeline Variant

This variant would slightly increase the road corridor width due to the co-location of the concentrate pipeline and the optional return water pipeline in a single trench with the natural gas pipeline at the toe of the road embankment. Addition of the concentrate pipeline would increase the average width of the road corridor by less than 10 percent; addition of the concentrate and water return pipelines would increase the average width of the road corridor by less than 3 feet. Because the Alternative 3 base case road width is conceptually engineered to accommodate the concentrate pipeline and optional return water pipeline, there is no change to the magnitude, duration, and extent of direct impacts to vegetation under the Concentrate Pipeline Variant.

Fugitive Dust

Under Alternative 3, the magnitude and extent of vegetation potentially impacted by dust deposition in the transportation corridor would be 6,799 acres across eight watersheds (Table 4.26-36). The open/closed forest vegetation type comprises 59 percent of this area of indirect impact; dwarf shrub represents an additional 15 percent cover. The duration of these potential impacts would be considered long-term.

Table 4.26-36: Alternative 3—Transportation Corridor Fugitive Dust Impact Area

Vegetation Type	Chekok Creek (Acres)	Chinitna River-Frontal Cook Inlet (Acres)	Headwaters Koktuli River (Acres)	Iliamna Lake (Acres)	Iliamna River (Acres)	Newhalen River (Acres)	Pile River (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
									Acres	Percent Area
Dry to Moist Herbaceous	<1	6	5	11	64	5	--	39	130	2
Wet Herbaceous	<1	2	<1	26	38	12	10	19	108	2
Dwarf Shrub	--	1	54	30	38	359	--	534	1,016	15
Open Low Shrub	6	37	3	62	83	126	<1	149	465	7
Open Tall Shrub	1	97	2	26	55	16	2	32	231	3
Closed Low Shrub	--	--	<1	2	17	3	--	11	33	<1
Closed Tall Shrub	2	165	5	125	182	14	1	154	648	10
Open/Closed Forest	138	--	--	2,540	399	815	145	4	4,040	59
Other	<1	69	<1	11	17	5	<1	25	128	2
Transportation Corridor Indirect Impact Area	**147**	**378**	**69**	**2,833**	**892**	**1,355**	**158**	**967**	**6,799**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Concentrate Pipeline Variant

There would be no change to the magnitude, duration, or extent of indirect impacts to vegetation in the transportation corridor under the Concentrate Pipeline Variant.

4.26.9.3 Port

Alternative 3 proposes a caisson dock design at a port site north of Diamond Point on Iliamna Bay. Due to the shallowness of Iliamna Bay, dredging would be required for boats to access the dock at this location. Dredged material would be stored in two bermed facilities, from which runoff would be channeled into a sedimentation pond before discharge to Iliamna Bay. Incidental leakage from this storage facility could degrade salinity-intolerant vegetation. Onshore facilities, temporary facilities, and physical reclamation and closure of the site would be the same as that for Alternative 2, but would occur at this location. An airstrip would not be constructed at the port site under Alternative 3.

Vegetation Removal

Under Alternative 3, 32 acres of vegetation would be permanently impacted, with temporary impacts to an additional 4 acres; impacts would be restricted to the Chinitna River-Frontal Cook Inlet watershed (Table 4.26-37). The closed tall shrub vegetation type comprises 65 and 84 percent of the areas of permanent and temporary impact, respectively.

Table 4.26-37: Alternative 3—Port Permanent and Temporary Impact Areas

Vegetation Type	Chinitna River-Frontal Cook Inlet			
	Permanent		Temporary	
	Acres	Percent Area	Acres	Percent Area
Dwarf Shrub	<1	1	<1	2
Open Low Shrub	<1	1	--	--
Open Tall Shrub	9	29	<1	11
Closed Tall Shrub	21	65	3	84
Other	1	4	<1	3
Port Direct Impact Area	**32**	**100**	**4**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Concentrate Pipeline Variant

There would be no change to the magnitude, duration, or extent of direct impacts to vegetation at the Alternative 3 port under the Concentrate Pipeline Variant.

Fugitive Dust

Under Alternative 3, 35 acres of vegetation would be exposed to the potential deposition of fugitive dust (Table 4.26-38). Similar to the areas of direct impact, the closed tall shrub vegetation type is dominant (85 percent) in the area of indirect impact. The deposition of fugitive dust is considered a long-term impact. The extent of any potential impacts would be restricted to the Chinitna River-Frontal Cook Inlet watershed.

Table 4.26-38: Alternative 3—Port Fugitive Dust Impact Area

Vegetation Type	Chinitna River-Frontal Cook Inlet	
	Acres	Percent Area
Dwarf Shrub	<1	<1
Open Tall Shrub	4	11
Closed Tall Shrub	29	85
Other	1	4
Port Indirect Impact Area	**35**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Concentrate Pipeline Variant

There would be no change to the magnitude, duration, or extent of indirect impacts to vegetation at the Alternative 3 port under the Concentrate Pipeline Variant.

4.26.9.4 Natural Gas Pipeline

The natural gas pipeline corridor under Alternative 3 follows the same general route from the Kenai Peninsula to the mine site as Alternative 2; however, due to greater co-location of the pipeline with the road corridor, many of the impacts associated with installation of the pipeline are evaluated under the Alternative 3 transportation corridor. Furthermore, the three temporary access points described for Alternative 2 would not apply to Alternative 3. Impacts evaluated here are for the pipeline-only sections of the natural gas pipeline that are not co-located with access roads.

Vegetation Removal

Under Alternative 3, the magnitude and extent of permanent impacts to vegetation would be 13 acres across two watersheds (Table 4.26-39). The area of permanent impact is dominated by the open tall shrub types (35 percent), with the dry to moist herbaceous vegetation type subdominant at 26 percent, and the open/closed forest comprising an additional 16 percent of the area. Temporary impacts associated with installation of the natural gas pipeline would affect 125 acres of vegetation across four watersheds (Table 4.26-40). The area of temporary impact is dominated by tall shrub types (50 percent collectively) with dwarf shrub (19 percent), and the dry to moist herbaceous vegetation type (15 percent) subdominant.

Table 4.26-39: Alternative 3—Natural Gas Pipeline Corridor Permanent Impact Area

Vegetation Type	Chinitna River-Frontal Cook Inlet (Acres)	Stariski Creek-Frontal Cook Inlet (Acres)	Combined Watershed	
			Acres	Percent Area
Dry to Moist Herbaceous	3	<1	3	26
Dwarf Shrub	<1	--	<1	4
Open Low Shrub	1	--	1	6
Open Tall Shrub	5	--	5	35
Closed Low Shrub	--	<1	<1	1
Closed Tall Shrub	2		2	13
Open/Closed Forest	--	2	2	16
Other	--	<1	<1	<1
Natural Gas Pipeline Corridor Permanent Impact Area	**11**	**2**	**13**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Table 4.26-40: Alternative 3—Natural Gas Pipeline Corridor Temporary Impact Area

Vegetation Type	Chinitna River-Frontal Cook Inlet (Acres)	Headwaters Koktuli River (Acres)	Stariski Creek-Frontal Cook Inlet (Acres)	Upper Talarik Creek (Acres)	Combined Watershed	
					Acres	Percent Area
Dry to Moist Herbaceous	16	1	<1	1	19	15
Wet Herbaceous	<1	--	--	--	<1	<1
Dwarf Shrub	7	4	--	13	24	19
Open Low Shrub	12	--	--	4	15	12
Open Tall Shrub	31	--	--	2	33	26
Closed Low Shrub	1	--	--	--	1	1
Closed Tall Shrub	27	--	--	3	30	24
Open/Closed Forest	<1	--	<1	--	1	1
Other	2	--	<1	<1	3	2
Natural Gas Pipeline Corridor Temporary Impact Area	**97**	**5**	**1**	**23**	**125**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

Concentrate Pipeline Variant

There would be no change to the magnitude, duration, or extent of direct or indirect impacts to vegetation in the natural gas pipeline corridor under the Concentrate Pipeline Variant.

Fugitive Dust

Under Alternative 3, installation of the natural gas pipeline would expose 60 acres of vegetation to the potential deposition of fugitive dust (Table 4.26-41). The duration of these potential impacts would be considered long-term, and the extent of impacts would be restricted to the Chinitna River-Frontal Cook Inlet watershed. The area of indirect impact is dominated by tall shrub types (47 percent collectively), with open low shrub and the dry to moist herbaceous vegetation type representing an additional 16 and 17 percent of the area, respectively. Sparsely to partially vegetated land (i.e., 'other') represents 10 percent of the area of indirect impact.

Table 4.26-41: Alternative 3—Natural Gas Pipeline Corridor Fugitive Dust Impact Area

Vegetation Type	Chinitna River-Frontal Cook Inlet (Acres)	Combined Watershed	
		Acres	Percent Area
Dry to Moist Herbaceous	11	11	17
Wet Herbaceous	<1	<1	<1
Dwarf Shrub	3	3	5
Open Low Shrub	10	10	16
Open Tall Shrub	15	15	25
Closed Low Shrub	2	2	4
Closed Tall Shrub	13	13	22
Open/Closed Forest	<1	<1	1
Other	6	6	10
Natural Gas Pipeline Corridor Indirect Impact Area	**60**	**60**	**100**

Sources: HDR and Three Parameters Plus 2011a; HDR 2019i; Three Parameters Plus and HDR 2011a

4.26.10 Invasive Species

Project activities, especially those involving the movement of goods and people, could result in the introduction and spread of invasive species in the analysis area. All taxa of invasive species with documented potential to establish in the analysis area (e.g., terrestrial and freshwater plants, marine and terrestrial animals) are addressed in this section.

PLP has prepared an ISMP (Owl Ridge 2019d) to prevent, minimize, and control the introduction and spread of invasive plants during all project phases. The plan, if implemented, would reduce the likelihood of adverse impacts from non-native species. The ISMP makes recommendations towards the prevention and minimization of invasive terrestrial vascular plant species introductions related to project activities, as well as recommendations for the management and control of any future infestations in the project area. Specifically, the plan recommends operational and behavioral methods to prevent the introduction of non-native plant propagules; encourages monitoring for non-native species so that populations do not reach sizes at which their control is no longer efficient or economic; and prioritizes treatment and sets management goals for the control of non-native species based on species invasiveness, population size, and infestation location. Although the plan does not specifically address aquatic plants, terrestrial animals, marine species, or insects, the principles of early detection and rapid response can be applied to all taxa. If implemented, the plan would be revised annually and updated as needed to meet its goals and relevance to project operations; aquatic, marine, and terrestrial species could be added to the plan during these annual revisions (Owl Ridge 2019d) (see Chapter 5, Mitigation).

A single population of the non-native terrestrial plant, lambsquarters (*Chenopodium album*), has been documented in the analysis area; this is a historical (pre-1950) record, and it is not known if the population still exists (ACCS 2018b). The infestation, if still present, would affect Alternative 2 and Alternative 3 near the Diamond Point port. Lambsquarters is considered very weakly invasive; and in Alaska, is rarely observed outside disturbed areas, has little to no effect on native plant communities, and likely has no measurable impact to ecosystem processes (lambsquarters species biography) (ACCS 2011a).

Eighteen additional invasive terrestrial plant species with the potential to occur in the analysis area include (listed in decreasing order of invasiveness rank):

- Reed canarygrass (*Phalaris arundinacea*)
- orange hawkweed (*Hieracium aurantiacum*)
- creeping buttercup (*Ranunculus repens*)
- foxtail barley (*Hordeum jubatum*)
- smooth brome (*Bromus inermis*)
- oxeye daisy (*Leucanthemum vulgare*)
- white clover (*Trifolium repens*)
- common dandelion (*Taraxacum officinale*)
- timothy (*Phleum pretense*)
- Kentucky bluegrass (*Poa pratensis*)
- fall dandelion (*Leontodon autumnalis*)
- common sheep sorrel (*Rumex acetosella*)
- redroot pigweed (*Amaranthus retroflexus*)
- prostrate knotweed (*Polygonum aviculare*)
- common plantain (*Plantago major*)
- common chickweed (*Stellaria media*)
- shepherd’s purse (*Capsella bursa-pastoris*)
- pineapple weed (*Matricaria discoidea*)

Although most of these species are considered moderate to very weakly invasive, the potential introduction of extremely invasive reed canarygrass or orange hawkweed to the project area would carry high ecological risk. Reed canarygrass is a known invader of wetland habitat, where it forms dense monocultures that increase siltation and alter hydrology (ACCS 2011b). Once established, it is extremely difficult to eradicate. Orange hawkweed also establishes as dense monocultures at the expense of native plants. It is one of the few invasive plants in Alaska able to establish in organic soils and subalpine habitats, and therefore has the potential to invade a niche unavailable to most non-natives in Alaska (ACCS 2011c). Under metrics set forth in the ISMP (Owl Ridge 2019d), both reed canarygrass and orange hawkweed are high-priority (Priority 1) species for treatment; all other plant species detected in proximity to the analysis area are categorized in the lowest priority level (Priority 3) for treatment.

No freshwater aquatic invasive species are documented in the analysis area; however, waterweed (*Elodea* spp.) is a species of statewide concern due to its ability to reproduce vegetatively, its capacity to survive freezing and brackish water, and potential for long-range dispersal via boat and floatplane. Once established, waterweed forms dense monocultures that displace native flora and alter freshwater habitats by decreasing flow and increasing sedimentation (ACCS 2011d; Nawrocki et al. 2011). Such impacts have been shown to degrade habitat for waterfowl and freshwater fish, and reduce floatplane travel (Schwoerer 2017).

Invasive marine species have not been documented in the analysis area; however, the carpet sea squirt (*Didemnum vexillum*) and the European green crab (*Carcinus maenas*) are present in ecologically similar regions of Alaska and are species of statewide concern. The carpet sea squirt drastically modifies invaded habitats through the rapid and smothering overgrowth of native sessile species. The species has also demonstrated high niche plasticity. If introduced to project waters, the carpet sea squirt could have significant negative impact to native species and a variety of marine habitats, as well as the mariculture industry and shellfish and groundfish fisheries (Bullard et al. 2007).

The European green crab feeds on rockweed species (*Fucus* spp.), which are abundant and widely distributed along the Alaska coast, smaller native shore crabs, mussels, and oysters; it also outcompetes the native Dungeness crab for food and habitat (McDonald et al. 2001). If introduced to project waters, it is expected to have negative impacts on marine habitat, food webs, and local commercial, personal use, and subsistence fisheries (Klassen and Locke 2007; Therriault et al. 2008).

Terrestrial vertebrate species have not been documented from the project area; however, the Norway rat (*Rattus norvegicus*) is a species of high concern due to damaging effect in neighboring ecosystems. Norway rats have high reproductive capacity and are opportunistic feeders capable of large effect on a variety of wildlife populations. Rats may also carry parasites, pathogens, and diseases that can be harmful to other species. In the Aleutian Archipelago, seabird colonies have suffered significant losses due to predation by rats (Buckelew et al. 2011). Most rat infestations in Alaska have resulted from rats escaping from ships while in port (USFWS 2007).The magnitude of impacts from the introduction or spread of additional invasive species would be measured by population size or infested area, the relative invasiveness of the species, and infestation location. Although difficult to quantify, the magnitude of potential invasive species introductions are expected to vary among action alternatives as the routings differ in their proportions of habitat susceptible to the establishment of non-native species. For example, alternatives intersecting the shallow marine environments at Diamond Point port or the shallow island environment at the northeastern end of Iliamna Lake present greater opportunity for the establishment of marine and freshwater aquatic invasive species (e.g., waterweed, European green crab) that exploit these littoral habitats. With regard to the potential introduction of terrestrial invasive plant species, alternatives with longer road lengths and more stream crossings would be more susceptible to infestation by non-native plant species adapted to roadside or riparian environments. Sweetclover (*Melilotus alba*) is a particularly effective competitor in fine-grained, disturbed mineral soils such as those found along gravel roadsides and river bars (Conn et al. 2008), and reed canarygrass (*Phalaris arundinacea*) is one of the most aggressive invaders of riparian habitat in Alaska (Lavergne and Molofsky 2004). Vehicles traveling along the transportation corridor could act to spread any roadside populations of invasive plant species. Although not considered sources of introduction, because they would be constructed on site, vessels operating in Iliamna Lake could disperse aquatic invasive species. The risk of introduction and spread of invasive species would remain post-closure due to monitoring activities. The duration of impacts could span the life of the project and continue after closure if invasive species established during the life of the project were not adequately controlled.

4.26.11 Cumulative Effects

Cumulative effects are the interactive, synergistic, or additive effects that would result from the incremental impact of the action, together with other past, present, and reasonably foreseeable future actions (RFFAs). Impacts to vegetation would include the direct impacts of vegetation removal and the potential for elimination of rare or sensitive plant species and habitat, and the indirect impacts of fugitive dust deposition and the potential introduction and spread of invasive species. The cumulative effects analysis area for vegetation is the maximum geographic extent of the footprint of the project, including all alternatives and variants, the Pebble Project expansion (including road, pipeline, and port facilities), and the area where direct and indirect effects to vegetation can be expected from project construction and operations, as well as any other past, present, and RFFAs that are in the vicinity of, and have the potential to contribute to the impacts of the project (see Figure 4.1-1 in Section 4.1, Introduction to Environmental Consequences, for an inset of the Pebble Project expansion).

Past, present, and RFFAs identified for the cumulative impact analysis area are detailed in Section 4.1, Introduction to Environmental Consequences. Not all RFFAs are considered to have potential for cumulatively impacting vegetation. Offshore-based developments, including oil and gas lease sales and non-industrialized, point-source activities, are unlikely to result in impacts beyond a temporary basis (e.g., tourism, recreation, fishing, and hunting). Other RFFAs removed from further consideration include those sufficiently distant from the analysis area to preclude the efficient co-use of infrastructure by other parties.

4.26.11.1Past and Present Actions

Past and present actions that have affected or are currently affecting vegetation in the analysis area are minimal, because most vegetation in the area is undisturbed and in pristine condition. Past activities include limited infrastructure development, mining and oil and gas exploration, and small areas of residential development. Present activities, such as infrastructure and mining exploration projects currently have minimal impacts on vegetation. These impacts include vegetation removal and dust deposition, and may result in the undocumented elimination of rare or sensitive species or the introduction or spread of invasive species. Although these actions affect localized areas, they are additive to other vegetation-disturbing actions, thereby increasing the total acreage affected, and reducing the ecological functions that intact vegetation communities provide. Ground-disturbing actions are additive to dust impacts insofar that the more dust is produced, the more vegetation is potentially subject to dust deposition. Similarly, the movement of goods and people increase the likelihood of invasive species introduction and spread, with consequences for plant community species composition.

4.26.11.2Reasonably Foreseeable Future Actions

RFFAs that could contribute cumulatively to known and projected impacts to vegetation in the analysis area were advanced for consideration. The following RFFAs, identified in Section 4.1, Introduction to Environmental Consequences, are included: Pebble Project expansion scenario, mining exploration activities for Pebble South/PEB, Big Chunk South, Big Chunk North, Fog Lake, and Groundhog mineral prospects; onshore oil and gas development; Lake and Peninsula/Kenai Peninsula Transportation and Community Infrastructure, including the potential Kaskanak Road, other road improvements, and the continued development of the Diamond Point rock quarry.

These projects are anticipated to include vegetation removal, dust deposition, and increased risk of invasive plant species introduction and spread. These actions would result in a net loss of vegetation, and likely precipitate changes in plant community composition, structure, and function.

Mineral exploration is likely to continue in the analysis area for the Pebble South/PEB, Big Chunk South, Big Chunk North, Fog Lake, and Groundhog projects (all based out of Iliamna). These exploration activities would include summer borehole drilling and temporary camp facilities that would result in limited vegetation removal related to core sampling and placement of facilities. Movement of personnel and equipment into these remote areas would increase the likelihood of introduction of invasive species. Ground-disturbing activities would increase the susceptibility of habitats to establishment of invasive terrestrial plant species and travel along gravel roads would be expected to increase dust deposition on vegetation, and potentially increase the spread of invasive plant species. Impacts to vegetation are expected to be temporary; limited in extent to the project footprint, except in the case of invasive species, which could spread beyond the footprint; and limited in magnitude, because not much activity would be expected.

Anticipated road improvement projects in the region include new transportation corridors currently being studied in the Lake and Peninsula Borough (LPB), such as the Williamsport-Pile Bay Road upgrade, Nondalton-Iliamna River Road corridor and bridge, and Kaskanak Road/Cook Inlet to Bristol Bay. The strategic plan for Iliamna includes a road connection to all villages in the lake area for safer travel. As discussed previously, roads affect vegetation through the direct removal of vegetation, and indirectly through dust deposition and increased likelihood of introduction and spread of invasive terrestrial plant species. Although BMPs can reduce the risks of invasive species introduction and spread, the potential for impacts remains as long as roads are in operation.

The cumulative effects from past, present, and RFFAs are expected to be consistent across project alternatives, except for the Pebble Project expansion scenario. This development scenario would involve expansion of the mine site, and construction of a concentrate pipeline and transportation corridor from the existing mine access road to a new deepwater port at Iniskin Bay; details of the Pebble Project expansion are given in Section 4.1, Introduction to Environmental Consequences. Although expansion of the mine site and development of the Iniskin Bay port would be the same for all alternatives, the length of the transportation and concentrate pipeline corridor varies by alternative due to the extent to which development could use existing infrastructure. Because Alternative 2 would include a northern access road and ferry and natural gas pipeline along the same corridors that would be used under mine expansion, further development would only require construction of a short (8-mile) road and pipeline segment from Williamsport east to Iniskin Bay. Therefore, cumulative effects to vegetation are least for this alternative. Alternatively, cumulative effects to vegetation would be greatest under Alternative 1, because this alternative would include development of transportation and natural gas pipeline corridors separate from the alignment that is proposed for Pebble Project expansion, and would therefore require construction of a longer (76-mile) concentrate pipeline and transportation corridor.

A summary of impacts associated with the Pebble Project and mine expansion scenario is provided in Table 4.26-42. Under mine expansion, cumulative direct and indirect impacts to vegetation are highest under Alternative 1 (55,243 acres) and lowest under Alternative 2 (53,897 acres). The No Action Alternative would not contribute to cumulative effects on vegetation, and is not evaluated here. Although expansion of the mine site and development of the Iniskin Bay port would be the same for all alternatives, the length of the transportation and concentrate pipeline corridor varies by alternative due to the extent to which development could use existing infrastructure. Because Alternative 2 would have a northern access road, ferry route, and natural gas pipeline along the same corridor that would likely be used under the Pebble Project expansion, further development would only require construction of a short (8-mile) road and pipeline segment from Williamsport to Iniskin Bay. Alternatively, cumulative effects to vegetation would be greatest under Alternative 1, because this alternative would develop transportation and natural gas pipeline corridors separate from the alignment that would be used for expanded development, and would therefore require construction of a longer (76-mile) concentrate pipeline and transportation corridor.

Because project-specific base maps for vegetation have not been produced for the alignment of the concentrate pipeline, transportation corridor, and Iniskin Bay port that are proposed under mine expansion, the areas of impact given for this corridor and port should be considered estimates and used for comparison purposes only. Regardless of alternative, the expanded mine scenario would increase the area of vegetation lost or altered, impacts that would be additive to those of the project. Although expansion of the mine would result in impacts to vegetation across multiple watersheds, the Headwaters Koktuli River and UTC watersheds would experience the greatest magnitude of impact. In these watersheds, direct and indirect impacts to vegetation would increase from 4 to 17 percent under mine expansion[3]. A summary of cumulative effects on vegetation is presented by project alternative for all RFFAs in Table 4.26-43.

Table 4.26-42: Summary of Cumulative Impacts to Vegetation under the Pebble Project and the Project Expansion Scenarios

	Impact	Alternative 1a	Alternative 1	Alternative 2	Alternative 3
All Project Components (Acres)					
Project	Permanent	9,504	9,482	9,637	10,081
	Temporary	822	671	1,241	777
	Indirect	9,159	9,295	8,236	9,915
Expansion	Permanent	30,047	30,584	29,572	29,142
	Temporary	67	67	67	67
	Indirect	5,144	5,144	5,144	5,144
Cumulative	Permanent	39,551	40,066	39,209	39,223
	Temporary	889	738	1,308	844
	Indirect	14,303	14,439	13,380	15,059
Mine Site (Acres)					
Project	Permanent	8,292	8,292	8,399	8,292
	Temporary	1	1	1	1
	Indirect	3,022	3,022	3,012	3,024
Expansion	Permanent	29,007	29,007	29,007	29,007
	Temporary	-	-	-	-
	Indirect	4,397	4,397	4,397	4,397
Transportation (Acres)					
Project	Permanent	1,188	1,165	896	1,681
	Temporary	594	602	428	648
	Indirect	6,053	6,189	4,424	6,799

[3] Although total areas of direct and indirect impacts are different among alternatives for the proposed project and mine expansion, the variability among totals is not large enough to produce different percentages with respect to the watersheds impacted.

Table 4.26-42: Summary of Cumulative Impacts to Vegetation under the Pebble Project and the Project Expansion Scenarios

	Impact	Alternative 1a	Alternative 1	Alternative 2	Alternative 3
Port (Acres)					
Project	Permanent	21	22	42	32
	Temporary	7	7	9	4
	Indirect	84	84	85	35
Natural Gas Pipeline (Acres)					
Project	Permanent	2	2	300	13
	Temporary	220	62	803	125
	Indirect	-	-	715	60
Concentrate Pipeline/Transportation (Acres)					
Expansion	Permanent	1,007	1,544	532	102
	Temporary	61	61	61	61
	Indirect	682	682	682	682
Iniskin Bay Port					
Expansion	Permanent	33	33	33	33
	Temporary	6	6	6	6
	Indirect	65	65	65	65

Note:
Project-specific landcover mapping is not available for the full extent of the expanded mine development scenario. Therefore, the acreages provided above for the concentrate pipeline/transportation corridor and the Iniskin Bay port include impacts to vegetation and open water.

Table 4.26-43: Contribution to Cumulative Effects on Vegetation

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Pebble Mine Expansion Scenario	**Mine Site**: Under the Pebble Project expansion scenario, the mine site footprint would be larger due to a larger open pit and new facilities to manage water and store tailings and waste rock. Pebble Project expansion would increase the amount of vegetation removed, fugitive dust generated, and likelihood of invasive species introduced or spread; impacts would be additive to those of the project, and would expand the extent of impacts in the UTC watershed. At the mine site, an additional 21,240 acres of vegetation would be removed. It is assumed that the vegetation types affected would be similar to those affected by the project (dwarf and open low shrub). **Other Facilities**: Under the Pebble Project expansion scenario, a north access road corridor would be constructed from the Eagle Bay ferry terminal, along the proposed Alternative 3 road alignment, and then extended to Iniskin Bay; new concentrate and diesel pipelines would be constructed from the mine site to Iniskin Bay along this same alignment. Development of these facilities would permanently impact an additional 1,040 acres. It is assumed that the vegetation types affected would be similar to those affected by the project in the Alternative 3 transportation and natural gas pipeline corridor (open/closed forest and dwarf shrub). **Magnitude**: The Pebble Project expansion scenario for Alternative 1a would permanently impact a total of 22,280 additional acres. **Duration**: The duration of cumulative impacts to vegetation would vary from temporary disturbance during construction to permanent removal of vegetation within the footprint of the mine and other project facilities. The duration of impacts would be extended as processing of low-grade ore and PAG waste material would continue for 20 to 40 years past the end of mining. This would delay the reclamation of vegetation	**Mine Site**: Identical to Alternative 1a. **Other Facilities**: Pebble Project expansion scenario under Alternative 1 is similar to Alternative 1a, except that the portion of the access road from the Eagle Bay ferry terminal to the existing Iliamna area road system would not already be constructed. The north access road would be extended east from the Eagle Bay ferry terminal to the Pile Bay terminus of the Williamsport-Pile Bay Road. Concentrate and diesel pipelines would be constructed along the proposed Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. **Magnitude**: Pebble Project expansion under Alternative 1 would permanently impact a total of 22,817 acres, slightly more acreage than Alternative 1a. **Duration/Extent**: The duration/extent of cumulative impacts to	**Mine Site**: Identical to Alternative 1a. **Other Facilities**: The north access road would be extended east from the Eagle Bay ferry terminal to the Pile Bay terminus of the Williamsport-Pile Bay Road. Concentrate and diesel pipelines would be constructed along the proposed Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. Because the natural gas pipeline and portions of the road would already exist under Alternative 2, the acres of disturbance resulting from the Pebble Project expansion would be fewer than those impacted under Alternative 1a. **Magnitude**: Pebble Project expansion under Alternative 2 would permanently impact a total of 21,699 acres, less acreage than Alternative 1a. **Duration/Extent**: The duration of impacts would be similar to the	**Mine Site**: Identical to Alternative 1a. **Other Facilities:** Overall expansion would use the existing north access road. Concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay. Because the natural gas pipeline and most of the road would already exist under Alternative 3, the amount of additional disturbance resulting from the Pebble Project expansion scenario would be less than all other alternatives. **Magnitude**: Pebble Project expansion under Alternative 3 would permanently impact a total of 21,375 acres, Alternative 1a, which would be less than all other alternatives. **Duration/Extent**: The duration of impacts would be similar to Alternative 1a, although affecting fewer acres. **Contribution**: The contribution to

Table 4.26-43: Contribution to Cumulative Effects on Vegetation

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	affected by the low-grade ore and PAG material storage areas, thereby extending the duration of long-term impacts from dust deposition and risk of invasive species introduction and spread. **Extent:** The extent of impacts would be limited to the immediate vicinity of the disturbance footprint, except in the case of invasive species, which could spread beyond this footprint of direct disturbance. **Contribution:** Pebble Project expansion would impact vegetation through direct removal, deposition of dust, and increased potential for invasive species introduction and spread. These actions would be expected to contribute to the permanent loss of vegetation, reduction of ecological function, and changes in species composition. The contribution to cumulative effects is expected to be greater under Alternative 1a and Alternative 1, because expansion of these two alternatives would require the construction of separate transportation/pipeline corridor, and then concurrent use of the two corridors through the operational life of the mine. The extended duration of direct impacts contributes to cumulative effects insofar that it increases the likelihood of invasive species introduction and spread, as well as the magnitude, duration, and extent; and duration of indirect impacts related to fugitive dust and invasive species.	vegetation would be similar to Alternative 1a, although affecting more acres. **Contribution**: The contribution to cumulative effects would be similar to Alternative 1a, although affecting the most acres of any alternative.	Applicant's Proposed Alternative, although affecting fewer acres. **Contribution**: The contribution to cumulative impacts would be similar to Alternative 1a, although affecting fewer acres.	cumulative impacts would be similar to Alternative 1a, although affecting the least acres of any alternative.
Other Mineral Exploration Projects	**Magnitude**: Mining exploration activities, including additional borehole drilling, road and pad construction, and development of temporary camp facilities, would result in adverse effects to vegetation; however, this added impact would be limited in extent and localized to the disturbing action. For example, the 2018 drilling program proposed by PLP consisted of 61 geotechnical boreholes and 19 diamond-drilled core boreholes with diameters ranging from 2 to 8 inches.	Similar to Alternative 1a.	Similar to Alternative 1a.	Similar to Alternative 1a.

Table 4.26-43: Contribution to Cumulative Effects on Vegetation

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Duration/Extent: Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. Table 4.1-1 identifies seven mineral prospects where exploratory drilling is anticipated (four of which are in proximity of the Pebble Project). Because permit requirements typically stipulate site reclamation, the duration of some portion of these actions would be considered temporary. **Contribution**: Other mineral exploration would contribute to cumulative effects on vegetation through direct removal, deposition of dust, and increased potential for invasive species introduction and spread. These actions would be expected to contribute to the permanent loss of vegetation, reduction of ecological function, and changes in species composition.			
Oil and Gas Exploration and Development	**Magnitude**. Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration; and in limited cases, drilling. Seismic exploration would involve overland activities, with permit conditions stipulating the avoidance and minimization of disturbance to vegetation. Should it occur, exploratory drilling would involve the construction of temporary pads and support facilities, with permit conditions to minimize impacts to vegetation and restore drill sites after exploration activities have ceased. **Duration/Extent**: Seismic exploration and exploratory drilling are typically single-season, temporary activities. The 2013 BBAP amended plan shows 13 oil and gas wells drilled on the western Alaska Peninsula, and a cluster of three wells near Iniskin Bay. It is possible that additional seismic testing and exploratory drilling could occur in the analysis area; however, based on historic activity, it is not expected to be intensive. Because permit requirements typically stipulate site reclamation,	Similar to Alternative 1a.	Similar to Alternative 1a.	Similar to Alternative 1a.

Table 4.26-43: Contribution to Cumulative Effects on Vegetation

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	the duration of some portion of these actions would be considered temporary. **Contribution**: Onshore oil and gas exploration activities would contribute to cumulative effects on vegetation through direct removal, deposition of dust, and increased potential for invasive species introduction and spread. These actions would be expected to contribute to the permanent loss of vegetation, reduction of ecological function, and changes in species composition.			
Road Improvement and Community Development Projects	**Magnitude**: Road improvement projects would require grading and filling, which would increase the generation of fugitive dust and the risk of invasive species introduction and spread. Road improvements in the communities of Iliamna, Newhalen, and Kokhanok would make the greatest contribution to cumulative effects. Limited road upgrades could also occur in the vicinity of the natural gas pipeline starting point near Stariski Creek, or in support of the mineral exploration previously discussed. The expansion of Diamond Point rock quarry would disturb 140 acres (ADNR 2014a) and has potential to adversely affect vegetation. The vegetation types affected are expected to be similar to those documented in the Diamond Point port analysis area for Alternative 2 and Alternative 3. **Duration/Extent**: Disturbance from road construction would typically occur over a single season, whereas development of the Diamond Point quarry is expected to last several years. Impacts to vegetation in the direct disturbance footprint of these projects would be permanent; construction-related impacts outside the footprint of direct disturbance are expected to be temporary; deposition of fugitive dust on vegetation would be long-term. Extent would be limited to the vicinity of communities and Diamond Point.	Similar to Alternative 1a; with greater impacts than Alternative 2 and Alternative 3.	The footprint of the Diamond Point rock quarry coincides with the Diamond Point port location for Alternative 2 and Alternative 3. Cumulative impacts under Alternative 2 would likely be less than Alternative 1a and Alternative 1 due to overlap between the Diamond Point port and rock quarry.	Similar to Alternative 2; less than Alternative 1a and Alternative 1.

Table 4.26-43: Contribution to Cumulative Effects on Vegetation

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Contribution: Road improvements would contribute to cumulative effects on vegetation through direct removal, deposition of dust, and increased potential for invasive species introduction and spread. These actions would be expected to contribute to the permanent loss of vegetation, reduction of ecological function, and changes in species composition.			
Summary of Project contribution to Cumulative Effects	Overall, the contribution of Alternative 1a to cumulative effects on vegetation, when taking other past, present, and RFFAs into account, would impact an estimated 0.8 percent of watersheds intersecting the Pebble Project expansion footprint.	Similar to Alternative 1a, although slightly more acres would be impacted by Pebble Project expansion.	Similar to Alternative 1a, although fewer acres would be impacted by Pebble Project expansion.	Similar to Alternative 2, although slightly fewer acres would be impacted by Pebble Project expansion.

Notes:
Percent vegetation impacted by watershed is calculated as the cumulative acres of vegetation directly and indirectly impacted under a given alternative and mine expansion, relative to the combined area HUC 10 watersheds intersected by the proposed project and mine expansion. The Cook Inlet watershed is not included because it supports minimal vegetation. Because the total area of other HUC 10 watersheds includes open water, the percent of vegetation impacted by watershed is likely underestimated.
BBAP = Bristol Bay Area Plan
PAG = potentially acid-generating
PLP = Pebble Limited Partnership
RFFA = reasonably foreseeable future action
UTC = Upper Talarik Creek

4.27 SPILL RISK

This section addresses the spill risk for diesel fuel, natural gas, copper-gold concentrate, chemical reagents, bulk and pyritic tailings, and untreated contact water. The substances analyzed do not include all of the hazardous materials that would be used for the project. A list of hazardous materials that would be used by the project is provided in Appendix K2 under "Mine Site Supplies and Quantities."

Substances analyzed in this section were selected based on their spill potential (probability) and potential impacts (consequences). Probability and consequences are analyzed and addressed separately throughout the section.

Because the potential spill scenarios addressed are hypothetical, this section cannot provide the same level of quantitative impacts analysis as is provided in other sections of the EIS. Quantitative analysis (modeling) is provided for the release scenarios of tailings and untreated contact water.

The "Fate and Behavior" subsections address the probable outcomes that would result from a release into the environment, considering a wide range of potential spill circumstances. The "Historical Data" subsections review data on past spills, where available, including probabilities and consequences. The "Existing Response Capacity" subsections list any organizations or plans that may be available as resources in the event of a spill. The "Mitigation" subsections address design features or practices that would reduce the likelihood of a spill, and/or minimize potential impacts in the event of a spill. The "Scenario" subsections describe seven hypothetical spill scenarios that were selected for impacts analysis, including spill response. The "Potential Impacts" subsections address potential impacts from each of the spill scenarios. Impacts assessments assumed that the spill response as outlined in each scenario would be followed.

4.27.1 Alternatives Analysis

For most of the spill scenarios analyzed in this section, the potential impacts would be similar across all alternatives. Where there is significant variation across alternatives, individual alternatives are addressed as relevant, such as the Diamond Point port alternative, and the Alternative 3—North Road Only transportation corridor, which eliminates the potential for spills from the ferry into Iliamna Lake. Table 4.27-1 summarizes the variation in spill risk across all alternatives.

Table 4.27-1: Summary of Spill Risk by Alternative

Spill Scenarios	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Diesel Spill from Tanker Truck Rollover	Spill risk as analyzed herein for 72 miles of road transport.	Spill risk similar to Alternative 1a, with 65 miles of road transport.	Similar to Alternative 1a, with fewer miles of road transport (53 miles).	The transport of diesel by road under Alternative 3 eliminates the potential for spills of diesel from the ferry into Iliamna Lake. Otherwise, there is a similar/slightly higher diesel spill risk from trucking compared to Alternative 1a, with slightly increased miles of road transport (82 miles) and possibly steeper grades on some road segments.

Table 4.27-1: Summary of Spill Risk by Alternative

Spill Scenarios	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Diesel Spill from Marine Tug-Barge Allision	Spill risk as analyzed in this section.	Same spill risk as Alternative 1a.	The Diamond Point port site generally has thicker sea ice in higher concentrations for longer periods than the Amakdedori port site. The Diamond Point port area has additional biological resources that could be impacted by a spill, compared to Amakdedori.	The Diamond Point port site generally has thicker sea ice in higher concentrations for longer periods than the Amakdedori port site. The Diamond Point port area has additional biological resources that could be impacted by a spill, compared to Amakdedori.
Natural Gas Releases from Pipeline	Spill risk as analyzed in this section.	Same spill risk as Alternative 1a.	The transport of natural gas by overland pipeline from the port eliminates the potential for gas releases into Iliamna Lake.	The transport of natural gas by overland pipeline from the port eliminates the potential for gas releases into Iliamna Lake.
Concentrate Spill from a Truck Rollover	Spill risk as assessed herein for 72 miles of road transport.	Spill risk similar to Alternative 1a, with 65 miles of road transport.	Similar to Alternative 1a, with fewer miles of road transport (53 miles).	The transport of concentrate by road under Alternative 3 eliminates the potential for concentrate spills from the ferry into Iliamna Lake. Otherwise, there is a similar/slightly higher concentrate spill risk from trucking compared to Alternative 1a, with increased miles of road transport (82 miles) and possibly steeper grades on some road segments.
Concentrate Slurry Pipeline Rupture	No concentrate pipeline for Alternative 1a.	No concentrate pipeline for Alternative 1.	No concentrate pipeline for Alternative 2.	The transport of concentrate by road or pipeline under Alternative 3 eliminates the potential for concentrate spills from the ferry into Iliamna Lake. Under the Alternative 3 Concentrate Pipeline Variant return water pipeline option, there would be an additional potential for spills of untreated contact water from the return water pipeline.

Table 4.27-1: Summary of Spill Risk by Alternative

Spill Scenarios	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Reagent Spills	Different ferry routes across Iliamna Lake may have different navigational challenges.	Different ferry routes across Iliamna Lake may have different navigational challenges.	Different ferry routes across Iliamna Lake may have different navigational challenges. If two ferry vessels are needed for summer-only ferry operations, increased ferry traffic could increase the risk of vessel collisions that could result in spills.	The transport of reagents by road under Alternative 3 eliminates the potential for reagent spills from ferry into Iliamna Lake.
Bulk Tailings Delivery Pipeline Rupture	Spill risk as analyzed in this section.	Same spill risk as Alternative 1a.	Centerline versus downstream dam designs may have different spill risk, although built to same FoS (dam design not relevant to scenario).	Same spill risk as Alternative 1a.
Pyritic Tailings South Embankment Release into the SFK	No variation in spill risk across alternatives.	No variation in spill risk across alternatives.	No variation in spill risk across alternatives.	No variation in spill risk across alternatives.
Untreated Contact Water Release Scenario	No variation in spill risk across alternatives.	No variation in spill risk across alternatives.	No variation in spill risk across alternatives.	No variation in spill risk across alternatives.

Notes:
FoS = Factor of Safety
SFK = South Fork Koktuli

4.27.2 Spills Impact Analysis Areas—Affected Environment

The geographic extent of potential impacts of four of the spill scenarios extends beyond the Environmental Impact Statement (EIS) analysis area for other potential impacts analyzed in the EIS. The affected environment for these extended analysis areas is described here for surface water, water and sediment quality, and biological resources.

4.27.2.1 Affected Environment of the Analysis Area for the Diesel Spill from a Marine Tug-Barge in Lower Cook Inlet

The analysis area for the marine tug-barge diesel spill scenario extends from Kamishak Bay across Lower Cook Inlet and northern Shelikof Strait to the shores of Shuyak and Afognak islands, and Cape Douglas.

Surface Water

General surface water conditions, meteorology, and oceanography characteristics in the marine environment of Kamishak Bay and northern Shelikof Strait are comparable to those described for

Lower Cook Inlet in Section 3.16, Surface Water Hydrology. The area has high exposure to wind, often resulting in strong wave action. Wave climate, tides, currents, and storm surge conditions vary widely across the analysis area, depending on local geography, bathymetry, etc. Sea ice conditions vary substantially across Kamishak Bay and Shelikof Strait, both geographically and annually; ranging from sporadic ice cover to compact accumulations of ice in and around Kamishak Bay for several weeks per year.

Water and Sediment Quality

Water and sediment quality in Lower Cook Inlet approaching the entrance to Shelikof Strait are similar to that discussed previously for the area surrounding the marine ports, as addressed in Section 3.18, Water and Sediment Quality. The area has low to moderate turbidity and suspended sediment load, which vary with proximity to input from silt-laden, glacier-fed rivers. Salinity and temperature conditions are also comparable to those previously discussed.

Biological Resources

The biological resources found in this region would be similar to those described in previous sections for the coastal and marine portions of the EIS analysis area. The marine and estuarine waters of Lower Cook Inlet have been described in Section 3.22, Wetlands and Other Waters/Special Aquatic Sites, including nearshore and deepwater habitats. The fish and shellfish of Lower Cook Inlet have been discussed in Section 3.24, Fish Values; and Section 3.6, Commercial and Recreational Fisheries. This information includes the five species of Pacific salmon, resident fish species, and other important commercial and recreational fisheries. Birds, described in Section 3.23, Wildlife Values, include raptors (eagle, falcons, hawks, owls, and corvids), waterbirds (ducks, geese, and swans), landbirds (songbirds), and shorebirds (plovers and sandpipers). The analysis area also includes the habitats of seabirds such as puffins, cormorants, murres, kittiwakes, murrelets, guillemots, and storm-petrels, among others. The habitats of terrestrial wildlife, which includes caribou, moose, black and brown bear, gray wolf, and smaller terrestrial vertebrates (including furbearers), are discussed in Section 3.23, Wildlife Values.

Marine mammals that are not federally listed as threatened or endangered species (TES) under the Endangered Species Act are discussed in Section 3.23, Wildlife Values; and include gray whale (Eastern North Pacific distinct population segment [DPS]), minke whale, killer whale, Dall's porpoise, harbor porpoise, harbor seal, and California sea lion. TES are described in Section 3.25, Threatened and Endangered Species; and include humpback whale (Mexico and Western North Pacific DPSs), fin whale, sei whale, blue whale, North Pacific right whale, gray whale (Western North Pacific DPS), sperm whale, beluga whale (Cook Inlet stock), Steller sea lion (Western DPS), northern sea otter (Southwest Alaska DPS), Steller's eider (Alaska breeding population), and short-tailed albatross. Some of these TES are present or have a potential to occur in the diesel spill analysis area from Kamishak Bay in Lower Cook Inlet south to the Shelikof Strait, including Shuyak and Afognak islands in the Gulf of Alaska. Some whale species occur south of Kodiak Island in the Gulf of Alaska and are not anticipated to be impacted by the spill scenario; these include blue whale and sei whale. These two whale species are not included in the analysis herein because it was determined that under the 300,000-gallon Ultra-Low Sulfur Diesel (ULSD) spill scenario, diesel impacts would not extend to areas where these whale species are normally present. In addition, the short-tailed albatross does not breed, stage, migrate, or regularly feed in the area that may be impacted by this spill scenario, and is therefore not included in the discussion on TES impacts.

There is also a potential for federally designated and proposed critical habitat in lower Cook Inlet for humpback whale, Cook Inlet beluga whale, Steller sea lion, and northern sea otter to experience impacts under this spill scenario.

4.27.2.2 Affected Environment of the Analysis Areas for the Bulk and Pyritic Tailings, and Untreated Contact Water Releases

The analysis areas for the bulk and pyritic tailings spill scenarios extend about 230 river miles downstream from the mine site to the Nushagak River Estuary. The analysis area for the untreated contact water spill scenario extends downstream along the Koktuli River to just above the confluence with the Swan River, approximately 45 river miles downstream of the mine site. The analysis area for the untreated contact water release is contained in the analysis area for the tailings releases, so they will be addressed together. Maps of the analysis areas for the bulk tailings release, pyritic release, and untreated contact water release are provided under their respective sections below.

A bulk tailings release and an untreated contact water release would both follow the North Fork Koktuli (NFK) into the mainstem Koktuli, while a pyritic tailings release would follow the South Fork Koktuli (SFK) into the mainstem Koktuli. The affected environment of the NFK and SFK are fully described in Section 3.16, Surface Water Hydrology. This additional analysis area for the spill scenarios extends from the mainstem Koktuli (where the NFK and the SFK meet), into the Mulchatna River, and finally into the Nushagak River Estuary, which feeds into Nushagak Bay, part of greater Bristol Bay. The affected environment for this extended analysis area is described below.

<u>Surface Water</u>

The mainstem Koktuli flows for approximately 38 miles and has a drainage basin of 634 square miles. The river flows within a broad, densely vegetated valley with numerous cutoff channel sloughs and ponds, and is bounded by sparsely vegetated alluvial and lacustrine terraces. The Koktuli has a relatively low gradient, with an average valley slope of 0.1 to 0.2 percent. The river has a dominantly multi-thread channel, with typical channel widths of 100 to 200 feet. Gravel bars, active side channels, and vegetated islands are abundant (Knight Piésold 2018p). Mean annual discharge (MAD) of the Koktuli varies from 508 cubic feet per second (cfs) below the NFK/SFK confluence to 1,431 cfs below the Swan River Confluence, about 10 miles upstream from the Mulchatna River confluence (Knight Piésold 2018p).

The Koktuli feeds into the Mulchatna River, which drains an area of 4,294 square miles. MAD on the Mulchatna River is 7,897 cfs below the Koktuli confluence, and 9,387 cfs below the Stuyahok River Confluence (see Figure 3.1 in Knight Piésold 2018p).

The Mulchatna River flows into the Nushagak. The Nushagak River drains 12,284 square miles, and the MAD varies from 22,276 cfs below the Mulchatna River confluence to 28,569 cfs at the mouth. The river mouth widens in the lower 19 miles of the drainage, where it is referred to as the Nushagak River Estuary, which then drains into Nushagak Bay, part of greater Bristol Bay.

<u>Water Use/Drinking Water</u>

The downstream communities of New Stuyahok, Wood River, Dillingham, and Clarks Point use groundwater as a drinking water source. No downstream communities have been documented as using surface water from the waterways described herein as a drinking water source (ADEC 2018f). It is unknown/not documented if private users use surface water as a drinking water source. Extensive mitigation measures would be in place to protect surface water for drinking water use (see Section 4.18, Water and Sediment Quality).

Water and Sediment Quality

Water and sediment quality in the extended analysis area are generally comparable to that described for the NFK and SFK (Section 3.18; Water and Sediment Quality, and Appendix K3.18). Groundwater quality meets drinking water standards and is used by several downstream communities (ADEC 2018f).

Biological Resources

The biological resources found in this extended analysis area would be similar to those described for the terrestrial portions of the EIS analysis area (detailed in Section 3.23, Wildlife Values), with the addition of species associated with the Nushagak River drainage, including the Nushagak River Estuary.

Wetlands and waterbodies, including vegetated wetlands, ponds, lakes, streams, and rivers, have been described in Section 3.22, Wetlands and Other Waters/Special Aquatic Sites. Resident and anadromous fish species and their spawning, rearing, and migratory habitats are discussed in Section 3.24, Fish Values. The Nushagak River system (which includes the main stem of the Koktuli River), supports eight anadromous species, including five species of Pacific salmon, 16 resident species, and four estuarine species. The system provides quality spawning and rearing habitat for Pacific salmon and supports one of the largest Chinook salmon runs in the world. A large portion (24 percent) of the Nushagak River Chinook salmon population spawn in the Koktuli River watershed (Schwanke 2007). A description of the commercial and recreational fisheries in the Mulchatna and Nushagak rivers is provided in Section 3.6, Commercial and Recreational Fisheries.

The Nushagak River area vegetation is primarily composed of tundra, mixed coniferous forests, and an abundance of willow, cottonwood, and alder riparian vegetation. Above approximately 900 feet, bare rock, heath tundra, and alpine meadow dominate the watershed area. At the lowest elevations, wet tundra marsh is common, and a large tidal estuary exists at the mouth of the Nushagak River.

Birds in the region around the project are described in Section 3.23, Wildlife Values, and include raptors (eagles, falcons, hawks, owls, and corvids), waterbirds (ducks, geese, and swans), landbirds (songbirds), and shorebirds (plovers and sandpipers). The Nushagak River watershed provides important staging, nesting, molting, and year-round habitat for many bird species, including waterfowl, shorebirds, songbirds, seabirds, and raptors, among others.

Common mammals in this analysis area would be similar to those described in Section 3.23, Wildlife Values. The area provides quality habitat for numerous terrestrial mammals, including moose, brown and black bears, caribou, wolves, wolverine, fox, and multiple small mammals. Beaver are common throughout most streams and lakes in the area. The wood frog is the only amphibian species known to occur in the area. Brna and Verbrugge (2013) developed a thorough list terrestrial vertebrate species that have been documented seasonally and year-round in the Nushagak River watershed.

There are no federal TES that occur in the terrestrial portions of the mainstem Koktuli, Mulchatna, and Nushagak river drainages. Several TES occur in the greater Bristol Bay region outside of the extended analysis area and are not discussed in this section.

Marine mammals that swim up and feed in the Nushagak River and estuary have a potential to be impacted. The non-federally listed Bristol Bay stock of beluga whales is known to swim at least 18 miles up the Nushagak River and occurs year-round in Bristol Bay, and may be impacted by a tailings release (Citta et al. 2016). Other marine mammals that occur near the mouth and in the Nushagak River include harbor seals and killer whales (Limpinsel 2013). There are additional marine mammal species that occur farther away from the mouth of the Nushagak River in Bristol Bay, outside of the extended analysis area, and are not discussed herein.

4.27.3 Spill Preparedness, Prevention, and Response Measures

The Applicant would implement a variety of spill preparedness, spill prevention, and spill response measures, discussed below, that would apply to spills addressed herein (PLP 2019-RFI 126). Additional details related to individual substances are provided throughout this section. The Applicant has committed to specific remedial actions in the event of a tailings spill; these actions are included in the bulk and pyritic tailings release scenarios in the "Spill Response" subsections (see Chapter 5, Mitigation). These measures would apply to all alternatives, as relevant.

4.27.3.1 Spill Preparedness Measures

The Applicant would develop Oil Discharge Prevention Contingency Plans (ODPCPs), Spill Prevention, Control, and Countermeasure (SPCC) Plans, and Facility Response Plans (FRPs) to prevent and respond to fuel and hazardous spills at the Pebble Project. Because of the overlap between the different regulations that govern ODPCP, SPCC, and FRP plans, the Applicant may consider combining the plans into one larger plan that encompasses all the requirements. Such considerations would take place on completion of detailed project regulatory and compliance planning review. Other required plans, such as Stormwater Pollution Prevention Plans, also have roles in spill prevention. As applicable, the plans would describe:

- Spill prevention actions, including inspection and maintenance programs; training programs and requirements; secondary containment; substance abuse policies; medical monitoring; analysis of potential spill volumes and conditions increasing the risk of discharge; and description of discharge detection systems for above-ground storage tanks and piping.
- Spill response actions, including spill notification, safety and communications procedures; spill response resource deployment and cleanup strategies; procedures to stop a discharge; fire prevention; discharge tracking; identification of environmentally sensitive areas for priority protection sites; and wildlife protections plans.

The Applicant has committed to the following:

- Provide annual training for fuel and hazardous material-handling personnel in equipment operation and maintenance to prevent discharges; discharge procedures protocols; applicable pollution control laws, rules, and regulations; general facility operations; and the contents of applicable spill response plans.
- Establish an Incident Management System (IMS) to respond to emergency situations, including large spills.
- Require emergency response personnel to participate in regular emergency response and spill drill exercises.
- Contract the services of an Oil Spill Removal Organization (OSRO) that could provide resources to contain, control, and clean up spills. Pebble Limited Partnership (PLP) is currently a member of Alaska Chadux, an OSRO with headquarters in Anchorage, Alaska. Chadux currently maintains 17 equipment response hubs throughout Alaska, including locations at Anchorage, Dillingham, Homer, King Cove, and Nikiski.
- Establish additional spill response equipment storage hubs at the mine site, north and south ferry terminals, and the port site to ensure a timely response and minimize environmental impacts from a spill.

- Ensure spill response supplies are on hand at fuel and hazardous substances storage sites, and during any transfer or handling of fuel or hazardous substances. The quantity and type of supplies would be sufficient and appropriate to respond to the most probable spill volume.
- Ensure that spill response supplies at the port include kits for wildlife hazing, bird capture, otter captures, and otter pens.
- Require that containment booms be available at the ferry terminals, the port, and on vessels, consistent with 33 Code of Federal Regulations (CFR) Part 154.1045.
- Conduct regular inventories and maintenance of spill equipment at each location to ensure its response readiness.

4.27.3.2 Spill Prevention Measures

The Applicant has committed to the following:

- Provide secondary containment for the storage of fuel and hazardous substances, sized as appropriate to the container type and according to governing regulatory requirements in 18 Alaska Administrative Code (AAC) 75 and 40 CFR Part 112. Containers with an aggregate storage capacity greater than 55 gallons that contain fuel or hazardous substances would not be stored within 100 feet of a waterbody or within 1,500 feet of a current surface drinking water source.
- Install secondary containment consisting of a bermed and dual-lined area designed to meet regulatory requirements for bulk storage fuel tanks at the mine site, the port site, and the south ferry terminal. Sump and truck pump-out facilities would be installed to handle any spills.
- During equipment storage or maintenance, protect the site from leaking or dripping fuel and hazardous substances by placing drip pans or other surface liners designed to catch and contain fluids under the equipment, or by creating an area for storage or maintenance using an impermeable liner or other suitable containment mechanism.
- During fuel or hazardous substance transfer, place a secondary containment or a surface liner under all containers or vehicle fuel tank inlet and outlet points, hose connections, and hose ends.
- Prohibit vehicle refueling in the annual floodplain, except as addressed and approved in relevant spill plans. This measure does not apply to water-borne vessels.
- Label all fuel and hazardous substance containers to clearly identify their contents.
- Develop a program for and conduct integrity testing, and routinely inspect above-ground bulk storage containers with a capacity of 55 gallons or more and their associated piping.
- Implement a drug and alcohol abuse prevention program for employees and contractors involved in all phases of the project, including personnel handling fuel and hazardous materials.
- Require all fuel barges to be double-hulled and have multiple isolated compartments to reduce the risk of a spill.
- Prepare written procedures for fuel transfer between vessels and facilities to ensure that all fuel transfer equipment and procedures specified in 18 AAC 75.025 and 33 CFR Parts 155 and 156 are followed, including:
    - Require vessels to be securely moored.

- Ensure that the transfer connector (e.g., hose, loading arm, or transfer piping) would be long enough to allow the vessel to move to the limits of its mooring without placing strain on the transfer connector.
- Ensure that the end of each hose not connected to the transfer would be blanked off using closure devices.
- Ensure that each overboard discharge or sea suction valve that is connected to the vessel's transfer or cargo tank system would be sealed or lashed in the closed position.
- Ensure that the sequence of transfer operations, transfer rate, and procedures to ensure the transfer pressure does not exceed the maximum allowable working pressure for each of the equipment components is communicated and acknowledged. The volume/quantity to be transferred would be verified and agreed on by the responsible person on each vessel/facility, including the system of measurement (e.g., gallons).
- Confirm that the prevailing weather conditions (sea state, ice, and winds) would not prevent the deployment of spill containment booms and oil recovery vessels from carrying out an effective response in the event of a spill. If pre-booming is not possible, alternative options are to delay the transfer until pre-booming is possible, or to transfer at a rate below 500 gallons per minute (gpm).
- Ensure that required secondary containments (33 CFR Parts 154.530 and 155.310) would be in place and periodically drained to provide required capacity.

- Place containment booms around vessels engaged in fuel or oil transfer operations greater than 10,500 gallons (250 barrels) or during high-flow fuel transfer, typically greater than 500 gpm. The vessel would be surrounded by an oil-spill containment boom during the entire transfer operation to help minimize any adverse effects from a fuel spill. The transfer of smaller quantities of fuel would be exempt from pre-booming, but would be required to have booming material in the immediate vicinity of the fuel transfer operations.
- Equip fuel dispensing lines with automatic shutoff devices.
- Operate a special International Standards Organization (ISO)-approved tank for the overland and ferry transport of fuel. The frames of ISO-approved tanks are equipped with corner castings, allowing them to be loaded and locked into place on trailers or on vessel decks in the same manner as standard shipping containers. The stainless-steel construction is resistant to corrosion, and the outer frame provides strength to allow the tanks to be safely transported when full, as well as offering impact protection. The ISO tanks would be top-loading and unloading, and the valves would be fitted with a blanking plate during transport to prevent accidental opening.
- Store or park ISO-approved tanks or other hazardous materials in designated areas.
- Ship hazardous materials in original, approved containers that are appropriate for transport, and transport the materials in closed shipping containers, with appropriate placarding as required by US Department of Transportation (USDOT) regulations.
- Equip trucks with spill kits containing plugs, trenching tools, and sorbent materials that can be used to stop fuel leaks and limit damage to the environment.
- Equip the vehicle fleet, including fuel transport trucks, with real-time GPS location communication devices and verbal in-cab driver coaching alerts for speed exceedances to ensure safe driving practices. This system would also allow rapid identification of the precise location in the event of an incident.

- Manage truck driver fatigue by capping the number of hours per day and week drivers work and by mandating break times. Drivers would be instructed to take a break when necessary if they feel fatigued.
- Prohibit the use of distraction devices, such as mobile phones and electronic devices, when operating equipment, vehicles, and vessels.
- Establish environmental factor and weather condition parameters that would require a temporary halt to road traffic on a section(s) or entire access corridor, or vessel operations, during potentially dangerous conditions (e.g., limited visibility due to snow or fog, icy road conditions, wildlife presence).
- Implement a communication system that includes road hazard signage, safety briefings, and vehicle-to-vehicle communication to alert vehicle operators of potential road hazards,.

4.27.3.3 Spill Response Measures

The Applicant has committed to the following:

- In the event of a spill of fuel or hazardous material, personnel and contractors would follow established notification procedures, and take prompt action to control, contain, and clean up spills commensurate with the volume of the spill, type of material, and receiving environment, as defined in applicable spill response plans.
- Releases of a hazardous substance or oil would be reported to the State of Alaska Department of Environmental Conservation (ADEC) and/or US Coast Guard, consistent with mandated regulatory requirements.
- Satellite tracking and monitoring of trucks on the road to enable rapid identification of the precise location in the event of an incident.
    - Computerized load/container tracking from the consolidation facility to the mine site would allow for rapid identification of possible contaminants in the event of an incident.
- Project personnel would immediately contain and control the spill and seek approval of cleanup and disposal plans to be used for the release. After obtaining approval of clean up and disposal plans, the Applicant would perform a cleanup of the discharge or release and disposal plans per the approved plan.
    - Appropriately trained staff would be on site for all shifts to respond to incidents.
    - Pre-positioned response equipment would be at all major project facilities to allow for rapid response to incidents.

4.27.4 Diesel Spills

ULSD (or diesel) fuel is a refined petroleum product that has been the US Environmental Protection Agency (EPA)-mandated industry-standard diesel fuel since 2010. ULSD is a relatively light, thin oil with low viscosity that readily evaporates into the atmosphere, disperses quickly in water compared to heavier oils, and is naturally degraded by microbes. It can be toxic to organisms, but has only a moderate concentration of soluble compounds (NOAA 2018i). Diesel is used globally and transported regularly over land and water without incident. Minor diesel spills occur frequently in Alaska and globally and are difficult to contain. Impacts of historic diesel spills have ranged from negligible to severe.

The Pebble Project would use approximately 16 million gallons of diesel annually to operate mine site vehicles, haul trucks, and the ferry; as well as for use in explosives (combined with ammonium nitrate), and other miscellaneous mining needs. Diesel fuel would be delivered to the port by double-hulled fuel barges with approximately 4 million gallons of diesel distributed across 12 to 14 compartments, with an estimated 300,000 gallons of diesel held in each compartment. Four barge-loads of diesel would be required annually, each requiring approximately 3 days to unload, with fuel barges in port for approximately 12 days each year (PLP 2018-RFI 060).

At the port, diesel would be pumped from the barge holding tanks into four 1.25-million-gallon tanks for storage at the port (Owl Ridge 2018b), and also into 6,350-gallon stainless-steel ISO-approved tanks for transport to the ferry terminals and the mine site (PLP 2018d). ADEC oversees storage tank compliance. Diesel storage tanks at the port would be in dual-lined and bermed secondary containment, sized as appropriate to the container type, and according to governing regulatory requirements in 18 AAC 75 and 40 CFR Part 112. Storage tanks would not be within 100 feet of a waterbody or within 1,500 feet of a current surface drinking water source. Fuel dispensing lines would have automatic shutoff devices, and spill response supplies would be stored and maintained on site wherever fuel would be dispensed. Sump and truck pump-out facilities would be installed to handle any spills (PLP 2019-RFI 126).

Individual ISO tanks would be enclosed in a steel outer frame with the same dimensions as a 20-foot shipping container. The ISO tanks inside the frames would be loaded onto trailers to be transported by fuel haul trucks to Iliamna Lake for the ferry crossing. Trucks would haul three trailers per trip, with one 6,350-gallon ISO tank per trailer, for a total of 19,050 gallons of diesel per haul-truck trip. Haul trucks would average two to three round trips per day, for an approximate total of 840 haul-truck trips annually (PLP 2018-RFI 060).

Alternative 1a and Alternative 1 would use the ice-breaking ferry for one round trip across Iliamna Lake per day to haul diesel and other mining supplies on the north-bound trip, and to haul ore concentrates on the south-bound trip. Each north-bound ferry trip would carry diesel fuel from two or three haul-truck loads (three trailers per load), for a total of between 38,100 and 57,150 gallons of diesel crossing Iliamna Lake each day (PLP 2018-RFI 060). The ferry crossing is approximately 28 miles long for Alternative 1a. The ferry crossing is 18 miles long for Alternative 1. The Alternative 1 crossing would be expected to take 1.5 hours in open water, and 3 hours during ice conditions, while Alternative 1a route would likely take longer. Under the Alternative 1 Summer-Only Ferry Operations Variant, additional storage of fuel would be needed at the mine site and the port site.

The use, containment, and transport of diesel by PLP would be in accordance with ADEC regulations and would follow approved ODPCPs and FRPs. Spill response supplies would be maintained at the mine site, ferry terminals, fuel storage sites, and on vessels and fuel tanker trucks; and crews would be trained in spill response. See Chapter 5, Mitigation, and below for a summary of design features to reduce the risk of diesel spills and spill response information (also see the "Spill Preparedness, Prevention, and Response Measures" subsection). The tanker truck and marine tug-barge spill scenarios provide more details on spill response.

4.27.4.1 Fate and Behavior of Spilled Diesel

This section describes the general fate and behavior of spilled diesel for a wide range of hypothetical releases. Specific impacts from the selected release scenarios are presented below.

When diesel is released into the environment, it naturally begins to degrade through a variety of weathering processes. Some components of diesel may persist in the environment after most components have weathered. Toxic components of diesel can also be entrained in turbulent water such as stream riffles, river rapids, or tidal areas.

Diesel is lighter than water, and when released into a marine or aquatic environment, it floats on the water surface, spreading out to leave a thin film, or sheen. Diesel cannot sink to the bottom of a waterbody and accumulate as free oil (NOAA 2019d). Floating diesel quickly disperses, especially under the influence of strong waves, wind, tides, and currents. Wave action can also emulsify, or break up, the diesel into small droplets that stay suspended in the water column (NOAA 2018i, 2019d).

Diesel is moderately volatile, and readily evaporates into the atmosphere. After a few days floating on marine water, about two-thirds of the volume of a small diesel spill (less than 5,000 gallons) is lost to the atmosphere, even in cold water (NOAA 2018i, 2019d). A Cook Inlet Maritime Risk Assessment (Glosten 2012) was conducted to determine the potential risk from oil spills in the greater Cook Inlet area. The spill rate projections as presented in Glosten (2012) are based on incidents and vessel traffic from the greater Cook Inlet Region and are not specific to the area of the Amakdedori/Diamond Point ports or to the anticipated level of vessel traffic from the project. The risk assessment, however, is the most relevant, site-specific data available for oil spill risk assessment for marine operations of the project. Glosten (2012) predicts that after 24 hours, 16 percent of a spilled diesel volume would evaporate at 1 degree Celsius (°C; project area winter temperature range), while 34 percent would evaporate at 15°C (project area summer temperature range; Glosten 2012 Technical Appendix C). This equates to approximately half the spilled diesel evaporating after a few days during the winter, and the majority of the spilled diesel evaporating after a few days in the summer. Evaporation rates would vary with the volume of the spill and with the temperature, with evaporation rates lower during freezing and below-freezing conditions.

Diesel can adsorb, or adhere, to particles (e.g., silt) suspended in the water column. Over time, some of these particles may eventually settle to the bottom of the waterbody, so that small amounts of diesel can accumulate in the substrate beneath a waterbody.

Dissolution is not a dominant weathering process for diesel, although some constituents of diesel would eventually dissolve. When dissolution occurs in an isolated body of water where dilution and dispersion are limited, the dissolved constituents would increase the level of water contamination.

Photodegradation, or the breakdown due to light, can be a substantial weathering process on sunny days. Diesel can become more soluble after photodegradation, increasing the toxic impacts.

For spills in marine waters, evaporation and dispersion are the dominant weathering processes. Most diesel from a small spill (less than 5,000 gallons) would evaporate or naturally disperse within hours to days of a spill, especially in windy conditions; therefore, diesel from such small spills is generally not recoverable (NOAA 2018i, 2019d). For a large diesel spill on the order of 300,000 gallons in cold water with no recovery efforts, a conservative estimate suggests that the fuel would be fully evaporated and dispersed after a maximum of 10 to 20 days (AECOM 2019a; SL Ross et al. 2003). A site-specific oil spill trajectory analyzing a 300,000-gallon spill during winter conditions estimates that 67 percent of the diesel would evaporate or disperse within 4 days; during spring conditions, 89 percent would evaporate or disperse within 4 days (Owl Ridge 2018c).

Diesel washed onto a beach or spilled on land can "oil" the land by leaving an oily sheen on the surface. Wave action on a beach may help to flush the diesel off of the wet sediments (NOAA 2018i). Diesel that pools up on land can penetrate porous soil and sediments and become trapped in sediment pore spaces. Naturally occurring microbes present in the soil can degrade diesel oil from a small spill on land within 1 or 2 months (NOAA 2018i), although this rate would vary locally depending on the presence of microbes and would be a slower process in cold climates.

Diesel that percolates down into soils and sediments can potentially reach shallow aquifers. The diesel would float on top of the groundwater surface (water table) and contaminate the groundwater. Travel times for diesel to reach shallow aquifers are variable and could be on the order of months to years. For minor spills, microbial activity would likely degrade the diesel prior to it reaching groundwater.

Note that impacts from diesel cannot be compared directly to those of heavier fuels, such as the crude oil that was released in Alaska's 1989 *Exxon Valdez* oil spill. Crude oil and heavy distillates can persist for months to years if not recovered, whereas diesel is naturally flushed and biodegraded much more readily.

Diesel fuel is extremely flammable and can pose a serious fire hazard if not contained.

Fate and behavior of a diesel spill can also be influenced by water salinity, air and water temperatures, and weather and season conditions. During ice-free conditions, spilled diesel can readily permeate soil and sediments, and be transported by moving water. During frozen conditions, diesel is more likely to pool up on frozen ground and frozen waterbody surfaces. Diesel can permeate into frozen materials to a limited depth. Snow may slow the spread of spilled diesel on land.

4.27.4.2 Historical Data on Diesel Spills

Spill Frequency and Volume

More than 15,000 diesel spills have been reported across Alaska since 1995. The vast majority are minor spills of 1 to 10 gallons. There are also infrequent (less than 1 per year) truck rollovers that release more than 3,000 gallons; and rare marine vessel incidents, which have released more than 300,000 gallons. Smaller spills have a higher probability/frequency of occurrence, while larger spills are less probable/frequent.

Diesel currently accounts for more than half the volume of all spills in Alaska. Common causes of diesel spills include mechanical failure, human error (especially overfill of tanks), and vessel or trucking accidents. From 2003 to 2018, 165 diesel spills in Alaska were considered to have the potential to significantly impact human health, public safety, or the environment, warranting a spill response effort from the ADEC (ADEC 2018d).

Tanker Trucks

Nationwide data on oil spills from various sources show that small and very small spills are quite common, while high-volume spills are rare. The probability of oil spills from vehicles is high, but the volumes of such spills are generally low (Etkin 2006). Low-volume, high-probability spills of hydrocarbons and other toxins are addressed in Section 4.14, Soils; and Section 4.18, Water and Sediment Quality.

Due to the remote nature of the mine and port access roads, and Alaska's challenging weather and road conditions, Alaska-specific historical data are considered most relevant. The transport of diesel by tanker trucks along the Dalton Highway in Northern Alaska can be considered as an analog to diesel transport on PLP's road corridor. The Dalton Highway is a 414-mile-long public road between Livengood and Deadhorse, Alaska, used primarily for hauling industrial supplies to oil exploration and production facilities on the North Slope. The highway is a rough, narrow, two-lane, gravel and paved road (BLM 2018), and is maintained by the Alaska Department of Transportation & Public Facilities (ADOT&PF). Conditions on the Dalton Highway can be challenging, especially under extreme winter weather conditions, with icy roads, high winds, low visibility from blowing snow, and other large trucks present on the road. Diesel is currently hauled in ISO-compliant fuel tanks of approximately 10,000-gallon capacity by trucks with single trailers.

ADEC reported 22 trucking-related diesel spills (averaging one per year) on the Dalton Highway, including at least seven truck rollovers, between 1995 and 2017 (ADEC 2018h). Spill volumes ranged from 1 gallon to 3,000 gallons, with an average spill volume of 400 gallons. Most diesel spills on the Dalton Highway report successful cleanup operations, with most of the spill volume recovered (ADEC 2018h).

Colville Transport, LLC is currently the primary fuel delivery company transporting diesel on the Dalton Highway. Colville trucks about 15 to 20 million gallons of diesel up the highway every year, requiring up to 2,000 trips per year (Colville 2018; Simton 2018). Between 2011 and 2017, Colville reported two trucking-related diesel spills on the Dalton Highway: a spill of 100 gallons, and a truck rollover that released 2,800 gallons (ADEC 2018h). This equates to about 105 million gallons transported over 7 years; and 14,000 trips, totaling over 5.7 million miles of transport, releasing 2,900 gallons.

Due to challenging road conditions on the Dalton Highway, ADOT&PF restricts cargo to set weight limits; for a fuel truck, the maximum weight that can be hauled is a single trailer with 10,000 gallons. Double trailers are used elsewhere in Alaska, while triple trailers are rare. The ADEC spills database does not provide information on the number of trailers involved in trucking-related spills. PLP would haul diesel tanks on three separate trailers, which may increase spill risk compared to single or double trailers. Triple trailer loads are uncommon in Alaska; therefore, incident data are not available. Incident rates for the triple trailer loads may not be directly comparable to incident rates for trucks hauling single or double trailers.

Marine Tanker Vessels

Data from the US Department of Interior Bureau of Ocean Energy Management (BOEM) for Oil-Spill Occurrence Rates for Oil-Spill Risk Analysis (OSRA; BOEM 2016) support the general well-established trend that minor diesel spills from marine vessels are a common occurrence around the world, while high-volume releases are rare. Alaska-specific data from the ADEC show that this trend is also true in Alaskan waters. State data also show that spills from State-regulated facilities, which include marine tank vessels, occur much less frequently than spills from unregulated facilities, such as fishing boats (ADEC 2018h).

Globally, the rate of oil spills from marine barges has decreased in recent years (Owl Ridge 2018b), possibly due to the increased use of double-hulled barges. Double-hulled barges transport fuel in segregated compartments in a secondary inner hull, providing an extra layer of protection from any potential damage to the outer hull. This reduces the likelihood of spills from groundings or collisions (USACE 2018d). One study on global rates of shipping-related oil spills showed that out of 105 accidents involving single-hulled fuel barges/tankers, 14 spills resulted, releasing more than 70 million gallons; while out of 53 accidents involving double-hulled barges/tankers, four spills resulted, releasing 115,000 gallons (DeCola 2009, as cited in Owl Ridge 2018b). PLP has committed to transporting diesel in double-hulled barges.

In Alaska, between 2003 and 2018, the ADEC responded to five diesel spills from barges that had the potential to significantly impact human health, public safety, or the environment. Of these five spills, the volumes for four of them were small/unknown quantities, while one barge grounding released approximately 6,000 gallons of diesel (ADEC 2018h). Between January 1995 and July 2013 (the most recent year available when the study was completed), no oil spills greater than 10,000 gallons occurred from barges in Alaska (ERM 2017; ADEC 2018h).

Studies of oil spill risk from tank barges, specifically in Cook Inlet, show that the overall risk of any oil release is very small (Nuka and Pearson 2015). In addition, a recent project-specific study on maritime oil spill risk assessment (Owl Ridge 2018c) found that the overall risk of a significant marine oil spill in Lower Cook Inlet is low, and that the highest risk is from allision (i.e., collision with a stationary object) and errors during transfer operations.

Data suggest that a diesel spill from a marine tug-barge would be small or very small, but there is a slight possibility that a high-volume spill could occur (AECOM 2019a). Based on the most recent data from BOEM for Oil-Spill Occurrence Rates for OSRA (BOEM 2016), the probability of a spill of between 42,000 and 420,000 gallons is 2.5×10^{-4} per year, or a 0.025 percent chance of occurring in any given year. This equates to an average recurrence rate of 4,000 years, or a probability of occurrence of 0.50 percent in 20 years, or 1.9 percent in 78 years (AECOM 2019a). These probability data are based on the Cook Inlet area north of the project area, and are not specific to Kamishak Bay. The probability of large oil spills on the approach to Amakdedori and Diamond Point ports may be different than for the broader Cook Inlet region. Both Amakdedori and Diamond Point ports have nearby rocky shoal outcrops that could pose a hazard to ships (see Section 3.15, Geohazards and Seismic Conditions). The Diamond Point port site generally has thicker sea ice in higher concentrations for longer periods than the Amakdedori port site (see Section 3.16, Surface Water Hydrology).

Ferries

The spill rates discussed above for marine barges appear consistent with the available historic data for lake ferries operating in arctic or sub-arctic conditions, which appear to indicate zero spill rates over the period of record.

Ice-breaking vessels are used in northern Canada to supply mining operations and transport ore concentrate. Three examples were provided by PLP. The 32,000-tonne icebreaking bulk carrier Umiak 1 transports concentrate 1,100 nautical miles from a mine in northern Labrador to Quebec City, navigating through ice up to 5 feet thick and making 12 trips per year (PLP 2018-RFI 052). The similar ice-breaking bulk carrier MV Arctic has supported mines in the High Arctic since 1978. No incidents associated with either of these two vessels are logged in the Transportation Safety Board of Canada database (TSB Canada 2018). The Nunavik is a similar ice-breaking bulk carrier that transports fuel, supplies, and ore concentrate in northern Quebec. It sustained damages from a collision with another bulk carrier in 2016. No injuries or pollution releases were reported (TSB Canada 2018).

The ice-breaking ferry M/V *Williston Transporter*, which operates in British Columbia, Canada, is considered the best analog to the project ferry. The 360-foot-long vessel provides transportation for logging and mining operations around Williston Lake. The ferry has operated year-round since 1995 without “loss of cargo or release of pollution” (PLP 2018-RFI 052). See the Transportation Spill Scenario Probabilities Memo (AECOM 2019a) for statistical analysis on the probabilities of diesel spills from ferries.

4.27.4.3 Existing Response Capacity

PLP would maintain oil spill response and recovery equipment at the mine site, the ferry terminals, and the port site, including booms, sorbents, pumps and hoses, recovery and disposal containers, and personal protective equipment (PPE) for personnel. A skiff and personal flotation devices would also be maintained at the ferry landings and the port. Marine tugs, diesel haul trucks, and the ferry would also be equipped with spill response kits. Operators would be trained in spill reporting and procedures to minimize and contain low-volume spills (PLP-RFI 060).

Spill response supplies would be on hand at fuel and hazardous substances storage sites, and during any transfer or handling of fuel or hazardous substances. The quantity and type of supplies would be sufficient and appropriate to respond to the most probable spill volume. Spill response supplies at Amakdedori port would include kits for wildlife hazing, bird capture, otter captures, and otter pens. Containment booms would be available at the ferry terminals, Amakdedori port, and on vessels, consistent with 33 CFR Part 154.1045. Regular inventories and maintenance of spill equipment would be conducted at each location to ensure its response readiness (PLP-RFI 126).

ADEC establishes response procedures in its Alaska Responders manual (PLP 2018-RFI 060). Tactics include deployment of booms, berms, dikes, dams, use of sorbent, digging of pits and trenches, and pumping of spilled diesel. Recovery procedures cover on-land, marine, and shoreside environments.

In the event of a large spill that requires additional recovery efforts, PLP would contact Alaska Chadux, an OSRO that provides experienced response personnel and oil recovery/cleanup equipment such as pumps, absorbent pads, sweeps, booms, land bladders, towable bladders, tanks, skimmers, rope mops, drums, harbor and shore seal booms, and response vessels, as required. Chadux personnel and supplies would be mobilized from one or more of their hubs closest to the impacted area, including Nikiski, Homer, Kodiak, and/or Anchorage. Chadux may also maintain some response equipment at the project site (PLP 2018-RFI 060).

In addition, ADEC maintains pre-positioned equipment depots across the state, including a container of supplies in Iliamna that would be available at cost to responsible parties (ADEC 2018i).

See also the "Spill Preparedness, Prevention, and Response Measures" subsection.

4.27.4.4 Mitigation/Avoidance and Minimization

Design Features of ISO Diesel Storage and Transfer Tanks

- ISO tanks are the industry standard for transporting both hazardous and non-hazardous liquids in bulk, and are built to withstand extreme pressure and damage.
- The cylinder-shaped tanks are constructed of stainless-steel to resist corrosion, and are housed in a steel outer frame that provides strength and impact protection during transport.
- Tank valves would be fitted with a blanking plate during transport to prevent accidental opening (PLP 2018-RFI 060).
- Each tank is designed with three separate closures; all three closures would have to fail for the tanks to leak (PLP 2018-RFI 060).
- The outer frames of the ISO tanks would be equipped with corner castings that allow them to be loaded and locked into place on the haul truck trailers and the ferry deck like a standard shipping container.
- Secondary containment would be provided for all diesel storage (at tank farms, etc.) and transfer operations.
- Inspection and maintenance programs.
- Discharge detection systems would be employed for above-ground storage tanks and piping.
- Emergency response personnel would be required to participate in regular emergency response and spill drill exercises.

- Spill response supplies would be on hand at fuel and hazardous substances storage sites and during any transfer or handling of fuel or hazardous substances.
- Additional spill response equipment would be kept at storage hubs at the mine site, the north and south ferry terminals, and Amakdedori port (PLP 2019-RFI 126).

Design Features of Marine Tug-Barges

- Marine vessels used to deliver fuel to Amakdedori port would be Alaska Class ice-rated articulated tug-barges similar to the 483-foot, 100,000-barrel articulated tug-barges currently under construction for Crowley Marine.
- All tug-barges used to deliver fuel would be double-hulled, which are designed to reduce the likelihood of diesel spills from vessel collision or grounding.
- The barges would have at least 12 to 14 water-tight compartments, with an estimated capacity of approximately 300,000 gallons each (PLP 2018-RFI 060). If one or more compartments were to flood, the vessels are designed to maintain buoyancy and stability.
- Marine radar would be used to avoid other vessels and accurately approach the dock (Owl Ridge 2018b).

Design Features of Iliamna Lake Ferry

Incidents with the ferry could include collision, sinking, loss of power or steering capabilities, grounding, fires, and flooding of engine rooms or other compartments. Such vessel incidents are generally attributable to human error more often than mechanical failures or adverse weather conditions. PLP would employ experienced crews, and crews would receive ongoing training. The ferry would be designed with state–of-the-art navigation and propulsion systems, with four azimuthing thrusters, and have the ability to operate in 100-mile-per-hour (mph) winds, with safe station-keeping at winds up to 150 mph (PLP 2018-RFI 052). Additional vessel safety features that would mitigate the potential for incidents are as follows:

- One-inch-thick heavy steel shell (required for ice breaking) would result in very low potential for damage to the ferry from grounding or a collision.
- Fuel tanks would be located away from the shell of the vessel so that the tanks would not be impacted in the event of a collision.
- Multiple watertight compartments would reduce the chance of sinking. If any one of the compartments was to flood, the vessel is designed to remain afloat, stable, and operational.
- The ferry would have two fully independent engine rooms so that if one engine room was to flood or suffer damage, the ferry would lose half its power, but the remaining engine room would supply sufficient power to keep all four propellers fully functional.
- Fire detection and fire-fighting systems, including an automatic sprinkler system in the crew accommodation spaces.
- The engine control room would have a backup operating station (in the event that the wheelhouse is not operational).
- Remote monitoring and/or remote control capabilities would be available, as needed, from a remote operations center.
- Stowage plan would be designed to ensure no movement of cargo at a list (tilt) of 8 degrees (e.g., in the extreme case of loss of one of the engine rooms) (PLP 2018-RFI 052).

- Corner castings on the outer frames of the ISO tanks would enable the tanks to be loaded and locked into place on the ferry vessel deck like a standard shipping container (PLP 2018-RFI 060).
- The sides of the ferry would contain upset conditions (PLP 2018-RFI 065).
- ISO tanks would also be required to be stored in secondary containment on the ferry.
- The vessel would be designed specifically for operations in ice (PLP 2018-RFI 052). An icing prevention plan would be considered a standard best management practice (BMP) to be employed by the Applicant.
- Additional mitigation identified during the EIS process includes a coastal and ocean engineering analysis for both Iliamna Lake and the port, which would help ensure that project vessels are fit-for-purpose. Likelihood of implementation of this mitigation measure is considered probable.

See Chapter 5, Mitigation, for complete design/safety specifications.

4.27.4.5 Diesel Spill Scenarios

Diesel spills from a tanker truck rollover and a marine tug-barge allision were analyzed for potential impacts. Large diesel spills from the Iliamna Lake ferry and a tank farm were ruled out as not realistic probabilities of occurrence, so were not selected for impacts analysis, and are addressed briefly below.

Overfilling of tanks resulting in a release of diesel outside of secondary containment is a relatively high probability scenario that is not analyzed in this EIS. Potential impacts from such a scenario would likely be similar to, but on a smaller scale than, those described below for a diesel spill from a tanker truck rollover. Diesel spills from handy-size vessels would likely have smaller volume but higher probability than spills from marine tug-barges. Analysis of the larger-volume marine tug-barge spill was selected here to address a larger magnitude of potential impacts.

Scenario: Diesel Spill from Tanker Truck Rollover

This scenario addresses the probability and consequences of a release of 3,000 gallons of diesel into the environment due to a tanker truck rollover at a location along the mine and port access roads. No studies have been identified that analyze fuel spill rates on private, controlled-access industrial roads, such as the mine and port access roads (ARCADIS 2013). The probability of this scenario is therefore based on available historic spill data for diesel transport along the Dalton Highway (as discussed above); the most relevant fuel transport analog in Alaska. Note that diesel transport on the Dalton Highway is mostly hauled in double-trailer ISO-compliant tanks, not ISO tanks mounted on triple trailers, as intended by the Applicant. Triple-trailer setups may be at a higher risk of upset than single or double trailers. Spill risk may also vary between transport in ISO tanks versus tanker trucks. The spill volume of 3,000 gallons represents the largest diesel spill volume reported on the Dalton Highway between 1995 and 2017.

Based on interpretation of the available Dalton Highway data, the potential annual spill rate for a 3,000-gallon spill was calculated to be 2.0×10^{-7} spills per truck mile traveled, or 0.011 spill per year over 66 miles of road transport (55,433 truck miles traveled per year). (Note that miles of road transport varies by alternative from 53 to 82 miles [Table 4.27-1]. The original calculation used for the Alternative 1 road corridor was 66 miles.) This equates to a probability of a 3,000-gallon spill of 1 percent in any given year; 20 percent in 20 years; 55 percent in 78 years; or an average of one 3,000-gallon spill every 90 years (AECOM 2019a). Although these estimates are based on limited historical data, the calculated spill rate of 2.0×10^{-7} per truck mile is essentially identical to the 1.9×10^{-7} rate identified in a separate analysis by the EPA Watershed Assessment (EPA 2014).

As noted above and as outlined in AECOM 2019a, the probability of lower-volume spills is higher than the probability of higher volume spills. A 3,000-gallon spill from a tanker truck rollover represents the largest diesel spill volume reported on the Dalton Highway between 1995 and 2017, and therefore represents the range of higher-volume, lower-probability spills of this type. This scenario was selected to address a wider range of potential impacts than a smaller-volume spill. Smaller diesel spills from truck accidents may occur more frequently.

In this scenario, a tanker truck hauling three trailers, each loaded with a full 6,350-gallon ISO tank of diesel, is headed north when the truck veers off the road, resulting in a rollover. The vehicle would be equipped with a real-time GPS location device, which would allow rapid identification of the precise location of the incident (PLP 2019-RFI 126).

One of the ISO tank outer frames is crushed and punctures one of the ISO tanks, causing a steady release of diesel. Some released diesel would begin to evaporate immediately. Depending on the seasons/weather conditions, some of the diesel would begin to slowly percolate into the soil; some would pool up on the ground and bury low-lying vegetation; and some would flow downslope. Less than half the volume contained in the punctured tank is released in this scenario, for a total release of 3,000 gallons of ULSD.

There are numerous stream crossings along the road corridors for all alternatives. If this scenario were to occur at a stream crossing, diesel could directly enter surface water and be rapidly transported downstream. There is a variety of small ponds along the transportation corridor (especially the port access road) that would serve as natural containment, slowing the spread of diesel. Depending on the location of the spill, small amounts of diesel could reach Iliamna Lake and float on the surface as a sheen.

If the release were to occur in winter, the diesel would pool up on the frozen ground and would be less likely to permeate into the soil. Diesel could flow downgradient onto the surface of frozen waterbodies and would pool up, likely not being carried downstream where streams are frozen. In areas where ice is inconsistent, thin, or fractured, diesel could enter partially frozen waterbodies or flowing water. Diesel trapped under ice would complicate recovery efforts and could reduce/delay evaporation of volatile components of the diesel.

Spill Response

See the "Spill Preparedness, Prevention, and Response Measures" subsection for the actions that the Applicant has committed to. Alaska regulations 18 AAC 75.432(a)(1) and 18 AAC 75.432(2) outline the requirements for responding to a spill that enters open water, including containing or controlling the spill within 72 hours, and cleaning up the spill within the shortest possible time to minimize damage to the environment. Alaska State regulation 18 AAC 75.425 outlines requirements for an ODPCP.

PLP would have an ODPCP plan (or a more comprehensive plan that covers all requirements) in place that would detail the measures to prevent, respond, contain, report, and clean up diesel spills (PLP 2019-RFI 126). Drivers would be trained in spill reporting and procedures to minimize and contain low-volume spills, and the driver would be able to conduct an initial response and call for assistance immediately. Tanker trucks would be equipped with spill response kits, which the driver would be able to deploy to help contain and slow the spread of diesel. Adverse weather conditions could challenge early response procedures. Frozen conditions could challenge some aspects of the response.

Additional spill response supplies would be maintained at the mine site and both ferry terminals (PLP 2018-RFI 060). PLP employees would likely be able to respond to the spill site with additional supplies within 1 to 3 hours, depending on the location of the spill, weather conditions, etc. Relatively effective containment of the 3,000-gallon spill could likely be completed the same day. Spilled fuel would be recovered with sump and truck pump-out systems and/or sorbents, and the bulk of the spilled volume would be pumped into spill response containers. Soil with residual diesel contamination may need to be excavated and removed off site for remediation.

Response efforts could be focused on sensitive areas, such as wetlands or anadromous fish streams, as needed.

Alternatives Analysis

The potential for a diesel spill due to tanker truck rollover could vary slightly by alternative; road corridor lengths and road conditions, such as grade, would vary between alternatives. Alternative 1a would include 72 miles of road transport to haul diesel; Alternative 1 would include 65 miles of total road transport; Alternative 2—North Road and Ferry with Downstream Dams would include 53 miles of road transport; and Alternative 3 would include 82 miles of total road transport. The road corridors for Alternative 2 and Alternative 3 would be expected to have more road segments with higher grade, based on more steep topography in the southern and eastern portions of the road corridor, which could increase the potential for truck accidents and potential spills. Final road design, including grades, has not yet been determined. Alternative 3 would not involve any transport by ferry, so there would be no potential for diesel spills from the ferry into Iliamna Lake under Alternative 3.

Potential Impacts of a Diesel Spill from Tanker Truck Rollover

This section addresses potential impacts of a diesel spill from the tanker truck rollover scenario described above. Impacts are considered in terms of their magnitude, duration, geographic extent, and potential to occur. A diesel spill on the road corridor would not necessarily impact all the resources addressed in this EIS. The following resources were selected for analysis due to the higher potential significance of the impacts.

Soils

A spill of 3,000 gallons of diesel along the road corridor could have direct impacts on soil quality. Under non-frozen conditions, diesel may penetrate and be held within porous soils, so that soil would be contaminated with hydrocarbon levels that would exceed regulatory limits. During frozen conditions, diesel would pool up on the frozen ground, and could potentially permeate the soil to a limited depth.

The magnitude of soil contamination in this scenario would depend on the location of the spill, the permeability of the soils at the site, the season, and the speed and effectiveness of the spill response. The extent of the impacts would be limited to soils near the spill site that are directly in contact with spilled diesel.

Containment and recovery of spilled diesel would reduce the impact to soils. If diesel is recovered promptly and does not permeate the soil, impacts to soils could be negligible. Residual diesel that is not recovered from soil surfaces would likely evaporate or biodegrade from microbial activity.

Contaminated soils could be excavated and removed for off-site remediation if necessary. Potential soil erosion during excavation and remediation could be avoided by use of BMPs. Impacted areas could be recontoured and revegetated, which could take multiple seasons due to the climate. The duration of impacts could therefore last until soils have been fully recovered, likely within 2 to 4 years.

Water and Sediment Quality

Surface Water—A 3,000-gallon spill of diesel along the road corridor has the potential for a direct impact on surface water quality. All road alternatives have a high number of stream crossings, so that a truck rollover has a reasonable probability of occurring at or near a stream. Diesel spilled near a stream or other waterbody could flow downslope and enter surface water. Spilled diesel would float on the surface of the waterbody, and the high concentration of hydrocarbons would greatly exceed applicable water quality criteria (WQC) in the upper portions of the water column. Toxic components of diesel could also be entrained in turbulent water such as stream riffles and river rapids. Some toxic components of diesel could persist in the environment after most diesel has weathered or evaporated.

The magnitude of the contamination would depend on the location of the spill in terms of proximity to waterbodies, the topography at the site, the season, and the speed and effectiveness of the spill response. If the spill were to occur away from surface water, and cleanup and recovery are successful, there could be no impacts to surface water quality.

The extent of surface water contamination would vary depending on the type of waterbody impacted and the season. A spill that reaches an isolated waterbody such as a lake or pond would not be likely to spread farther, but the diesel could concentrate into a thicker sheen in these environments. This natural containment could facilitate recovery of spilled diesel. If diesel enters a flowing stream, however, the fuel could be carried tens of miles downstream before evaporating and dispersing. Stream volumes and velocities would also influence the spread of diesel. Diesel spilled into streams that feed Iliamna Lake could produce a floating sheen on the lake surface. During frozen conditions, spilled diesel would likely pool up on the surface of frozen waterbodies, and would be less likely to spread out, likely increasing the rate of recovery.

The duration of the contamination would last until hydrocarbon levels of impacted waters returned to below threshold levels specified by applicable WQC (15 micrograms per liter [µg/L]; ADEC 2018a). This time period would vary, depending on the waterbodies involved, the season, and the effectiveness of spill response. Evaporation would remove up to half of the spilled diesel from all types of waterbodies within a few days; and more quickly in summer. Dispersion and emulsification would be dominant weathering processes in streams, but not in lakes or ponds. Recovery of spilled diesel would likely be effective in lakes and ponds and on frozen surfaces, but not in flowing streams. The duration of impacts would likely be a few days to a few weeks.

Sediments—If the spill of diesel were to occur some distance from a waterbody, there would likely be no impacts to waterbody sediments.

If the spilled diesel were to reach a waterbody, sediments in the waterbody could be susceptible to hydrocarbon contamination from adsorption of diesel. Sediment that is contaminated would be diluted by surrounding clean sediment and may or may not exceed sediment quality guidelines (SQG). The extent of contamination would include any waterbodies impacted by diesel.

Diesel that becomes trapped within sedimentary particles would be biodegraded by naturally occurring microbes over a time period of months to years (NOAA 2018i). If a high volume of diesel is adsorbed onto sediment, the diesel trapped within sedimentary particles could persist for years. Diesel trapped in sediments could also re-contaminate overlying surface water at a later time, although the contamination may or may not exceed SQG because of dilution.

Groundwater—In this scenario, assuming the anticipated spill response, spilled diesel would likely be recovered prior to impacting groundwater resources.

Under non-frozen conditions, spilled diesel that is not recovered could penetrate through porous soils into shallow groundwater aquifers, directly impacting groundwater quality. The road corridors north of Iliamna Lake contain abundant shallow aquifers. Diesel that reaches shallow aquifers would float on the upper surface of the water table (the phreatic surface), so that the concentrations of diesel-range organics in groundwater could exceed the 1.5-milligram-per-liter (mg/L) groundwater cleanup level (ADEC at 18 AAC 75).

The magnitude of the contamination would depend on the volume of diesel that reaches the aquifers, which would be influenced by factors such as soil type, viscosity, and temperature of the diesel; and weather conditions.

Most aquifers in the project area are discrete and discontinuous, but some aquifers are more extensive. Diesel spills in most locales would be unlikely to spread long distances underground. Groundwater contamination would be localized to areas near the spill site, but some contamination could extend to a larger area.

During frozen conditions, diesel would be less likely to penetrate soils, and would likely pool up on the surface. However, some diesel could reach groundwater resources, even in the winter.

Noise

Noise could be generated from spill recovery operations, including increased vehicle traffic, and use of cleanup equipment. If the increased vehicular traffic would be less than double the amount of existing traffic, then the noise level increase would be less than a 3-decibel (dBA) increase over existing traffic noise levels (generally less than noticeable). Noise from cleanup equipment would depend on the type of equipment used. However, equipment such as pumps, tractors, heavy-haul trucks, and Vac-trucks would have a maximum noise level of approximately 85 dBA or less at 50 feet (Federal Highway Administration [FHWA] Roadway Construction Noise Model), and would be limited to the cleanup area for the duration of the cleanup and recovery effort.

Air Quality

Volatile organic compounds (VOCs), hazardous air pollutants (HAPs) and greenhouse gas (GHG) pollutants resulting from a spill would be high in the immediate vicinity of the spill area, but would decrease quickly due to the dispersion of the spill itself, and dispersion of pollutants by the winds, waves, and currents. Ambient concentrations eventually return to pre-spill conditions within a relatively short period of time (BOEM 2012).

In situ burning, a potential component of spill response strategy, would generate products of combustion (carbon monoxide, oxides of nitrogen, sulfur dioxide, particulate matter [PM], and black smoke). Ambient air quality would return to pre-burn conditions relatively quickly (BOEM 2012).

The magnitude and potential of the impacts would depend on the amount of diesel fuel that evaporates, disperses, or burns. With greater amounts of fuel that evaporates or burns, the impacts would be more likely and larger in magnitude. Concentrations of criteria pollutants could temporarily exceed the National Ambient Air Quality Standards (NAAQS) concentrations; but over time, the air quality would return to pre-spill conditions. The duration of air quality impacts would be temporary, and return to pre-activity levels at the completion of the activity. The extent of impacts would be limited to discrete portions in the project area where the spill took place.

Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

Across all alternatives, less than 10 percent of the road corridor passes through wetlands or waterbodies, while the remainder is uplands. This analysis describes the impacts if the spill were to occur in wetlands or waterbodies. A spill into a pond, lake, or stream would impact surface waters, as discussed above for Water and Sediment Quality. A spill of diesel into wetland soils could cause high plant mortality (NOAA 2019d). A spill into vegetated wetlands would primarily affect scrub-shrub and emergent vegetation, because these wetland types represent over 99 percent of the vegetated wetlands in the transportation corridor. Diesel has been shown to have high acute toxicity to marsh plants and associated communities (Michel and Rutherford 2013). Diesel can also impact other components of wetland ecosystems, such as aquatic and terrestrial invertebrates and soil microorganisms. Individual species can express greater or lesser sensitivity to exposure, but this information is not known for species in the project area. It is possible that evergreen trees and shrubs like Labrador tea would be less sensitive to diesel due to their waxy coatings.

The magnitude of impact is directly related to the extent of oiling of plant surfaces. Large spills resulting in heavy oiling of wetland vegetation and soils would likely cause extensive plant mortality through both direct physical damage to contacted tissues and translocation of toxic components to the root systems. In such cases, regeneration of wetland vegetation would depend on propagules from off site, and restoration of the wetland may take several years. Where oiling of vegetation is not complete or does not extend into root systems or soils, little plant mortality would be expected, and impacted vegetation may recover within one or two growing seasons.

In addition to the size of the spill, the hydrologic status of the wetland and the timing of the spill both influence the extent of wetland damage from diesel spills. Spills into inundated wetlands or saturated soils are less likely to result in complete vegetation mortality, because the diesel would remain on the surface and be dispersed or evaporated (Michel and Rutherford 2013). Biodegradation of diesel by soil microorganisms can deplete oxygen and micronutrient levels around plant roots, potentially resulting in plant mortality. Spills that occur when vegetation is dormant are also not as likely to result in vegetation mortality.

Terrestrial Wildlife

Potential impacts of the spill scenario on terrestrial wildlife would vary depending on the species, time of year, and location of the spill. It is important to note that most studies on impacts to wildlife from oil spills referenced in this section are related to spills of heavier oil (such as crude oil) and are not specific to lighter oils such as ULSD. Heavier oils and diesel both contain polycyclic aromatic hydrocarbons (PAHs), which are harmful to wildlife; are some of the last components of oil to degrade; and can persist in the environment for years (Burns et al. 2014). Some of the direct impacts of oil spills on wildlife may include temporary physical harm to wildlife, trauma such as skin irritation, altered immune system, reproductive or developmental damage, liver disease, chronic effects such as cancer, and direct mortality (Ober 2010). Wildlife come into contact with oil (including ULSD) through three primary pathways: ingestion (via swallowing of oil or consuming oiled prey items); absorption (direct skin contact); and inhalation (breathing in of volatile organics). Less-direct impacts may include relocation of home ranges as wildlife search for new food sources, increased time spent foraging, and disruption of natural lifecycles (Ober 2010). These impacts vary depending on the amount of time oil persists in the environment, location of the spill, natural dispersal activity (via wave action), photodegradation, weathering processes, including microbial activity, and effectiveness of cleanup efforts. Impacts on wildlife can be both acute (occur at the time of the spill), and chronic (occur later in time or over the long-term). Generally, acute impacts occur over a short duration (hours to days), while wildlife is directly exposed to ULSD through inhalation, ingestion, and adsorption of PAHs and other compounds in the ULSD prior to it degrading. Acute impacts generally affect wildlife that is in the immediate vicinity of the spill, or enters an area affected by a spill prior to it being cleaned up or naturally degraded. Chronic impacts are more likely to occur after the acute impacts have passed, and can make the duration of a spill last longer. Further discussion of acute versus chronic impacts on wildlife from oil spills is included under the marine tug-barge allision scenario.

Overall impacts from a diesel spill on terrestrial wildlife under the 3,000-gallon scenario are anticipated to be at a lower magnitude than a heavy oil spill, and have a short duration (several months to a few years), because diesel rapidly evaporates, disperses, and is broken down by soil microbes. Impacts are anticipated to be localized to the immediate area of the spill, but this would vary depending on the time of year (summer versus winter conditions), specific location of the spill (upland versus wetland habitat), and effectiveness of spill response and cleanup activities.

If a terrestrial spill occurs in upland vegetated environments, impacts are anticipated to be of low magnitude, short duration (several months to a few years), and small geographic extent limited to the area immediately around the spill. The spill is anticipated to be cleaned up quickly, with most of the diesel evaporating or seeping into the soil before being removed. Impacts to terrestrial wildlife would be limited, because most species would avoid the area during the spill and cleanup activities. Small mammal species (e.g., mice, voles, lemmings, shrews, ground squirrels) and wood frogs may not be able to immediately vacate the area during the spill, especially if they are underground at the time of the spill. There is the potential for acute toxicity over a brief time span before the diesel evaporates, dissipates, or is broken down by natural weathering processes. Acute toxicity is anticipated to occur only to small mammal species and wood frogs that live in the immediate vicinity of the spill, or come in direct contact with the diesel before it evaporates. Small mammals and wood frogs have a potential to become coated in diesel, and ingest vegetation coated in diesel. Impacts are anticipated to remain localized in the immediate area of the spill. Acute impacts would last a few days to months (depending on temperature and time of year) until the diesel has evaporated and been broken down by soil microbes. No long-term impacts are anticipated.

Larger terrestrial mammals such as bears (*Ursus* species), moose (*Alces alces*), and caribou (*Rangifer tarandus*) are unlikely to be impacted by a terrestrial diesel spill because it is unlikely they would be in the immediate vicinity during the spill, and are likely to vacate the area during active spill cleanup. Vegetation in the localized area of the spill may have the portion along the ground coated in diesel; but due to evaporation, little vegetation that may be consumed by large mammals would be impacted. Cleanup activities would involve removal of contaminated soils and vegetation. Soil microbes would further degrade any diesel in the soil, and rain or snow events would flush the diesel off vegetation. For terrestrial mammals that might be exposed, the number of individuals is expected to be small.

If a spill occurs adjacent to a lake, stream, marsh, or other waterbody during summer months, impacts are more likely to extend quickly beyond the immediate spill site as diesel disperses rapidly across water (or is carried downstream). Species such as moose, beaver (*Castor canadensis*), and river otters (*Lontra canadensis*), which forage in wetlands, are the most likely terrestrial mammals to be impacted. Both beavers and river otters may experience toxic impacts of ULSD coating their fur via ingestion during self-grooming. There is also the potential for hypothermia if their fur becomes oiled. Species in the immediate vicinity may experience acute toxicity, especially if freshwater vegetation becomes covered in diesel. This is likely in the immediate vicinity of the spill. Impacts are anticipated to be localized, and vary depending on time of year and the efficiency of spill response activities. Terrestrial wildlife other than river otters and beavers are anticipated to vacate the area during the spill and cleanup activities. In addition, spill response equipment would be kept at the mine site, both ferry terminals, and port to enable rapid response to a spill anywhere along the transportation corridor.

If a spill enters a waterbody occupied by wood frogs, depending on the time of year, there could be acute toxicity to eggs, tadpoles, and adults. If ULSD becomes entrained in vegetation and sediment, there could be repeated exposure to ULSD until it is either cleaned up or degraded to the point where it is no longer toxic. If wood frog eggs, tadpoles, or adults suffer mortality, there could be localized impacts to the population in the affected area. Wood frogs from adjacent unaffected areas are anticipated to recolonize waterbodies that are affected by a ULSD spill.

Spills that occur during winter months may be less likely to impact wildlife species, because frozen substrates may limit the spread of diesel and permit more efficient spill cleanup. During partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), diesel may be trapped beneath ice, potentially prolonging cleanup and duration of impacts. Impacts would be localized to the immediate vicinity of the spill. Spills that occur adjacent to frozen waterbodies are anticipated to have a low to negligible impact, because ULSD is easier to contain and clean up on frozen surfaces.

Because this spill scenario does not include transport on Iliamna Lake, no impacts to harbor seals that live in Iliamna Lake are anticipated, apart from impacts to foraging habitat in river mouths that empty into Iliamna Lake. If a diesel spill were to occur near a waterbody that empties into Iliamna Lake, there is a potential for harbor seals to be exposed to oily water and temporarily disturbed while cleanup activities occur; however, the seals are anticipated to avoid the area (or be hazed) while cleanup is occurring.

Birds

It is important to note that most studies on impacts to birds from oil spills are related to spills of heavier oil (such as crude oil) and are not specific to lighter oils such as ULSD. Although both oil types contain some of the same compounds, they react differently when spilled into the environment and have different persistence rates. A ULSD spill may affect a small number of birds in the immediate vicinity of the accident, and small areas of adjacent habitat. Sources of injury or mortality may include oiling of body feathers, inhalation of toxic volatile compounds (especially for birds with impaired mobility such as molting birds and nestlings), potential mortality from ingestion while preening, hypothermia from oiled feathers, and consumption of oiled food (vegetation, fish, insects, etc.). The intensity of a spill would vary depending on the time of year and habitat where it occurs. If a spill occurs during the spring and fall, migratory birds are more likely to be impacted. If the spill occurs during the summer, then resident breeding species (and their nests and young) have a potential to be impacted. A spill during the winter is likely to have the lowest impact, because most avian species have vacated the area, and only a few resident species remain year-round. In addition, a diesel spill in upland vegetation would have a lower geographic extent compared to a spill in a marsh or waterbody. If diesel disperses to a nearby stream, the effects could spread further and affect aquatic birds, such as spotted sandpiper (*Actitis macularius*), American dipper (*Cinclus mexicanus*), mergansers (*Mergus* species), and other waterbird species, if present. Response efforts, including increased human activity, could disturb birds, causing them to temporarily avoid the area. If birds are nesting in roadside vegetation that becomes oiled, nests and/or eggs and young may be impacted. Species known to occur in the area that nest close to or on the ground include spruce grouse (*Falcipennis canadensis*), ptarmigan species (*Lagopus* species), fox sparrow (*Passerella iliaca*), common redpoll (*Acanthis flammea*), and dark-eyed junco (*Junco hyemalis*), among others. Because the area affected would be small, the number of birds likely to ingest diesel or contaminated food would be small. A spill in or adjacent to marsh habitat may impact breeding birds such as species of yellowlegs (*Tringa* species), solitary sandpipers (*Tringa solitaria*), rusty blackbirds (*Euphagus carolinus*), swans (*Cygnus* species), ducks (*Anas* species), geese (*Branta* species), phalaropes (*Phalaropus* species), and species that feed on fish and freshwater invertebrates such as loons (*Gavia* species), grebes (*Podicpes* species), and belted kingfishers (*Megaceryle alcyon*).

The most severe impacts would occur to birds that are not able to leave the area immediately, such as juveniles from nearby nests and molting (temporarily flightless) birds. Birds that nest in marshy/freshwater habitats are more likely to be impacted than species that nest in upland habitats. Residual contamination that enters the food chain could affect raptors such as bald (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*), osprey (*Pandion haliaetus*), and northern harriers (*Circus hudsonius*) that may eat contaminated fish or small mammals. In summary, a diesel spill from a tanker truck rollover is anticipated to have a small, localized impact on a discrete geographic area (while it is cleaned up and dispersed), with a low magnitude and short duration (a few months to several years), depending on the amount of time to clean up and/or allow the diesel to fully decompose, and any vegetation/habitat to return to pre-impacted conditions.

Alternative 2 and Alternative 3—Diamond Point Port

Potential impacts to birds would be similar regardless of the specific port location under Alternatives 2 and 3. Therefore, impacts are discussed collectively herein. If a tanker truck rollover occurred along the Alternative 2 and Alternative 3 transportation corridor in the short segment along the shore with Iliamna Bay, there is a potential for marine birds to be oiled. Marine birds that could be impacted include black oystercatchers, harlequin ducks, goldeneyes, common mergansers, scoters, long-tailed ducks, and other species that feed along the rocky shoreline where the transportation corridor abuts Cook Inlet waters. Any birds in the immediate vicinity of the spill have a potential for inhalation and ingestion toxicity while preening. There is also a potential for secondary exposure by feeding on contaminated bivalves or other invertebrates. If a spill were to occur along the shoreline of Iliamna Bay, the impact would be localized, and cleaned up fairly quickly due to the close proximity of the port and spill response equipment. If the spill occurred at low tide, the spill may be able to be contained faster, limiting spread. However, if the spill occurred at higher tides, then some adjacent water may become oiled. Wave action and tidal fluctuation have a potential to expose birds to oil that is not cleaned up and entrained in porous substrates, such as unconsolidated material and sand or mud. Given the relatively low volume of spilled ULSD in the scenario, individual birds may suffer injury or mortality, but the overall magnitude would be low. The duration could range from several months to a few years, depending upon the number and type of species impacted.

Fish

As discussed above, floating diesel tends to evaporate over time from mixing with the stream currents, wind, and wave action; with no or very little visible sheen remaining within 3 days (NOAA 2006). Toxic components of diesel could also be entrained in turbulent water such as stream riffles and river rapids. Some toxic components of diesel could persist in the environment after most diesel has weathered or evaporated. The extent and duration of impacts to fish would be short-term, and expected to be limited to the waters in the vicinity of the spill, because the volume and concentration on the surface would attenuate downstream. Most adult and juvenile fish exposed to a diesel spill are mobile, and generally capable of limiting exposures until concentrations attenuate. Depending on the location, a spill occurring between mid-May and June could have impacts on out-migrating juvenile salmon species. These fish could experience acute toxicity, particularly in shallow water, stream margins, and off-channel habitats, where low stream currents could accumulate fuel. Impacts to these fish and invertebrates could include potential mortality, depending on the concentration and exposure time.

Threatened and Endangered Species

There are no federally listed TES that occur in the terrestrial portion of the project. Any spills that occur on land are anticipated to be dissipated, degraded, or contained prior to reaching the marine environment of Cook Inlet, where TES occur. The only instance where a terrestrial-based tanker truck rollover could impact the marine environment would be if a truck rolls over along the port access road for Alternative 2 and Alternative 3 at Diamond Point. The transportation corridor along the edge of Iliamna Bay is short, but immediately adjacent to marine waters. Therefore, a spill would have to occur along this road segment for it to enter the marine environment, which is highly unlikely given the short distance and slow speeds vehicles would be traveling as they leave the port. If a spill were to occur and not be contained prior to reaching the marine environment, some diesel may impact TES such as Cook Inlet beluga whale (rare in the area), northern sea otters (common in the area), Steller sea lions (occasional and uncommon in the area), and Steller's eiders (present from fall to spring). These species may experience inhalation and or ingestion toxicity (through preening for eiders or cleaning oiled fur for sea otters), or consume prey, such as bivalves that have consumed ULSD. Depending on the tidal stage and extent of the spill, various substrates may entrain oil resides. Mud flats and unconsolidated materials that are porous have a potential to trap oil; species may then become exposed again during high tides or storm events. Spills that occur in close proximity to the port have a higher potential to be contained and cleaned up relatively quickly due to the close proximity of spill response equipment. However, tides and wave action would likely disperse some of the diesel. Although there is a potential for a small amount of ULSD to reach the marine environment, impacts are likely to be short-term (several months to a few years) and restricted to the immediate vicinity of the spill. Any ULSD that spreads beyond Iliamna Bay would be highly dispersed, and would evaporate and degrade quickly. Additional details of impacts from ULSD in the marine environment are provided below under the marine tug-barge allision scenario.

Marine Mammals

A diesel spill that occurs on the Alternative 1a or Alternative 1 road corridor would not reach the marine environment of Cook Inlet and would have no impact on marine mammals in Cook Inlet. However, if a spill occurred in waters that flow into Iliamna Lake, there is a potential for harbor seals to be impacted. There is a potential for inhalation, ingestion, or dermal absorption of ULSD or consumption of contaminated prey. The magnitude would vary depending upon time of year, specific location in the lake and if harbor seals are present. If ULSD were to enter Iliamna Lake impacts are likely to be short-term (several months to a few years) and likely disperse downstream with continual flushing of the lake from stream inputs. In addition, the ULSD would continue to evaporate and degrade through natural weathering processes. The magnitude of potential impacts would likely be low due to the dispersed nature of the ULSD and may impact a few harbor seals if they are in the vicinity at the time of a spill.

Alternative 2 and Alternative 3—Diamond Point Port—If a diesel spill occurred along the Alternative 2 and Alternative 3 transportation corridor along the port access road at Diamond Point and some ULSD reached the marine waters of Cook Inlet in Iliamna Bay, some marine species may be impacted. Similar to impacts detailed above for TES, harbor seals, porpoises, whales, and other marine mammals that are in the immediate vicinity of the spill have the potential to be impacted by inhalation, ingestion, and consumption of oiled prey. Although there is the potential for a small amount of ULSD to reach the marine environment, impacts are likely to be short-term (several months to a few years), restricted to the immediate vicinity of the spill, and impact a few individuals present during the spill. Any ULSD that spreads beyond Iliamna Bay would be highly dispersed and would evaporate and degrade quickly. Additional details of impacts from ULSD in the marine environment are provided below under the marine tug-barge allision scenario.

Needs and Welfare of the People–Socioeconomics

It is unlikely that cleanup and remediation activities following a tanker truck release would result in increased employment opportunities in the region. Cleanup crews would be small, and likely consist of PLP personnel.

Commercial and Recreational Fishing

In the event of petroleum spills, Alaska Department of Fish & Game (ADF&G) has the power to close commercial fisheries through the Emergency Order process, as it did in July 2018 with the sinking of the Fishing Vessel Pacific Knight. The 3,000-gallon tanker spill scenario would not affect commercial fishing in the immediate term unless the spill occurred during the fishing season, and reached fishing grounds in visible concentrations. In the longer term, a spill could result in an extremely limited reduction in harvest value if the spill killed juvenile salmon or eggs that might have been future adult returners. Roughly 1 in 1,000 eggs turns into a returning adult salmon; and historically, the commercial fishery has harvested nearly 70 percent of returning adult sockeye. Therefore, roughly 1 in every 1,400 to 1,500 eggs is harvested as an adult by the commercial fishery; and over the last 20 years, the 10-year average ex-vessel value per harvested sockeye has ranged from $4.75 to $7.62 in 2019 US dollars.

Recreational fishing opportunities and effort could be affected in the near-term if the spill occurred during the open-water fishing season, and if anglers choose to avoid areas with visible ULSD concentrations. However, the stream receiving the spill would not likely comprise the majority of its watershed, and the clean portions of the watershed may continue to provide recreational fishing opportunities. Nearby unimpacted waterbodies may provide alternative recreational use sites. Large-scale mortality events are not expected, and the potential for longer-term impacts is extremely low.

Cultural Resources

Direct impacts to cultural resources from a potential spill resulting from a tanker truck rollover and release of 3,000 gallons of diesel to the surrounding environment would directly impact cultural resources or known or potential historic properties if such a release would occur within the bounds of a cultural resource area or historic property site. These impacts could include contamination of organic cultural materials and site sediments. Such an event would likely result in direct impacts through loss of integrity for eligibility to the National Register of Historic Places (National Register) from cleanup activities. These impacts would likely severely damage the site, and resources would not be anticipated to return to previous levels even after actions that caused the impacts were to cease. Indirect impacts could occur to the character or setting (visual, noise, and olfactory impacts) of cultural resources if the spill were to occur in the vicinity. These impacts are particularly acute where setting and feeling are crucial aspects of a cultural resource's importance. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Those impacts would be temporary and would cease when response efforts are completed.

Subsistence

A diesel spill resulting from a tanker truck rollover could have impacts on subsistence. Animals and subsistence users may temporarily avoid the area of the spill. The effects would be localized and temporary because fuel would evaporate, and be cleaned up. If soil excavation and/or site remediation are required, impacts to subsistence plants could last multiple seasons at the spill site. Quick response and cleanup of the spill, as well as clear and timely communication with nearby communities, would help ease concerns about contamination for subsistence users in nearby communities.

Health and Safety

A release of diesel could cause stress to community members in close proximity from real or perceived risks of contamination, and potentially impact human health. Spills create anxiety about the safety of subsistence foods and water quality. Quick response and containment of spills (particularly for spills in water), and a system of testing wild foods and drinking water for contaminants to give local people complete and understandable information in a timely manner, could help alleviate some anxiety and reduce potential impacts to human health. There would be potential adverse impacts to social determinants of health (Health Effects Criteria [HEC] 1), with psychosocial stress resulting from community anxiety over a tanker truck release. A tanker truck release may involve a surface transportation accident or injury, but would not likely create increased risks for transportation-related injury or accident (HEC 2). The duration of impacts would be short-term (1 to 12 months). There could be potential diesel or diesel fume exposure (HEC 3), and impacts to subsistence resources and food security (HEC 4).

Scenario: Diesel Spill from Marine Tug-Barge Allision

This scenario considers the probability and consequences of a 300,000-gallon spill of diesel from a marine tug-barge hauling diesel through Lower Cook Inlet into one of the potential ports in Kamishak Bay. The scenario addresses the diesel that would be transported by marine tug-barge each year for use at the mine site. Other oil products (e.g., bunker, lube oil, hydraulic fluid) are used in much smaller volumes by marine vessels and are not being analyzed here.

In this scenario, a barge allision with a rocky shoal results in a rupture of one of the fuel compartments, resulting in the release of 300,000 gallons of diesel into Lower Cook Inlet. There are a number of submarine rocky outcrops (shoals) in Kamishak Bay that pose a danger to passing ships. Ship captains would be aware of these shoals, and would operate vessels accordingly; but foul weather, strong currents, or a loss of power could cause ships to become grounded and damaged by the rocks. The outer hull of the double-hulled barges is designed to protect the fuel compartments from damage, so that the probability of a release from this scenario is very low.

The probability analysis herein is based on the most recent US data on marine oils spills from BOEM for OSRA (BOEM 2016), as well as a project-specific study on maritime oil spill risk assessment (Owl Ridge 2018c). Based on analysis of these data, a 300,000-gallon spill has a 1.5×10^{-4} annual probability of occurrence, or a 0.015 percent chance of occurring in any given year (BOEM 2016; Owl Ridge 2018c; AECOM 2019a). The estimated recurrence interval of such a spill is 6,600 years, with a probability of occurrence of 0.30 percent in 20 years, or 1.2 percent in 78 years (AECOM 2019a). Note that this spill risk is based on data from Cook Inlet, and is not specific to Kamishak Bay. See AECOM 2019a for details on the statistical analysis and review of relevant data.

As previously noted and as outlined in AECOM 2019a, lower-volume spills have a higher probability than higher-volume spills. A 300,000-gallon spill from a marine vessel has a low probability. The larger-volume spill scenario was selected to address a wider range of potential impacts that could occur compared to a smaller-volume spill.

On release of the diesel into Lower Cook Inlet, the diesel would rapidly spread out and float on the surface of the water in a thin film, while strong tides and currents would immediately begin to disperse it. Wave action could cause the diesel to emulsify, breaking it up into small droplets that float in the water column, and are then further dispersed by tides and currents. The spilled diesel would immediately begin to evaporate into the atmosphere. Within hours, the diesel would be widely dispersed over the water surface in the surrounding area. High wind and waves could increase the rate of dispersion. Photo oxidation would further break down the floating diesel over a period of days to weeks (NOAA 2018i). If no recovery efforts were made, the diesel would be expected to naturally evaporate and disperse within 10 to 20 days (AECOM 2019a). During winter conditions, an estimated 67 percent of the diesel would evaporate within 4 days (Owl Ridge 2018c). Evaporation rates would likely be higher during summer months.

A site-specific oil spill trajectory model predicts that the remaining floating diesel would be transported southward out of Kamishak Bay towards Shuyak and Afognak islands, north of Kodiak Island, and/or to Cape Douglas, depending on sea conditions. Much of the remaining diesel would likely evaporate and disperse before beaching on these shorelines. Depending on currents and proximity to the shoreline, remaining diesel could be washed ashore. The oil spill trajectory model predicts that most of the remaining diesel would be beached at Shuyak Island State Park and Kodiak National Wildlife Refuge (Owl Ridge 2018c).

Beached diesel could penetrate shoreline sediments, such as sandy beaches. Wave action would be expected to continue flushing the diesel back out to sea, while the diesel would continue to evaporate and disperse. Some diesel could penetrate into sandy surfaces and contaminate beach sand. Naturally occurring soil microbes would likely consume and decompose the diesel, although in a cold climate, it is unknown how long this process would take to fully consume the diesel. In the event of a near-shore diesel spill with heavy contamination of shoreline sediments, the contaminated sediments could be excavated and removed for off-site mitigation.

Spill Response

See the "Spill Preparedness, Prevention, and Response Measures" subsection for the actions that the Applicant has committed to. Alaska regulations 18 AAC 75.432(a)(1) and 18 AAC 75.432(2) outline the requirements for responding to a spill that enters open water, including containing or controlling the spill within 72 hours, and cleaning up the spill in the shortest possible time to minimize damage to the environment. Alaska State regulation 18 AAC 75.425 outlines requirements for an ODPCP. PLP would have an ODPCP plan (or a more comprehensive plan that covers all requirements) in place that would detail the measures to prevent, respond, contain, report, and clean up diesel spills (PLP 2019-RFI 126).

Diesel spill response would begin immediately with barge personnel. Barges would be equipped with oil spill response kits, and operators would be trained in spill reporting and procedures to minimize and contain low-volume spills. Due to the large size of this hypothetical spill, the operators would contact the Alaska Chadux oil spill response group for assistance. Chadux is able to respond to some spill sites around Alaska within 24 hours, but due to the remote location of Kamishak Bay, response times are unknown. Oil spill response efforts could also be delayed by adverse sea conditions, including storms and/or sea ice.

Response crews would likely deploy booms to contain the spill, pump diesel from the water's surface into secondary storage, and apply sorbents to collect residual fuel, etc. The longer the diesel remains in the water, the more difficult it would become to recover. Even assuming a rapid response within 24 hours, containment and recovery of light fuels such as diesel are extremely difficult, and only a portion of the diesel would likely be recovered. Much of the diesel would naturally evaporate and disperse within hours to days (NOAA 2018i; AECOM 2019a). Dispersants are typically not used for light oils such as diesel. Non-mechanical recovery (i.e., in situ burning off of diesel) could be used in extreme cases, such as to prevent diesel from entering a sensitive area. It may be necessary to clean up the shoreline through contaminated soil removal or other methods for areas with residual diesel.

Response efforts could also include helicopter overflights to observe the dispersal of the diesel, determine the extent of possible shoreline oiling, and determine if any marine mammals, birds, or other vulnerable species are present and at risk of oiling.

Alternatives Analysis

The potential for a marine tug-barge allision could vary somewhat by alternative. Alternative 1a and Alternative 1 would include the Amakdedori port location, while Alternatives 2 and 3 would use the Diamond Point port. Both Amakdedori and Diamond Point port have nearby rocky shoal outcrops (Section 3.15, Geohazards and Seismic Conditions). The Diamond Point port site generally has thicker sea ice in higher concentrations for longer periods than the Amakdedori port site (Section 3.16, Surface Water Hydrology). The variation in dock design between alternatives would not be anticipated to modify the potential for a marine tug-barge allision.

The protected nearshore waters around Diamond Point port have biological resources that are generally more abundant and concentrated compared to the Amakdedori port location, including several nearby seabird colonies. See the “Alternative 2 and Alternative 3—Diamond Point Port” subsection for impacts analyses specific to the Diamond Point port under wildlife, marine mammals, birds, fish, and threatened and endangered species.

Potential Impacts of a Diesel Spill from Marine Tug-Barge Allision

This section addresses potential impacts of a diesel spill from the marine tug-barge allision scenario described above. Impacts are considered in terms of their magnitude, duration, geographic extent, and potential to occur. A marine diesel spill would not impact all the resources addressed in this EIS. The following resources were selected for analysis due to the higher potential significance of the impacts.

Soils

Shoreline sediment contamination could occur where diesel washes onshore, but the contamination would likely be short-term. Any diesel washed onshore would be continually flushed by wave action, and unlikely to accumulate on soils (NOAA 2018i). If, however, a large volume of the spilled diesel were to be washed onshore, there is a potential for direct hydrocarbon contamination of soils. Impacts would be similar to those addressed above for the tanker truck scenario, with a greater or lesser magnitude, depending on how much diesel reaches land. The extent and duration of impacts would also vary, depending on the volume of diesel that comes in contact with soils.

Water and Sediment Quality

Marine Environment—A 300,000-gallon spill of diesel into Lower Cook Inlet would cause high-magnitude direct impacts to marine water quality from hydrocarbon contamination. The high concentration of hydrocarbons from the floating diesel would greatly exceed applicable WQC in the upper portions of the water column. Toxic components of diesel could also be entrained in turbulent water such as tidal areas. Some toxic components of diesel could persist in the environment after most diesel has weathered or evaporated. The extent of impacts would include the upper portions of the water column for potentially miles of open ocean, because the floating diesel would spread out immediately on release, and be distributed farther by currents, waves, and tides. Under the Fuel Oil Spill Trajectory Modeling Report for the Pebble Project (SLR 2018), a 300,000-gallon spill in Kamishak Bay directly south of Augustine Island would spread to the south, and reach the northern shores of Shuyak and Afognak islands and/or Cape Douglas, depending on sea conditions, within 4 to 5 days. Emulsification of the diesel could allow droplets of diesel to spread down through the water column, impacting water quality somewhat deeper beneath the surface. Cleanup efforts could reduce the geographic extent of the contamination by containing and recovering some of the spilled diesel.

The duration of the contamination would last until hydrocarbon levels of impacted waters returned to below threshold levels specified by applicable WQC (15 µg/L; ADEC 2018a). The persistence of the diesel would vary with weather and sea conditions. The ULSD would naturally evaporate and disperse after approximately 10 to 20 days (AECOM 2019a; SL Ross et al. 2003). Cleanup efforts would likely reduce the duration of the contamination by containing and recovering some of the spilled diesel. The duration of impacts would probably be on the order of 2 to 3 weeks or less before spill recovery efforts and natural weathering processes removed the spilled diesel.

Due to the presence of suspended sediment in Cook Inlet, a small volume of diesel could adsorb onto suspended sediment (mostly silt), and could eventually settle onto the seafloor. Although the extent could cover multiple square miles of seafloor and the duration could last for years, the magnitude of seafloor sediment contamination would likely not exceed SQGs due to dilution.

On-Shore Environment—A marine spill of diesel is unlikely to cause exceedance of water quality criteria for onshore surface water or groundwater. Diesel that is able to wash onshore would be continually flushed by wave action and diluted by uncontaminated seawater (NOAA 2018i). Variations in beach substrate would alter the ability of waves to flush diesel from the shoreline. If, however, a large portion of the spilled diesel were to be washed onshore, there is a potential to contaminate coastal waterbodies and shallow aquifers with elevated hydrocarbon levels. Some diesel could be trapped in shoreline sediments, including locally abundant tidal mudflats, possibly facilitated by burrows of various benthic invertebrates. Diesel trapped in shoreline sediments may be re-entrained in seawater before it fully degrades.

Diesel could potentially be washed onshore into a coastal pond, and stranded. Diesel emulsions and dissolved hydrocarbons could potentially infiltrate permeable beach deposits into shallow, unconfined aquifers and impact groundwater quality (Kuan et al. 2012). Impacts would be similar to those addressed above for the tanker truck rollover scenario.

Noise

Noise could be generated from spill recovery operations, including increased vehicle and/or helicopter traffic, and use of recovery equipment (such as pumps). However, the time over which additional noise would be generated would be limited to the time required for the recovery effort (limited duration); localized in the area of recovery operations; and with low increase in sound levels.

Air Quality

VOCs, HAPs, and GHG pollutants resulting from a spill would be high in the immediate vicinity of the spill, but would decrease quickly due to the dispersion of the spill itself, and dispersion of pollutants by the winds, waves, and currents. Ambient concentrations eventually return to pre-spill conditions in a relatively short period of time (BOEM 2012).

In situ burning, a potential component of spill response strategy, would generate products of combustion (carbon monoxide, oxides of nitrogen, sulfur dioxide, PM, and black smoke). Ambient air quality would return to pre-burn conditions relatively quickly (BOEM 2012).

The magnitude and potential of the impacts would depend on the amount of diesel fuel that evaporates, disperses, or burns. With greater amounts of fuel that evaporates or burns, the impacts would be more likely, and larger in magnitude. Concentrations of criteria pollutants could temporarily exceed the NAAQS concentrations; however, over time, the air quality would return to pre-spill conditions. The duration of air quality impacts would be temporary, and return to pre-activity levels at the completion of the activity. The extent of impacts would mostly be limited to near the spill location in Kamishak Bay.

Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

A marine spill of diesel is unlikely to have impacts on wetlands and special aquatic sites that would require remedial action. Any diesel washed onshore would be continually flushed by wave action, and would be unlikely to accumulate on shoreline vegetation (NOAA 2018i). If, however, a large volume of the spilled diesel were to accumulate, there is a potential for direct oiling of vegetation and contamination of sediments. This would most likely affect estuarine waters and mudflats in nearby protected bays. Effects on sediments are described above for Water and Sediment Quality. A large amount of diesel that penetrates wetland soils could cause high plant mortality (NOAA 2019d). Vegetated tidal wetlands, such as salt marshes, are very scarce in the project vicinity. Impacts to these wetlands would be similar to those addressed above for the tanker truck scenario, with a greater or lesser magnitude, depending on how much diesel reaches shore.

Terrestrial Wildlife

Impacts from a 300,000-gallon spill of diesel into Lower Cook Inlet are anticipated to have minor impacts on terrestrial wildlife. Most terrestrial species do not use the marine-terrestrial interface extensively, although some large mammals, such as brown bears (*Ursus arctos*) and other mammal species (such as river otters), may occasionally forage along exposed tidal flats in Kamishak Bay. In Kamishak Bay, there is a small area of razor clam (*Siliqua* species) beds at the mouth of Amakdedori Creek (GeoEngineers 2018), but the rest of Kamishak Bay does not support extensive razor clam beds (NOAA 2002), and therefore it is not a major clamming area for bears. There are exposed tidal flats in Kamishak Bay around Amakdedori port that may be impacted by a diesel spill. The closer to shore that the spill occurs, the more ULSD would end up along the shoreline; however, the further away from Amakdedori port that the spill occurs, the diesel is more likely to drift south in the Douglas River Shoals area, and beyond. The magnitude of the spill remains the same regardless of where the spill occurs; however, the geographic extent of the diesel spill increases the further from shore that the spill occurs. Under the Fuel Oil Spill Trajectory Modeling Report for the Pebble Project (SLR 2018), a 300,000-gallon spill in Kamishak Bay directly south of Augustine Island would spread south; and within 4 to 5 days, mass around the northern shore of Shuyak and Afognak islands. The scenario is similar if it occurs during November to December and March; therefore, the diesel ends up in the same location regardless of the time of year. There is a potential for marine bivalves and other invertebrate filter feeders to ingest diesel that washes onto tidal flats exposed during lower tides. They may experience mortality, depending on the concentration of diesel they ingest. Diesel trapped in shoreline sediments may be re-entrained in seawater before it fully degrades. Invertebrates and other terrestrial wildlife prey species may be consumed by terrestrial mammals foraging along the shore, which may lead to trophic-level transfer of ULSD contaminants. It is assumed that some diesel that comes in contact with the shore would be cleaned up during spill response efforts (although some diesel would likely soak into the ground and be lost), and the length of time required for cleanup would vary depending on the exact location and ability for cleanup crews to reach the affected area.

Overall impacts on terrestrial wildlife are anticipated to be localized, and the duration would vary (several months to a few years) depending on the amount of acute versus chronic impacts. During the chronic phase of the *Exxon Valdez* oil spill (which is not specifically comparable to an ULSD spill, but provides context for acute versus chronic impacts), much of the bioavailable oil was found in intertidal habitats, so wildlife that use those habitats were more likely to be exposed to oil and suffer chronic effects of exposure (Esler et al. 2018). Chronic effects of oil spills on wildlife can occur in several ways, including direct (i.e., lingering oil that has not broken down and occurs in sediments of beaches and other locations that sequester oil), and delayed toxic effects (i.e., immunity suppression, genetic material and organ system damage, and oxidative stress), demographic lags (i.e., delay in population recovery due to reduced reproductive potential, rates of dispersal, population structure), and indirect effects (impacts to prey and food web disruption)(Esler et al. 2018).

Individual terrestrial mammals may also be affected by wildlife protection measures, including hazing and pre-emptive capture and relocation activities designed to prevent animals from encountering the spill area. Capture and handling of wildlife can increase exposure to infectious diseases, and animals exposed to contaminants may have suppressed immune function (USFWS 2015b). Typical spill response actions are expected to be relatively small in scale, with impacts limited to the vicinity of the spill site and would therefore affect a limited number of terrestrial mammals. Impacts could extend until remnant diesel is cleaned up or broken down.

Research on brown bears along the Katmai coast was conducted following the *Exxon Valdez* oil spill to determine if there were population-level impacts (Sellers et al. 1999). Biologists observed brown bears in Katmai National Park feeding on oiled bird carcasses and intertidal invertebrates on oiled beaches (Lewis 1993). One yearling brown bear was found dead, with high concentrations of naphthalene and phenanthrene, and it is believed to have died from ingestion of crude oil (Sellers et al. 1999). Several other bears showed exposure to crude oil. To understand potential population-level effects, the survival and reproductive rates between radio-collared adult female brown bears whose movements indicated possible use of oiled shorelines were compared with bear locations at a different site (at Black Lake further south along the Alaska Peninsula), where there were no oiled beaches. Sellers et al. (1999) did not detected a significant difference in survival or reproductive rates from 1989 to 1991, compared to 1992-1995 (when toxicity and availability of oil from the spill was considered negligible). It was therefore concluded that the *Exxon Valdez* oil spill did not result in measurable impacts on the Katmai brown bear population.

Other species, such as river otters, were also affected, with fewer otters in oiled areas; and they appeared to be less healthy. Some river otters died directly from oil coating or toxic crude oil fumes (Lewis 1993). Based on Esler et al. 2018, river otter populations were impacted by the *Exxon Valdez* oil spill because they spend time in coastal environments feeding on nearshore marine fishes, which placed them in proximity to spilled oil and chronically lingering oil in intertidal beach sediments. River otters from oiled areas showed compromised health during the years immediately after the spill, and their population was considered recovered by 1997 (Esler et al. 2018). Therefore, terrestrial wildlife has a potential to be impacted both directly (through inhalation and coating in ULSD) and indirectly (through consuming oiled prey) with varied impacts depending on the species impacted. As detailed previously, multiple spill response measures would be implemented to the extent feasible if a spill were to occur. A large portion of the ULSD would evaporate, degrade, and dissipate, with impacts on species directly in the footprint of the ULSD spill. Overall impacts on terrestrial wildlife are anticipated to be localized and short-term (several months to a few years), but could extend longer depending on the resuspension of oil from semi-porous substrates such as unconsolidated materials, clay fines, and sands. The geographic extent of impacts would be influenced by tidal flow, and the exact location of the spill and direction it is carried in the current. It is assumed that some diesel that comes in contact with the shore would be cleaned up during spill response efforts (although some diesel would likely soak into the ground and be lost), and the length of time required for cleanup would vary depending on the exact location, and the ability for cleanup crews to reach the affected area.

Alternative 2 and Alternative 3—Diamond Point Port—If this spill were to occur near the Diamond Point port, ULSD could end up in several locations, depending on the time of year, currents, wind patterns, tidal stage, etc. If the spill occurred near the entrance to Iliamna and Iniskin bays, species in the bays and nearshore environments would likely be impacted. If the spill occurred further offshore, the ULSD would likely rapidly dissipate, with some of it adhering to the nearshore environment around Augustine Island. In either case, both marine mammals and marine birds, which are discussed below, would be impacted to a greater degree than terrestrial wildlife. Impacts to terrestrial wildlife (which are detailed above) may occur if species are foraging along the shore or consume oiled prey. In particular, bear surveys around the eastern part of Iliamna Lake to Diamond Point and Iliamna and Iniskin bays between 2004 and 2007 documented high densities of brown bears; particularly along the Iniskin River and the end of Iniskin Bay (ABR 2011c). Large numbers of brown bears were observed in the sedge meadows and mudflats at the heads of Iniskin and Chinitna bays during spring and summer each year, with the highest numbers in June (ABR 2011c). Therefore, there is a potential for bears (and other wildlife) that feed along the shoreline to be exposed to ULSD, depending on the time of year, location of the spill, tidal/wave action, and extent of spill containment and cleanup. Overall impacts are anticipated to be of low magnitude, and may impact a few individuals, with a duration lasting from several months to a few years, depending on how much ULSD is cleaned up and how quickly it is broken down by microbes.

Birds

The assessment of oil spill impacts to migratory birds is based on not only oil type (e.g., lighter diesel versus heavier crude), but a combination of risk factors, such as probability of a spill, spill size, spill duration, weather conditions, and effectiveness of oil spill response (Stehn and Platte 2000). Based on the Cook Inlet Maritime Risk Assessment: Spill Baseline and Accident Casualty Study (Glosten 2012), diesel is not as adhesive to substrates; evaporates more readily; and is considered relatively non-persistent in the environment compared to heavier crude oils. The anticipated persistence time in the environment for diesel can range from 1 month up to 1 year, depending on the concentration and location of the spill. Diesel also may show greater acute toxicity due to evaporation of volatile components, which can be inhaled. The following description of the short- and long-term effects of oil spills on birds is summarized from the US Fish and Wildlife Service (USFWS 2004b), EPA (1999b), and the National Oceanic and Atmospheric Administration ([NOAA] 2020).

Many studies on impacts to birds from large oil spills are related to heavier oil (such as crude oil) spills and are not specific to lighter oils such as ULSD. Although both oil types contain many of the same compounds, they react differently when spilled into the environment and have different persistence rates. Although many of the impact assessments are based on heavy oils, the severity of oil spills to birds relies more heavily on whether birds are present in the spill area and are likely to come in contact with the spilled oil, rather than the oil type.

Diesel can foul bird feathers as severely and readily as crude oil, destroying the insulation and/or buoyancy that feathers provide. Light oils, such as diesel, can also leave a film on intertidal resources, and have the potential to cause long-term contamination (through re-entrainment during storm surges and high tide events). Birds that use the intertidal zone to rest or forage can be exposed to these diesel residues (USFWS 2004b). The presence of diesel in the environment may be of shorter duration than heavy oils, but while diesel remains in the environment, the risk to birds (from physical fouling, acute toxicity, and sublethal toxicity) is probably very similar to that of heavy oil, given the presence of toxic PAHs in both.

Spilled oil (including diesel and heavier crudes) can adversely affect birds from both internal and external exposure (NOAA 2020). Oil harms birds through physical contact, toxicity through ingestion or inhalation, destruction of food sources or habitat, and through long-term reproductive impairment. Physical contact with oil destroys the insulation value of feathers, causing mortality from hypothermia or loss of buoyancy. Heavily oiled birds can lose their ability to fly and their buoyancy; causing drowning. In an effort to clean themselves (preen), birds ingest and inhale oil. Ingestion can kill animals immediately, but more often results in lung, liver, and kidney damage and subsequent death. Birds constantly preening to remove oil, or unable to fly due to the oil, would be more vulnerable to predators. In the long-term, oil ingestion has been shown to suppress the immune system, and cause organ damage, skin irritation and ulceration, damage to the adrenal system, and behavioral changes. Oil can also affect animals in non-lethal ways, such as impairing growth and reproduction, and from the loss of important habitat.

Diesel is considered to be one of the most acutely toxic oil types, and can affect marine birds by direct contact, but remains on the water surface for only a brief time and is rapidly diluted (NOAA 2018i). Several hundred small diesel spills from fishing vessels in Alaska over the past decade have resulted in few birds being directly affected. However, a small diesel spill occurring adjacent to a large nesting colony, or in a high bird concentration area, could cause more serious impacts (NOAA 2018i).

During most large oil spills (which are generally heavier oils compared with diesel), seabirds are harmed and killed in greater numbers than other kinds of creatures (NOAA 2020). The types of birds most affected by an oil spill at sea are those that spend a majority of their time on the surface of the water, such as gulls, geese, ducks, auks, grebes, terns, and loons. If the oil reaches shore, shorebirds and songbirds may be affected, as well as any birds that use these contaminated habitats. Migratory birds may be affected if critical migration staging, foraging, or resting areas are contaminated, especially if the spill occurs during a season of high migratory bird use (such as during spring migration). Shorebirds that feed on clams, mussels, worms, and other invertebrates in the intertidal zone may consume prey that has been exposed to oil along the shoreline (Ober 2010). There are several shorebird concentration areas where large numbers of shorebirds congregate, primarily during spring migration in Iliamna and Iniskin bays. Shorebird concentration areas are often situated where dense populations of *Macoma* clams are found (Glosten 2012). Bivalves, such as clams, are unable to metabolize PAHs, which are toxic components of oil. Therefore, this could lead to a reduction in prey source for migrating birds. Shorebird species such as least sandpipers (*Calidris minutilla*), western sandpipers (*Calidris mauri*), and semipalmated plovers (*Charadrius semipalmatus*) that stop-over during migration may be impacted. Migratory stop-over locations are critical staging and foraging areas for migrating shorebirds, because they rapidly feed for a few days before moving on.

If a spill occurs in winter, the only shorebird species present in Cook Inlet would be the rock sandpiper (*Calidris ptilocnemis*). However, in some winters, almost the entire population of the nominate race of rock sandpiper (*Calidris ptilocnemis ptilocnemis*), a species of high conservation concern, winters in Upper Cook Inlet (Ruthrauff et al. 2013). The species forages primarily on the bivalve (*Macoma balthica*) in areas where foraging substrates (intertidal mudflats) are accessible, even during periods of extreme cold (Ruthrauff et al. 2013). A spill during the winter could impact a primary rock sandpiper foraging area. Rock sandpiper distribution during the winter does not heavily overlap with Kamishak Bay or Iliamna or Iniskin bays (refer to Section 3.23, Wildlife Values, for numbers of shorebirds); therefore, a spill that impacts these areas along western Cook Inlet may impact several hundred foraging rock sandpipers.

If a ULSD spill occurred during the summer breeding season, impacts to birds would be especially intense due to large numbers of breeding seabirds in lower Cook Inlet. If birds came into contact with spilled diesel, individuals could be killed, sickened, lose food and habitat, or experience reproductive problems. If the spill spreads to shore, nesting birds may be affected. Later in the summer, any birds that may be molting in the vicinity of the spill would be vulnerable to adverse impacts due to their temporary inability to fly. The Douglas River Shoals area, which forms the southern boundary of Kamishak Bay, provides important molting and wintering areas for a variety of waterbirds in a complex matrix of tidal mudflats and marshes. This area is also important staging and breeding habitat for a variety of waterfowl species (NOAA 2002). Oil in this area has a potential to adhere to substrates and become re-entrained during high tides and storm events.

Numerous foraging areas of regional or global importance for sea ducks, seabirds, and breeding seabird colonies, as well as areas important for migratory shorebirds, are in lower Cook Inlet, as detailed in Section 3.23, Wildlife Values. Although there are no seabird colonies at Amakdedori port, there are several to the north and south; and multiple nesting areas are at the mouths of Iliamna and Iniskin bays. In addition, there are many seabird colonies around Cape Douglas at the mouth of Cook Inlet and Shuyak and Afognak islands, which may be impacted if spilled diesel spreads that far south (NOAA 1997). Seabird colonies that are south of Kamishak Bay that may be impacted by ULSD drifting on currents that head south out of Cook Inlet include colonies around Cape Douglas. Seabirds that breed in the area include pelagic and red-faced cormorants, black-legged kittiwakes, glaucous-winged gulls, tufted and horned puffins, pigeon guillemots, and black oystercatchers (NOAA 2002; Griffin 2018).

During the summer, seabird colonies on the northern sides of Shuyak and Afognak islands include many of the same species observed at Cape Douglas, and include glaucous-winged gull, mew gull, pelagic cormorant, tufted and horned puffins, parakeet auklet, pigeon guillemot, arctic tern, black oystercatcher, and common eider (NOAA 1997). These birds are generally present in and around their nesting colonies or in the general vicinity from April through October. During the winter, there are large concentrations of waterfowl off the coast on the northern side of Shuyak and Afognak islands. There are also bald eagles nesting in many locations around these islands. Oil has a potential to impact nesting seabirds and bald eagles that are foraging in nearshore waters through contamination of eggs and young from oiled feathers on adult birds, and potential for colony disturbances from cleanup activities. Waterbirds are particularly vulnerable to oil spills and response activities during the molting period from late June through mid-August, and during the wintertime (NOAA 1997).

Many bird populations can recover following a one-time mortality event (e.g., a localized oil spill) if the fraction of the total population killed remains small. However, as the fraction killed becomes larger, the severity of population impact can increase above that expected by a simple proportional change (Stehn and Platte 2000). Disruption of social behavior, loss of mates, competition with other species, or increased predation may prevent or extend the time before population recovery. Declining populations or populations with a limited capacity for growth would be at greater risk. All loons, eiders, and other sea ducks have a relatively low capacity for population growth (Stehn and Platte 2000).

The March 1989 *Exxon Valdez* oil spill has been heavily studied to understand the impacts on avian populations in Prince William Sound and the Gulf of Alaska. Although the *Exxon Valdez* oil spill (in which over 11 million gallons of crude were released into the environment) is not a suitable analogy for the 300,000-gallon ULSD spill considered in this scenario, it provides some insight into population-level impacts to birds in the area from oil spills. Various bird populations responded differently; and while some recovered quickly, some have yet to recover. Bald eagles were exposed to acute impacts of oil through depredating or scavenging on marine animals (including carcasses) nearshore and on oiled beaches (Esler et al. 2018). Bald eagle populations in the area affected by the spill experienced 5 percent acute mortality but had recovered by 1995 to pre-spill numbers. Other species such as harlequin ducks, pigeon guillemots, and marbled murrelets did not fare as well. Harlequin ducks, which have high site fidelity, relatively small home ranges, feed heavily in the intertidal habitat where oil persisted, consume benthic invertebrates, and have delayed maturity and limited annual productivity, were not considered recovered until 2014 (Esler et al. 2018). Both pigeon guillemots and marbled murrelets have undergone long-term declines, and have not recovered following the spill. The spill occurred at a time when many piscivorous seabirds declined in abundance in Prince William Sound, potentially due to a change in the pelagic food web (Esler et al. 2018). Therefore, the recovery of both species has been confounded by ecological changes in the marine environment that have reduced preferred prey availability. Both species have not fully recovered to pre-spill population estimates. Therefore, the impacts of a spill in the marine environment could potentially have vastly differing impacts on species, depending on their foraging habitats, locations, and prey. The *Exxon Valdez* oil spill illustrated that birds that consume benthic invertebrates were more likely to be exposed to oil, and subject to chronic direct effects compared with species that consumed fish. Invertebrate prey, particularly filter feeders, may accumulate hydrocarbons, which can lead to detrimental impacts on species consuming them, compared with fish, which possess mechanisms capable of metabolizing and eliminating hydrocarbons (Esler et al. 2018).

This spill scenario magnitude of impact on birds would vary depending on the location and timing of the spill, species impacted, and duration before cleanup activities and natural weathering processes degrade the diesel. The duration would also vary, depending on what proportion of bird populations are affected. Some bird species, such as bald eagles, may recover quickly or suffer minor mortality; other species, such as harlequin ducks and other seabirds, may have longer recovery times. If a spill occurred during the molting or breeding season, it could impact birds at particularly vulnerable time periods and could have colony-level impacts, depending on the precise location and timing of the spill. Spill response activities, including countermeasures such as deflection and containment, and hazing, may affect birds through disturbance and exposure to toxic substances. Individuals may also be affected by wildlife protection measures, including hazing activities designed to prevent birds from encountering the contaminated area. Capture and handling can increase exposure to infectious diseases, and animals exposed to contaminants may have suppressed immune function (USFWS 2015b). Spill response actions could impact birds near the spill site, as well as some distance away, because the diesel could readily travel more than 50 miles within 3 or 4 days (Owl Ridge 2018c).

Alternative 2 and Alternative 3—Diamond Point Port—There are many seabird colonies around Iliamna and Iniskin bays, and on Augustine Island. A review of the Cook Inlet and Kenai Peninsula Environmentally Sensitive Areas (ESA) maps for summer, fall, winter, and spring (NOAA 2002) identify a wide variety of sensitive biological resources at all times of the year. Based on the spring ESA map (and confirmed by surveys for the Environmental Baseline Data; see Section 4.23, Wildlife Values) there are waterfowl concentrations in Iliamna Bay (birds that are staging to head north for breeding) and many seabird colonies.

Based on surveys conducted by ABR in summer 2004 and spring 2005, the most commonly detected waterbird species (over 1,000 birds detected), in decreasing order of abundance across all surveys, were: glaucous-winged gull, harlequin duck, greater scaup, long-tailed duck, Barrow's goldeneye, and green-winged teal (ABR 2011d). Boat-based offshore surveys from summer 2004 to spring 2006 documented fewer birds; when all surveys were totaled, white-winged scoters, glaucous-winged gulls, and long-tailed ducks were the most abundant. Large numbers of waterbirds were detected in both spring and fall 2005, primarily in Iniskin Bay, with estimates of several thousand birds. In spring 2005, higher densities of waterbirds were located near the mouth and middle of Iniskin Bay; in fall 2005, higher densities were further back in Iniskin Bay. Historically, in the mid-1970s, the largest wintering concentration of seaducks in all of lower Cook Inlet occurred in Iniskin Bay; During summer, Iliamna and Iniskin bays contained a large concentration of scoters. Gulls, dabblers, and scaup concentrated in Iniskin and Chinitna bays in the summer (Erikson 1977). Agler et al. (1995) also documented large concentrations of birds on the western side of lower Cook Inlet in summer, and the number of wintering birds (primarily waterfowl) in Iliamna and Iniskin bays was the highest in western Cook Inlet.

The nearshore marine waters of Iliamna, Cottonwood, and Iniskin bays are important year-round habitat for a variety of shorebird species, primarily during spring migration. Surveys conducted by ABR from 2006 to 2012 documented a wide variety of species in Iliamna and Iniskin bays, with the highest numbers of shorebirds moving through the area in early May on their northern spring migration (ABR 2011c). On May 3, 2005, more than 5,000 shorebirds were recorded in Iliamna and Iniskin bays (ABR 2011c). Common shorebirds were western sandpipers and dunlin (ABR 2011c). These birds fed on the mudflats at the back end of Iniskin Bay. Low numbers of rock sandpipers (generally less than 200 birds) also used the bays during fall, winter, and spring from late October through late April; however, they were most abundant in November (ABR 2015c). The largest flocks of rock sandpipers were found foraging on the soft-sediment substrates of inner Iliamna and Iniskin bays.

Many rocky islands, islands, and cliff areas support colonies of breeding waterbirds during summer months at the mouths of Iliamna and Iniskin bays and around Augustine Island. The North Pacific Seabird Data Portal (an online database of seabird colony population numbers from various surveys[1]) includes several seabird colonies in this area. These are South Head, White Gull Island, North Head, Knoll Head, Toadstools, Entrance Rock, Vert Island, Scott Island, Mushroom Islets, Iniskin Island, Twin Rocks, Pomeroy Island, and Oil Reef (USFWS 2012b). Several of these islands (White Gull Island, Vert Island, Iniskin Island, and Pomeroy Island) had greater than 500 breeding birds in the late 1970s (Erikson 1977; ABR 2011a). The main nesting species include black-legged kittiwake, black oystercatcher, common eider, glaucous-winged gull, pelagic cormorant, double-crested cormorant, tufted puffin, horned puffin, and pigeon guillemot, among others. The exact numbers of nesting birds for each species varies depending on the year; however, additional details are provided in Section 3.23, Wildlife Values, regarding species abundance and trends for Iliamna and Iniskin bays. Birds may be impacted through direct oiling of feathers while resting, preening, and foraging on waters coated in ULSD. As the ULSD disperses, evaporates, and degrades, the impact would be reduced; however, ULSD may adhere to the nearshore environment. Species, such as black oystercatchers, that feed along the tide line may be exposed to ULSD. Although the exact fate of the spilled ULSD is unknown, there is a potential for a variety of waterbirds to be exposed. During fall and winter, the nesting waterbirds begin to migrate south, and wintering waterfowl arrive. Protected bays such as Iliamna and Iniskin provide important sheltered overwintering habitat for several species, including scoter species. Therefore, a ULSD spill at any time of year has the potential to impact a large number of birds from a variety of avian species.

A spill of this magnitude could potentially impact several nesting colonies, and result in oiled birds and decreased fitness for overwintering birds. The severity would depend on the timing of the spill in relation to avian activity (e.g., nesting, migrating, staging, molting), precise location, and ability for spill response measures to be implemented. Capturing and handling oiled birds can be difficult, and result in additional stress to handled birds.

Fish

As discussed above, floating diesel tends to weather and evaporate over time from mixing with the stream currents, wind, and wave action (NOAA 2006). Toxic components of diesel could also be entrained in turbulent water such as tidal areas. Some toxic components of diesel could persist in the environment after most diesel has weathered or evaporated. Several direct effects to fish or benthic invertebrates could occur in the spill footprint in littoral or intertidal zones, including:

[1] Analyses and conclusions contained in this document are based wholly or in part on information obtained from the North Pacific Pelagic Seabird Database. The author(s) have complied with published guidelines for the ethical use of data.

- Toxicological effects as fuel fractions are absorbed or consumed by organisms in the affected area.
- Habitat alteration as diesel fuel accumulates onto sediment habitats with the intertidal zone, causing toxicity to algae and marine macrovegetation, epibenthic, and benthic communities, and avoidance by more mobile macroinvertebrates and fish.
- Local disruption of the food web if algae, macrovegetation, and invertebrate communities important to fish are affected by the spill.

The magnitude of impacts would depend on the size of the spill in the nearshore intertidal zone and the character of the shoreline. Although the duration of the effects of diesel spills in open waters is relatively brief, areas that are physically protected have lower flushing rates and smaller tidal movements; therefore, the duration of the effects in those areas may be longer.

Shellfish in protected or shallow water would be at higher risk than finfish, because they are less mobile; unable to avoid exposure; and are indiscriminate filter feeders. Shellfish also lack the enzymes to process and break down ingested contaminants. Finfish are generally more mobile and selective of ingested food, and have enzymes to detoxify exposure to many oil contaminants. Larval life phases of finfish are less mobile, however, and would have a greater exposure to diesel spills than juveniles or adults (NOAA 2019a).

Intensity of the impacts would vary based on the location of the spill, and the species and life stage present. Impacts are not likely to last longer than 30 days in open water, but could be of longer duration in areas physically sheltered from wind, wave, and tidal influences. In these protected areas, there is a potential of mortality to larval fish such as herring and invertebrates, depending on the concentration and persistence of the contamination.

Alternative 2 and Alternative 3—Diamond Point Port—Fish resources of Diamond Point port are described in Section 3.24, Fish Values. Data indicate that juvenile Pacific herring and salmon use habitats in Diamond Point port for rearing. Surveys suggest that the Iliamna and Iniskin Estuaries represent a minor contribution to the Pacific Herring spawning in Cook Inlet (Owl Ridge et al. 2019). Mortality to juvenile fish could occur as described above; however, the soluble fraction compounds have relatively short residence times in water and sediments (Hayes et al. 1992) and can be reduced to below detection levels in a few days or weeks, depending on site-specific conditions.

Threatened and Endangered Species

North Pacific Right Whale, Sperm Whale, and Gray Whale (Western North Pacific DPS)—Under the Fuel Oil Spill Trajectory Modeling Report for the Pebble Project (SLR 2018), a 300,000-gallon spill in Kamishak Bay would spread south; and within 4 to 5 days, mass around the northern shore of Shuyak, Afognak, and adjacent islands. These three whale species have a potential to migrate through and feed in the upper portion of the Gulf of Alaska (through Shelikof Strait and across Stevenson Entrance) and encounter ULSD from the spill scenario as it is carried by ocean currents south through lower Cook Inlet and amasses around the northern shore of Shuyak and Afognak Islands. The period of exposure would likely be limited to a few days if the spill occurred when whales were migrating or present in the area. There is a known gray whale migration corridor in the spring (April to May) and during winter (November to March) along the northern side of these islands (NOAA 1997). The impacts to these species are anticipated to be similar to those detailed below for other whale species, which includes the potential for inhalation (particularly if they surface in an area of floating ULSD), ingestion (particularly if surface feeding), and skin/dermal irritation. The magnitude of potential impacts would depend on the time of year, if whales were present at the time when ULSD is traveling across Shelikof Strait and Stevenson Entrance to the northern shore of Shuyak and Afognak islands, and other environmental factors.

A ULSD spill could impact individuals in listed populations, and would have a greater impact if several whales were affected. If whales were feeding or surfaced in an area of ULSD, they could experience acute impacts. Chronic impacts are less likely to occur because these whale species would be transitioning through the area, and are more likely to occur further south in the Gulf of Alaska away from the modeled spill area. The extent would include the mouth of lower Cook Inlet and the waters on the northern side of Shuyak and Afognak islands. The duration of acute exposure would likely be a few days while ULSD is moved by ocean currents to the northern shore of these islands. The duration of chronic exposure could last longer, depending on impacts to prey species and potential for re-exposure, which in turn would depend on the extent of cleanup activities and natural weathering processes.

Cook Inlet Beluga Whale— The magnitude of potential impacts from the diesel scenario on the Cook Inlet beluga whale (*Delphinapterus leucas*) is high, because the stock and its critical habitat are only found in Cook Inlet (NMFS 2016b). Catastrophic events such as high-volume petroleum-based spills are infrequent, but may have effects on Cook Inlet beluga whale prey, whether through changes to spawning or migration patterns, direct mortality, or potential long-term sub-lethal impacts (Murphy et al. 1998). On contacting spilled oil, Cook Inlet beluga whales may experience inhalation, ingestion, and skin and conjunctive tissue irritation. Injury and mortality due to physical contact, inhalation, and ingestion is possible to beluga whales, especially calves of the year and juveniles (NMFS 2016b). The extent of a diesel spill depends on the location, weather conditions, and timing of the spill. Cook Inlet beluga whales are typically distributed in Upper Cook Inlet in summer and fall, and are more likely in the analysis area during winter and spring. Under the Fuel Oil Spill Trajectory Modeling Report for the Pebble Project (SLR 2018), a 300,000-gallon spill in Kamishak Bay directly south of Augustine Island would spread south; and within 4 to 5 days, mass around the northern shore of Shuyak, Afognak, and adjacent islands. This includes a variety of marine mammal habitat, including Cook Inlet beluga whale critical habitat (in Kamishak Bay). Localized effects from spills are generally limited to the direct damage to habitat in the immediate area of the spill; and the amount of critical habitat potentially impacted by a diesel spill is low in comparison to the total amount of critical habitat in Cook Inlet. The duration of acute impacts would be short because diesel rapidly evaporates, disperses, and is broken down. However, the duration of chronic impacts could be much longer (up to several years) depending on the extent of impacts to individual whales and their prey. Although much of the refined oil spilled is expected to either evaporate or naturally disperse into the water columns within a few days, the rate of weathering is dependent on temperature, light, and other environmental conditions.

Humpback Whale— On contacting spilled diesel, humpback whales may experience inhalation, ingestion, and skin and conjunctive tissue irritation similar to other whales, but may also experience baleen fouling. Repeated surfacing in a large diesel spill with high levels of volatile toxic hydrocarbon fractions present could potentially lead to organ damage and/or mortality of humpbacks. Spill modeling in SLR (2018) indicates that a potential diesel spill may travel as far south as Shuyak, Afognak, and surrounding islands adjacent to Kodiak Island, where there are biologically important feeding areas for the humpback whale (Ferguson et al. 2015). The extent of impacts from a diesel spill on humpback whales depends on the location, time, and weather conditions. Humpback whales are not present in the analysis area in the winter months; instead, depending on the stock, the whales travel south to breed. Therefore, humpback whales are projected to be at the highest risk from impacts to oil spills during the summer and fall in high-density feeding areas surrounding Kodiak Island (Ferguson et al. 2015). Humpback whales prey on schools of forage fish (capelin [*Mallotus villosus*], sand lance [*Ammodytidae* family], Pacific herring [*Clupea pallasii*]) species, as well as copepods and euphausids in the water column near the water's surface, where diesel may be present. The duration of acute impacts would be short-term, because diesel rapidly evaporates, disperses, and is broken down. However, the duration of chronic impacts could be much longer (up to several years), depending on the extent of impacts to individual whales and their prey.

Fin Whale—The magnitude of impacts from a diesel spill on fin whales would likely be low, because fin whale sightings in the analysis area are low, and whales are typically sighted in the Aleutian area, Bering Sea, and around Kodiak Island. The highest densities of fin whales in this area occur from June through August, although they may be observed in this area year-round by aerial and acoustic surveys (see Section 3.25, Threatened and Endangered Species). Fin whales would potentially be impacted by the diesel spill, because spilled diesel is modeled to contact waters surrounding Kodiak Island and Shelikof Strait, which are deemed Biologically Important Feeding area for fin whales (Ferguson et al. 2015). However, by the time the spilled oil reaches these areas, it would largely have dissipated. The duration of acute impacts would be short-term, because diesel rapidly evaporates, disperses, and is broken down, lessening the time available for fin whales to come into direct contact with the spilled diesel. However, should fin whale prey become contaminated, the duration of impacts could last for several years through the reduction or mortality of local prey, creating periods whereby summer prey would not be available for an undetermined time period depending on prey recovery rates. The likelihood of impacts from a diesel spill on fin whales is also low, because fin whales may, on contacting spilled oil, experience similar inhalation, ingestion, skin, and conjunctive tissue irritation, as discussed for other whales; but because they are also baleen whales, they may also experience baleen fouling.

Northern Sea Otter—The magnitude of potential impacts from a diesel spill on the southwestern stock of the Northern sea otter is high. The 2013 Southwest Stock of the Northern Sea Otter Recovery Plan lists oil spills and oiling as a threat and impediment to recovery. Sea otters are particularly vulnerable to contamination by oil (Williams and Randall 1995). Five characteristics of sea otter biology help explain their extreme vulnerability to oil contamination (USFWS 2013).

1. Sea otters depend on their fur and the air trapped within it for thermal insulation. Oil destroys the water-repellent nature of the fur, and it eliminates the air layer, thereby reducing the insulative value by 70 percent (Williams et al. 1988). The direct result is acute hypothermia.
2. Once the fur is fouled, sea otters ingest oil as they groom themselves. Ingested oil damages internal organs, resulting in acute and chronic effects on animal health and survival. Based on a mink model, oral exposure to low doses of oil can lead to changes in hematology, immune function, and reproductive success (Mazet et al. 2001; Schwartz et al. 2004).
3. Benthic invertebrates accumulate and store toxic hydrocarbons. Sea otters therefore ingest hydrocarbons when they feed on these organisms during and after an oil spill. Bivalves are unable to metabolize PAHs, which are toxic components of oil; therefore, otters can be exposed to these components while feeding even after oil has dispersed from the water's surface. Additional oil can become re-entrained in the water when sediment is disturbed during foraging.
4. Sea otters are nearshore animals that exhibit strong site fidelity, often remaining in or returning to oiled areas after release. In addition, they often rest in kelp beds, which collect and retain spilled oil.
5. Sea otters are often found in single-sex aggregations, which can include hundreds of individuals. Therefore, large numbers of sea otters (representing a portion of the reproductive potential of a population) can become fouled by oil simultaneously.

In addition, sea otters spend the majority of their time on the water's surface, increasing exposure and direct contact with a diesel spill. Oil-based product contamination can have both immediate and long-term effects on sea otters and on population recovery (Peterson et al. 2003). Potential impacts of oil spills on sea otters could range from negligible to severe, depending on the location, extent, and type of oil that is spilled. Direct, acute effects to sea otters from a large spill include mortality, and lung, liver, and kidney damage (Lipscomb et al. 1994). Chronic effects to sea otters from exposure to oil have been shown to affect mortality patterns, abundance, and survival rates in the years following the *Exxon Valdez* oil spill (Peterson et al. 2003) (Note: the oil spilled in the *Exxon Valdez* oil spill was crude, and not ULSD). Indirect, chronic effects to sea otters from a large oil spill may be caused by 1) sub-lethal initial exposure to oil, causing pathological damage to the otters; 2) continued exposure to hydrocarbons persisting in the environment, either directly or through ingestion of contaminated prey; and 3) altered availability of sea otter prey as a result of the spill (Ballachey et al. 1994). The *Exxon Valdez* oil spill had catastrophic impacts on sea otters, and it took 20 to 25 years after the spill for direct chronic or delayed toxic effects to no long cause sea otter mortality (Esler et al. 2018). In 2014, 25 years after the spill, sea otters were declared recovered. Although potential chronic impacts from a ULSD spill are not comparable with the recovery times for otters from the *Exxon Valdez* oil spill, they highlight the potential for longer-term impacts.

The extent of impacts from a diesel spill on sea otters depends on the location and size of the spill, and the weather conditions at the time of the spill. A large spill can cover a vast area, because sea otters prey on a wide variety of benthic marine invertebrates and forage in shallow coastal waters (Riedman and Estes 1990), which vary widely in exposure to the open ocean, substrate type, and community composition. In addition, sea otter density throughout Kamishak Bay is high (Klein, pers. comm., 2018; ABR 2019a, b, c, f), and a potential spill could cause displacement of sea otters from their habitat, which was observed after the *Exxon Valdez* oil spill (Burn 1994).

There are large numbers of sea otters along the Katmai National Park coastline from Douglas River Shoals, around Cape Douglas and south along the Alaska Peninsula. Based on aerial surveys conducted by the National Park Service from 2012 through 2015, the northern sea otter abundance in Katmai National Park appears to have stabilized, following more than a decade of growth (Coletti et al. 2018). The waters along the coastlines are shallow, with abundant mixed-sediment habitats that support high densities of clams, which are a preferred prey for sea otters (Coletti et al. 2018). There are also large concentrations of sea otters on the northern sides of Shuyak and Afognak islands (NOAA 1997). Therefore, a spill scenario that extends south of Cook Inlet has a potential to impact a large number of sea otters in the nearshore habitats of the Katmai coastline and Shuyak and Afognak islands.

Sea otters have high metabolic demands relative to other marine mammals and can consume 20 to 25 percent of their body weight per day in invertebrate prey (Costa and Kooyman 1984). The level of contamination in prey may depend on where prey is found (e.g., subtidal versus intertidal), and the effects of prey contamination on sea otters may depend on age class preferences for different prey types (e.g., juvenile sea otters preferring to forage in intertidal zones, which would be more contaminated than the subtidal zones in which adult sea otters prefer to forage). Although diesel rapidly evaporates, disperses, and is broken down, if sea otters come into direct contact with spilled diesel, the duration of impacts may potentially cause long-term, chronic effects to some individuals. A 300,000-gallon ULSD spill in an area with high sea otters use (such as Kamishak Bay, Douglas River Shoals, the coastline around Katmai National Park, and Shuyak and Afognak islands) could result in mortality of sea otters, and this acute loss in the local population could be felt for several years due to the demographic lag hindering recovery (Esler et al. 2018). This was the case in the *Exxon Valdez* oil spill; it took 25 years for the sea otter population to fully recover.

Steller Sea Lion— Although the density of Steller sea lions in Cook Inlet is low, a spill under this scenario has a greater chance of reaching Steller sea lion critical habitat features such as rookeries, major haulouts (and their surrounding aquatic zones), and foraging areas (i.e., Shaw and the Barren islands, described in further detail in Section 3.25, Threatened and Endangered Species). Steller sea lions also use North Douglas Point, and up to 50 individuals were documented on the island during a June 30, 2018 National Park Service aerial survey (Griffin 2018). Sea lions use the waters around the mouth of Cook Inlet, and may experience direct acute impacts of ULSD if they forage, surface, and swim through ULSD moving south through the mouth of Cook Inlet. The spill trajectory indicates that the ULSD would reach the northern shores of Shuyak and Afognak islands in several days. There are several Steller sea lion haulouts along the northern shore of these islands that have a potential to be impacted (NOAA 1997). Steller sea lions may contact ULSD as they enter and exit the water at these haulouts. Sea lions that contact diesel may become contaminated with hydrocarbons internally through inhalation, contact, and absorption through the skin; or ingestion, either directly or by consuming contaminated prey (Engelhardt 1987). The extent of impacts from a diesel spill on Steller sea lions is modeled to intersect with Steller sea lion critical habitat in Shelikof Strait, and could have negative impacts on the habitat, as well as the animals themselves, if they were to come into direct contact with the spilled diesel. However, after the *Exxon Valdez* Oil Spill, oil was not found to persist on the rookeries and haulout sites, probably due to their steep slopes and high surf activity (Calkins et al. 1994). The duration of acute impacts would be short-term, because diesel rapidly evaporates, disperses, and is broken down; however, if animals were to come into direct contact with the diesel, there could be longer-term, chronic impacts to the exposed animals resulting from toxicity affects.

Steller's Eiders—In the event of a diesel spill during fall, winter, or spring, the federally threatened Alaska population of Steller's eider (*Polysticta stelleri*) may be impacted. As detailed in Section 3.25, Threatened and Endangered Species, most Steller's eiders do not arrive in Kamishak Bay until late November, and tend to move north into more protected bays as winter progresses. By mid- to late-April, Steller's eiders have left the area to migrate to their breeding grounds along the northern slope of Alaska. Generally, spills in the summer would have no impact on Steller's eiders, because the diesel would evaporate, dissipate, photodegrade, and be cleaned up prior to the arrival of wintering Steller's eiders. However, some eiders molt in late summer and early fall at Douglas River Shoals, which may be impacted under the scenario. ULSD would be rapidly carried by currents south of the spill point and mass along the shoreline and rocky terrain at Douglas River Shoals (SLR 2018). Although a large portion of the ULSD would evaporate, a large spill of 300,000 gallons would cause acute oiling on birds that contact the oiled water. Fuels and oils can be toxic to Steller's eiders (Fox et al. 1997) and their prey; therefore, impacts from a diesel spill that reach Douglas River Shoals may have a high-intensity impact on Steller's eiders. In particular, because bivalves cannot metabolize PAHs, Steller's eiders may be exposed to toxic components even after oil has been removed from the water's surface. Bivalves, such as mussels and clams, form a large portion of the Steller's eider high-calorie diet necessary for molting and wintering in Cook Inlet. They would be especially vulnerable during their molting season (July to September), when they are temporarily unable to fly, making it more difficult for them to avoid an oil spill. Steller's eiders are gregarious, and often large numbers are closely grouped together; therefore, a single spill may result in a large number of birds being affected simultaneously. Steller's eiders maintain high site fidelity for molting locations, and throughout the winter. Therefore, they are at increased risk of chronic petroleum exposure if cleanup activities are not successful.

Of the Steller's eiders that winter and molt in Cook Inlet, the USFWS assumes that less than 1 percent are from the listed Alaska-based breeding population (USFWS 2008b). If diesel ends up at Douglas River Shoals, several thousand Steller's eiders may be impacted. During aerial transect surveys in 2005, approximately 2,000 molting Steller's eiders were observed in the Douglas River Shoals in late August and September. During winter surveys in 2005, 3,921 Steller's eiders were recorded in southern Kamishak Bay (Larned 2006). Therefore, depending on the location of a spill and time of year (if eiders are present), a diesel spill may impact between 20 and 39 Steller's eiders from the federally listed Alaska population (currently estimated at 577 individuals [USFWS 2017])). Alaska Chadux's wildlife response team would be deployed to assist in cleaning up and providing transportation to rehabilitation facilities for oiled birds, with the ability to capture, transport, clean, and rehabilitate affected birds depending on a variety of environmental factors. It is difficult searching for live oiled birds, safely capturing them, and then transporting them to rehabilitation facilities. Furthermore, if a large spill occurred, there would likely be other sea ducks and waterbirds that would require safe capture and transport to facilities for cleaning and rehabilitation. However, previous cleanup events have resulted in rehabilitated birds that lived for several decades after being oiled (International Bird Rescue 2019). King eiders (*Somateria spectabilis*) were oiled in February 1996 from the M/V Citrus Oil Spill in the Pribilof Islands. One hundred eighty-six birds, mainly eiders, were rescued, rehabilitated, and released. Of those birds, at least four king eiders have been reported to the Bird Banding Lab with the latest return in 2019. These data underscore the success that rescue, rehabilitation, and release can have on a long-lived species.

It is thought the Steller's eiders exist near the limits of their energetic thresholds; therefore, environmental perturbations that reduce prey availability or increase their energetic needs may harm the species (USFWS 2007). During winter, Esler et al. (2002) found that harlequin duck (*Histrionicus histrionicus*) survival was 5.4 percent lower in oiled areas of Prince William Sound compared to unoiled areas more than 6 years after the *Exxon Valdez* oil spill (Note: the oil spilled in the *Exxon Valdez* oil spill was crude, and not ULSD). This was attributed to lower survival during midwinter, when effects of oiling are exacerbated by environmental stressors. Harlequin ducks are similar in size to Steller's eiders, and occupy similar habitat during the winter; therefore, they are a reasonable surrogate species for impacts to Steller's eiders. Periodic releases of hydrocarbons from oiled beaches in Prince William Sound would be similar to periodic releases of hydrocarbons from oiled areas of Douglas River Shoals if not adequately cleaned up. If diesel remains in areas that are used during molt and throughout winter by Steller's eiders, there is a potential for chronic exposure, which may reduce survivorship. Petroleum products that are released into the marine environment can continue to cause adverse impacts that last up to several years, and include changes in prey abundance, distribution, diversity, and ingestion of chronic toxic levels of petroleum (USFWS 2007). In a study analyzing levels of PAHs (a harmful component of oil) in Steller's eiders, harlequin ducks, and blue mussels (*Mytilus trossilus*, a prey source) at seaports such as Dutch Harbor, it was determined that blue mussels can contain high concentrations of PAHs (Miles et al. 2007). Therefore, prey items are one pathway that harmful components of oil can be consumed by Steller's eiders. It was found that at higher doses, Steller's eiders may be more susceptible to harm from PAHs or other stressors (Miles et al. 2007). In addition, the severity of a diesel spill would increase if it resulted in decreased ability for Steller's eiders to recover through decreased reproductive potential, as documented for harlequin ducks by Esler et al. (2002). The extent and duration of the diesel spill would be directly related to ocean currents, time of year, and effectiveness of diesel cleanup.

In summary, although the probability of a 300,000-gallon ULSD spill is low, Steller's eiders may experience high-intensity impacts if the geographic extent of a spill reaches molting and wintering areas at Douglas River Shoals while eiders are present. Cleanup efforts could reduce the geographic extent of the contamination by containing and recovering some of the spilled diesel. Most direct impacts from exposure to ULSD are anticipated to be short-term, because ULSD rapidly evaporates, disperses, and is broken down. However, if cleanup activities are only partially successful, there is the potential for chronic toxicity for Steller's eiders and their prey. Cleanup and containment activities would be used to limit the spread of the spill, and Alaska Chadux's wildlife response team would be deployed to assist in cleaning up any oiled birds. Furthermore, if a large number of birds were impacted, there is a potential for long-term population effects because Steller's eiders are long-lived birds that breed only during optimal periods. If a spill impacted Douglas River Shoals while several thousand Steller's eiders were present, depending on the success of capture, rehabilitation, and release, the impact on the Alaska-based breeding population could extend for multiple years while bird numbers recover. However, there are examples where previously oiled eiders have been rehabilitated, released, and lived for many years afterwards.

Alternative 2 and Alternative 3—Diamond Point Port—If this spill occurred near the Diamond Point port, impacts to TES would be similar to those previously described, but impacts would occur further north around Iliamna and Iniskin bays, with ULSD likely extending to Augustine Island and then spreading further south. This area has the same TES as further south in Kamishak Bay, with similar impacts anticipated. There would be no difference in potential impacts to whale species that migrate past the mouth of lower Cook Inlet, except that ULSD may be more dispersed and weathered by the time it is carried out of Cook Inlet by currents. There would be differences in the numbers of marine mammals potentially impacted. Several beluga whales have been historically documented in Iliamna and Iniskin bays, and there are high densities of northern sea otters around Augustine Island (especially on the western side). Steller sea lions also occasionally occur near the mouths of Iliamna and Iniskin bays and around Augustine Island. No fin or humpback whales have been detected in either bay, but several humpback whales were detected on the western side of Augustine Island by ABR during surveys in summer 2018. There are several groups of Steller's eiders that winter in Iliamna and Iniskin bays, but in lower numbers compared to Douglas River Shoals. Impacts are anticipated to be similar to those detailed above. The magnitude of impacts to TES would be similar to that described previously for each species, with a similar duration, but the extent would be concentrated in the northern part of Kamishak Bay and nearby bays.

Marine Mammals

It is important to note that many studies on impacts to marine mammals from large oil spills are related to spills of heavier oil (such as crude oil) and are not specific to lighter oils such as ULSD. Although both oil types contain some of the same compounds, they react differently when spilled into the environment, and have different persistence rates. Many of the impacts from oil on marine mammals are based on data from heavy oil spills (such as the *Exxon Valdez* spill), and the text may describe a worst-case scenario. Impacts from a spill of ULSD would have a reduced magnitude compared to a spill of heavy oil, such as crude oil. Many of the impacts detailed previously for TES would also apply to non-TES described below.

Oil-based substances, such as diesel, can impact marine mammals in the following ways: 1) acute toxicity caused by an event such as an oil spill can result in acute mortality or injured animals with neurological, digestive, and reproductive problems; and/or 2) can cause detrimental effects through complex biochemical pathways that suppress the immune system or disrupt the endocrine system of the body, causing poor growth, development, reproduction, and reduced fitness (NMFS 2008a).

Although much of the ULSD spilled is expected to either evaporate or naturally disperse into the water column within a few days, the rate of weathering is dependent on temperature, light, and other environmental conditions. Once dispersed into the water column, or settled into substrates, petroleum compounds can remain bioavailable in lower concentrations, and pose a risk to marine organisms that come in contact with these compounds at a later time.

Chronic exposure to diesel spills and latent contamination in the sediments for nearshore species also pose risks to many marine organisms (NMFS 2005b). Prey species of marine mammals could also become contaminated, experience mortality, or otherwise be adversely affected by spilled oil and through indirect impacts (i.e., species fitness and distribution). Fish-eating marine mammals, such as killer whales (*Orcinus orca*), and Dall's (*Phocoenoides dalli*) and harbor porpoise (*Phocoena phocoeana*), could experience reduction in abundance, distribution, and diversity of prey species from contact with diesel spills, and experience injury from consuming contaminated food items or from direct contact with diesel fractions. Marine mammals could be excluded or redistributed from their habitat if their forage fish prey base is reduced for even a short period of time.

Killer whales suffered acute impacts from the *Exxon Valdez* oil spill, including mortality to both a major resident pod (AB pod) and a unique transient population (AT1 population) that occur in Prince William Sound (Esler et al. 2018). Neither group has recovered, despite a lack of chronic direct effects, and the AT1 population may never recover. Both groups have been constrained by demographic factors related to life history characteristics and small population size. In particular, the AT1 population, which suffered a loss of females, and has not produced a viable calf since 1984, may be headed for eventual extinction (Esler et al. 2018).

Harbor seals are common in Cook Inlet and may experience acute and chronic impacts of an ULSD spill. Harbor seals use Shaw Island, and more than 400 individuals were documented on the island during a June 30, 2018 National Park Service aerial survey (Griffin 2018). Harbor seals have been documented along the shoreline in Kamishak Bay, near the mouth of Cook Inlet and along the shores of Shuyak and Afognak Islands. Therefore, they have a potential to be exposed to ULSD in several locations, depending on the extent of the spill.

Baleen whales may, on contacting spilled oil, experience inhalation, ingestion, skin and conjunctive tissue irritation, and baleen fouling. Whales may not be able to detect oil or may not avoid it if they can detect it, thereby increasing their risk of exposure to oil. Effects to pinnipeds from exposure to oil (such as seen from the *Exxon Valdez* oil spill) can include mortality, brain and liver lesions, skin irritation and conjunctivitis, increased PAH concentrations in blubber, increased petroleum-related aromatic compounds in bile, and abnormal behavior, including lethargy, disorientation, and unusual tameness (Frost et al. 2005). If individual, small, or large groups of marine mammals were exposed to large amounts of fresh diesel from a spill, especially through inhalation of highly toxic aromatic fractions, they might be seriously injured or die from such exposure. The duration of potential impacts is expected to be temporary (until the diesel has evaporated and broken down by microbes). The extent of potential impacts would be localized to the immediate area of the spill, and generally represents a small portion of the available habitat in Cook Inlet.

Alternative 2 and Alternative 3—Diamond Point Port—Based on the ESA index maps (NOAA 2002) and data provided in Section 3.23, Wildlife Values, and Section 3.25, Threatened and Endangered Species, there are many harbor seal haulouts around the mouths of Iliamna and Iniskin bays and around Augustine Island. The magnitude and duration of impacts to harbor seals and other marine mammals would be similar to those described above, but the geographic extent of impacts is likely around Iliamna and Iniskin bays, and Augustine Island.

Needs and Welfare of the People—Socioeconomics

It is unlikely that a diesel spill in lower Cook Inlet would result in increased employment or income opportunities in the Bristol Bay region. Manpower requirements would be low.

The impacts on employment, income, and sales would be negative if commercial and recreational fishing and/or tourism were to suffer due to the real or perceived impacts of a spill. Although these negative employment, income, and sales effects would be brief, their intensity would vary, and could result in changes in socioeconomic indicators well outside normal variation and trends if a major spill occurs with shoreline contact and/or contamination of fish. Duration of impacts would likely be short-term, affecting socioeconomic resources during the spill and subsequent cleanup efforts. Disruptions of commercial or recreational fishing would likely affect communities in Southcentral Alaska.

Commercial and Recreational Fishing

Depending on the timing of the spill, it could affect commercial salmon fisheries in Kamishak Bay, the health and viability of Weathervane scallop resources in the Bay, and the health and viability of the Pacific herring resource, which spawns in the Bay. Shuyak and Afognak islands are in ADF&G's Kodiak Management Area, which hosts seasonal commercial and recreational fisheries. The harvest size of the Afognak District commercial fishery is quite limited, particularly compared to the rest of the Kodiak Management Area or the Bristol Bay fishery; but a spill in July or August could result in commercial fishing restrictions in the area. Coho salmon and halibut are the primary targets of the area's recreational fishery; anglers would likely avoid any areas with visible petroleum sheens on the water. Economic impacts from a marine diesel spill based on the perception of the quality and the value of seafood produced in this region are not likely, but are possible depending on the public awareness and perception of the spill.

Cultural Resources

A release into the waters of Lower Cook Inlet would have little or no impact on marine archeological sites, because the substance and response efforts would be on the surface. Depending on the location of the spill and prevailing weather conditions at the time of the spill, impacts to cultural resources potentially located along shorelines would vary. Impacts would range in intensity from undetectable changes in integrity, to measurable changes in integrity, but not sufficient to affect National Register eligibility. If ground-disturbing cleanup activities were to occur within the bounds of cultural resource areas, direct impacts would be of higher intensity, and resources would not be anticipated to return to previous levels even after actions that caused the impacts were to cease. Any cleanup that could impact cultural resources would likely require a mitigation plan to limit those impacts. Indirect impacts could occur to the setting (visual, noise, and olfactory impacts) of cultural resources if the spill were to occur in the vicinity. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Those impacts would be temporary, and would cease when response efforts are complete.

Subsistence

The impact to subsistence resources from a diesel spill in lower Cook Inlet would vary depending on the timing of the spill, the duration before cleanup activities, and the rate of natural weathering processes that would degrade the diesel. A diesel spill in lower Cook Inlet could lead to mortality and temporary displacement of marine and anadromous subsistence resources, including marine invertebrates, marine mammals, marine fish, and salmon. The release would impact subsistence resources in lower Cook Inlet; based on the analysis of impacts on biological resources, impacts to subsistence would be short-term. The spill could result in concerns regarding contamination for lower Cook Inlet subsistence users and could cause changes to harvest patterns as users avoid the area. Quick response times and cleanup of the spill, as well as clear and timely communication with nearby communities, would help ease concerns about contamination for subsistence users in nearby communities.

Health and Safety

There are potential adverse impacts to social determinants of health (HEC 1), with psychosocial stress resulting from community anxiety over a marine tug-barge rupture at sea. A rupture release may involve a vessel accident or injury, and monitoring overflights could increase the risk of injury or accident related to air transportation (HEC 2). There could be potential diesel or diesel fume exposure (HEC 3) and impacts to near-shore subsistence and food security (HEC 4). Human health impacts would be short-term (i.e., 1 to 12 months), and limited to the vicinity of the spill area. Impacts would result in risks of illness or injury patterns if little to no diesel reached the shoreline, but would increase in intensity as the volume of diesel spilled and the amount reaching the shoreline increased.

Iliamna Lake Ferry Release

Incidents with the ferry could include collision, sinking, loss of power or steering capabilities, grounding, fires, and flooding of engine rooms or other compartments. Such vessel incidents, however, are generally attributable to human error more often than mechanical failures or adverse weather conditions. PLP would employ experienced crews, and crews would receive ongoing training. There are historically low rates of spills of any type from ferries. The statistical rates of incidence for spills from ferries are lower than those of marine barges addressed above. The operation of the ferry would be more secure and regulated than that of marine barges. A large-volume release of diesel from the Iliamna Lake ferry was considered to be so improbable as to have negligible risk, and was therefore eliminated as a scenario for impacts analysis in the EIS.

The ferry would be custom-built specifically for Iliamna Lake conditions, and for hauling diesel, concentrate, and other mine materials. Fuel tanks would be stored in secondary containment on the ferry. A 1-inch-thick heavy steel shell (required for ice-breaking) would result in very low potential for damage to the ferry from grounding or a collision. Fuel tanks would be located away from the shell of the vessel, so that the tanks would not be impacted in the event of a collision.

The ferry would be designed with state-of-the-art navigation and propulsion systems, with four azimuthing thrusters, and have the ability to operate in 100-mile-per-hour winds, with safe station-keeping at winds up to 150 mph (PLP 2018-RFI 052). Although subject to potentially extreme weather conditions, the operational environment in the lake is expected to be generally less harsh than the marine environment affecting marine barges (see Section 3.16, Surface Water Hydrology).

Based on historic data, and these design and operational features, the probability of a large spill of transported diesel from the lake ferry was judged to be significantly less than the historic spill probability for marine barges. The estimated annual probability of occurrence of $1.5\text{x}10\text{-}^{4}$ would have a probability of occurrence of 0.30 percent in 20 years, or 1.2 percent in 78 years (AECOM 2019a). This frequency of occurrence is so improbable as to have negligible risk, and this scenario was therefore eliminated as a scenario for impacts analysis in the EIS.

In the event of a spill of diesel from the ferry, spill response would begin immediately with ferry personnel. Ferries would be equipped with oil spill response kits, and operators would be trained in spill reporting and procedures to minimize and contain low-volume spills.

Depending on the size of the spill, the Chadux oil response group could be mobilized for spill response, as discussed above for a release from a marine tug-barge. Chadux is able to respond to some spill sites around Alaska within 24 hours; however, due to the remote location of Iliamna Lake, response times are unknown. Chadux would coordinate with the Applicant at a later phase in the project to determine what oil spill response equipment they could potentially maintain on Iliamna Lake. The Applicant would also maintain spill response equipment at both ferry terminals (including booms, sorbents, pumps and hoses, recovery and disposal containers, and PPE, a skiff, and personal flotation devices) that could be used by Chadux or other spill response personnel.

Response crews would likely deploy booms to contain the spill, pump diesel from the water's surface into secondary storage, and apply sorbents to collect residual fuel, etc. The longer the diesel remains in the water, the more difficult it would become to recover. Even assuming a rapid response within 24 hours, containment and recovery of light fuels such as diesel are extremely difficult, and only a portion of the diesel would likely be recovered. Much of the diesel would naturally evaporate and disperse within hours to days (NOAA 2018i; AECOM 2019a).

Spill response efforts could also be delayed by adverse weather or lake conditions, including storms and/or ice cover. The presence of ice cover and/or "rotten ice" on the lake could make recovery of spilled diesel more difficult.

Diesel Tank Farm Spill

Diesel fuel to be used primarily for operation of mining vehicles and the ferry would be stored at fuel storage facilities (tank farms) at the mine site truck shop, Amakdedori port, and the ferry terminals. Diesel would be stored in a variety of tanks ranging in volume from about 10,000 to 1.25 million gallons (PLP 2018d; Owl Ridge 2018b). Diesel would be stored in bermed and dual-lined secondary containment areas (SCAs) designed to contain spilled fuel. Per federal regulations (40 CFR Part 112), SCAs must contain 110 percent of the largest tank volume. Alaska State regulations (18 AAC 75.057) also require SCAs to have extra capacity to allow for accumulation of precipitation.

Tank farm spills are usually small-volume, and are generally contained in the SCAs. Potential causes of a spill at the tank farms could include scenarios such as: 1) a leaking valve seal, resulting in a small release (less than 10 gallons) that would be detected during daily inspections; 2) human error, resulting in the overfilling of a vehicle; or 3) tank rupture, resulting in release of the entire tank contents into the SCA. In all of these scenarios, spills would be fully contained in the SCAs, and fuel recovery would be 100 percent, minus any losses to evaporation. Potential spills would therefore have a low-intensity impact to air quality, and no impact to soil or water quality. Any spilled fuel would be removed from the secondary containment with sump and truck pump-out systems and/or sorbents.

Due to the low probability of a tank farm release of diesel outside of secondary containment, this scenario was eliminated for impacts analysis in the EIS.

4.27.5 Natural Gas Releases from Pipeline

Natural gas is primarily composed of methane, which is a colorless, odorless, tasteless gas. Other components of natural gas vary by source, and can include ethane, propane, butane, pentane, nitrogen, and carbon dioxide. Natural gas releases can be hazardous to human health when gas accumulates in a confined space, wherein high concentrations of gas can be an asphyxiant; or to human health and the environment if exposed to an ignition source, which can lead to fire or explosion. The pipeline would be on the seafloor, lakebed, and buried in a shallow trench in the soil; and would not pass through any confined spaces, such as buildings, where gas could accumulate. The pipeline would be largely in remote areas where ignition sources would not be present, and where human presence would be limited.

The pipeline would be designed, constructed, and operated per federal pipeline safety and environmental regulations, including USDOT, Bureau of Safety and Environmental Enforcement (BSEE), and Pipeline and Hazardous Materials Safety Administration (PHMSA), 49 CFR Part

192.179). USDOT regulations would cover appropriate corrosion protection, pressure monitoring, and shutdown devices to allow for rapid response to any leaks. Regular inspections, including visual inspections and pigging, would be conducted as required by USDOT codes and regulations (PLP 2019-RFI 126).During pipeline operations, there could be minimal disruption to current activities in Cook Inlet or Iliamna Lake due to pipeline maintenance and repairs (PLP 2019-RFI BSEE 2). The gas transmission pipeline would transport only pipeline-quality gas (PLP 2019-RFI 126). See Chapter 2, Alternatives, for pipeline design and safety features.

4.27.5.1 Pipeline Hazards

Common causes of pipeline leaks and releases include damage to pipe from excavation, damage to pipe from a motor vehicle, and material failure of the pipe or weld (PHMSA 2018). Due to the remote location of the pipeline and restricted access of the corridor, erroneous excavation would be unlikely, and motor vehicle damage would not occur, because the pipe would be buried in the over-land segments. Anchor damage could be a potential hazard to the pipeline in segments where pipeline is laid on the lakebed or seafloor and not buried, particularly in areas of high vessel traffic.

In Alaska, earthquakes and volcanic activity are potential sources of pipeline damage. No known active surface faults intersect the pipeline corridor (Figure 3.15-1); therefore, damage to the pipeline from surface fault displacement would not be expected. Seismic activity associated with nearby Augustine volcano is rarely of high magnitude, even during eruptive activity, and would not be expected to impact the pipeline. In the event of a major earthquake, liquefaction of wet soils or sediments in the pipeline corridor could potentially lead to pipeline displacement, flotation, and/or rupture, which could result in a release of gas. Pipeline design and engineering would account for potential liquefaction, thereby reducing the risk of pipeline rupture. See Section 4.15, Geohazards and Seismic Conditions, for a complete discussion of seismic hazards.

The pipeline would traverse the floor of Cook Inlet south of the active Augustine volcano. Lava flows from Augustine rarely reach the shoreline, and are not capable of traveling very far through water. Periodic debris avalanches—chaotic mixtures of volcanic rock, ash, and debris—do flow from Augustine into Cook Inlet on average once every 150 to 200 years (Beget and Kienle 1992). Due to the infrequency of such events, and the distance between the volcano and the pipeline, such volcanic flows would be unlikely to impact the pipeline during the life of the project. See Section 4.15, Geohazards and Seismic Conditions, for a complete discussion of volcanic hazards.

4.27.5.2 Fate and Behavior of Released Gas

Potential gas leaks from the pipeline would be released into the surrounding soil or water column, rise buoyantly up to the surface, and dissipate readily into the air. Potential natural gas releases from the pipeline would have a low-intensity impact on air quality by introducing dominantly methane, a GHG, into the air.

Due to its buoyancy, natural gas generally does not accumulate in water, and would not have an impact on water quality. Ongoing releases of natural gas that extend for weeks to months, however, can allow small bubbles of natural gas to accumulate and remain temporarily suspended in the water column in the immediate area. This can lead to locally high levels of methane and oxygen-depleted zones in the water column, which may impact aquatic life. Large-scale releases from offshore natural gas wells have impacted marine fish (Patin 2001).

Methane can sometimes accumulate in deeper soils beneath structures, under certain conditions. Accumulation of natural gas in the shallow soil beneath the narrow buried pipeline is not likely, and impacts on soil exceeding soil quality criteria would not be expected.

Natural gas pipeline releases would not be expected to cause contamination of water or soil; therefore, detailed impact assessment of leak scenarios is not included in this section.

4.27.5.3 Spill Response

PLP would have a spill response plan in place that would cover potential leaks/releases of natural gas. Federal code regulates natural gas facility safety features.

Mainline sectionalizing valves would be installed with a spacing of no more than 20 miles for the onshore sections of the pipeline (PLP 2020d). Offshore segments would not be equipped with valves, as allowed by 49 CFR Part 192.179. In the event of a gas release, valves would be shut off to limit the gas release.

The natural gas pipeline would be constructed of new pipe specifically designed for natural gas transmission in a cold climate through diverse terrain, including marine and lake water. The pipeline would be equipped with a leak detection system. In the event of a release, shut-off valves would be closed to limit the extent of the natural gas release. On the eastern side of Cook Inlet, near the compressor station, an automatic shut-off system would be installed. On the western side of Cook Inlet, at the port site, either an automatic or manual shut-off valve would be installed. Port personnel would always be on site and able to respond with manual shut-off if needed (see Chapter 5, Mitigation).

In the event of a natural gas release from the pipeline and/or pipeline repair, there could be minor disruption to current activities in Cook Inlet and Iliamna Lake.

Alternatives Analysis

The potential for a natural gas release from the pipeline could vary by alternative based on pipeline lengths and routes. The pipeline total lengths would vary slightly by alternative, including 193 miles for Alternative 1a; 187 miles for Alternative 1; 164 miles for Alternative 2; and 165 miles for Alternative 3. The pipeline routes for Alternative 1a and Alternative 1 would including a crossing of Iliamna Lake, while the pipeline route for Alternative 2 and Alternative 3 would follow the northern transportation corridor to the mine site, with no segments crossing Iliamna Lake. Therefore, under Alternatives 2 and Alternative 3, there would be no potential for a gas release into Iliamna Lake.

4.27.6 Concentrate Spills

Ore concentrate is composed of finely ground rock and mineral particles that have been processed from raw ore to concentrate the economic metallic minerals. For the project, raw ore from the open pit would be crushed and milled until it reaches the consistency of very fine sand, and then go through multi-phase processing to separate the metallic minerals from the waste rock, including flotation with chemical reagents, thickening, and filtration. The resulting concentrate would be dewatered and shipped off site for smelting (PLP 2018d). Copper-gold and molybdenum concentrates would contain sulfide minerals and other heavy metals, and would be considered potentially acid-generating (PAG), and capable of metals leaching (ML). Concentrates may also contain residues of chemical reagents, including sodium ethyl xanthate and sodium hydrogen sulfide, both of which can be toxic to fish in low concentrations. See discussion of chemical reagents below under Reagent Spills.

4.27.6.1 Copper-Gold Concentrate

Approximately 97.5 percent of the ore concentrate produced by the project would be copper-gold concentrate. A daily amount of 2,400 wet tons of copper-gold concentrate would be transported from the mine site to the port, for a total of 876,000 wet tons per year (PLP 2018-RFI 065).

The method of copper-gold concentrate transport would vary by alternative. For alternatives 1, 1a, and 2, concentrate would be transported by truck and ferry from the mine site to one of the port sites. For the Alternative 3 base case, truck/trailer combinations would haul concentrate from the mine site to the Diamond Point port along the north access road. The Alternative 3 base case does not include a ferry crossing on Iliamna Lake. The Alternative 3 concentrate pipeline variant would include transport of concentrate by pipeline from the mine site to Diamond Point port, and would also not include ferry transport. Potential impacts of concentrate spills from both truck and pipeline are addressed below.

For Alternative 1a, Alternative 1, Alternative 2, and the Alternative 3 base case (i.e., without the concentrate pipeline variant), copper-gold concentrate would be loaded into specialized heavy-steel bulk shipping containers with locking lids at the mine site (Figure 4.27-1). Containers would be 20 feet long, 7 feet tall, and 8 feet wide, and would hold a maximum of 724 cubic feet (ft^3) of material. Each container would hold 76,000 pounds (38 tons) of concentrate. Containers would have ISO container twist-lock systems on the corners, like a standard shipping container, for securing the container onto a tractor trailer (PLP 2018-RFI 045).

Each truck would pull three trailers, with one container per trailer, for a total of 228,000 pounds (114 tons) of concentrate per truck trip. For Alternative 1a, Alternative 1, and Alternative 2, truck/trailer combinations would haul concentrate to the north ferry terminal, where the containers would be loaded onto the ferry and secured with pins to prevent shifting during transit across Iliamna Lake. A second layer of containers would be stacked on top using the same twist-lock system on the corners (PLP 2018-RFI 045). Containers would be unloaded at the south ferry terminal, loaded onto haul truck/trailers, and transported to the marine port.

Once the concentrate containers are delivered to the marine port, containers would be transferred from truck trailers onto lightering vessels (barge/tug combination) and secured on the barge decks with pins. Three to four lightering vessels would transport the copper-gold concentrate containers out to waiting bulk carrier vessels, and load the concentrate for transport to off-site smelters for further processing. See Chapter 2, Alternatives, for lightering locations.

The primary lightering locations for Alternative1a and Alternative 1 have been identified as having high wave potential. Operational limits for the vessels loading concentrate would be a function of their seaworthiness in various sea states. The vessel operators would be responsible for loading concentrate in accordance with those operational limits.

To minimize the potential for over-water spills of concentrate or release of fugitive dust, the containers would be equipped with locking lids, and the containers would be lowered deep within the hold of the bulk vessel before being overturned, and the lids released. The hold would be filled with concentrate to only approximately 50 percent of the maximum capacity of the hold, due to the density of the material. Therefore, there would be adequate space to maneuver the containers in the hold above the cargo and below the hatch. The highest discharge elevation of concentrate would be 20 feet below the hatch (PLP 2018-RFI 009). See the “Mitigation” subsection for more details. Loading operations would be interrupted when warranted by sea and weather conditions (PLP 2018-RFI 032; PLP 2018-RFI 045). A total of 10 trips by lightering vessel would be required to load each bulk carrier, which would remain at anchor for 4 to 5 days. The peak production rate of copper-gold concentrate would require transporting a total of approximately 22,800 specialized bulk shipping containers of concentrate by truck, ferry, and barge each year (PLP 2018-RFI 065).

Annually, there would be an estimated 27 bulk marine vessel cargo shipments of copper-gold concentrate exported out of the port, with vessels anchored at the lightering locations, for a total of 108 to 135 days (Owl Ridge 2018c).

For the Alternative 3 Concentrate Pipeline Variant, copper-gold concentrate would be transferred from the mine site to the Diamond Point port as a concentrate slurry by pipeline. The concentrate pipeline is described in Chapter 2, Alternatives. The concentrate pipeline would be mostly buried, except where attached to bridge infrastructure at major stream crossings. The slurry would be dewatered at the port site, and stored in a bulk cargo pile in a dedicated concentrate storage building between bulk carrier sailings (PLP 2020d; PLP 2019-RFI 066a).

For barge loading, the concentrate would be reclaimed from the storage building and transferred to the barge loading area by fully enclosed conveyors with a tubular structure to contain dust and shed snow. At the barge loading dock, the barge loader would employ an enclosed conveyor boom and telescoping spout to distribute the cargo onto the barge deck with mechanical dust collection. The barge loader would load lightering barges with approximately 6,000 tons of concentrate per barge to transport to the bulk carrier ships. The lightering barges would have a dust-cover system to prevent fugitive dust and protect the cargo from rain/snow (PLP 2020d; PLP 2019-RFI 066a).

Once loaded, the barges would be transported to and secured against Handysize vessels at the mooring location in Iniskin Bay. The barges would be equipped with an internal reclaim system and conveyors (PLP 2019-RFI 066a) or use wheel loaders (PLP 2020d) to feed a self-discharging boom conveyor (ship loader) that would transfer the concentrate to the bulk carrier. The barge location would be adjusted along the ship during the loading process. The boom conveyor/loading trunk would be fully enclosed and equipped with a telescoping spout and mechanical dust collection to prevent spillage and fugitive dust. The loading trunk would extend down into the hold of the ship to minimize the potential for generation of fugitive dust, and mist sprays would be used to further control dust (PLP 2020d; PLP 2019-RFI 066a).

Due to the high density of the concentrate, the holds would not be loaded to the top, further reducing any potential for concentrate dust to escape the hold. Approximately five to six trips by the lightering barges would be required to load a bulk carrier, which would be anchored for 3 to 4 days at the lightering location. The bulk carrier ships would transport the concentrate to out-of-state smelters. Up to 27 Handysize ships would be required annually to transport concentrate.

Under the Alternative 1 Summer-Only Ferry Operations Variant, additional storage of concentrate containers would be needed at the mine site and the port site.

Sources: PLP 2018-RFI 045

US Army Corps of Engineers®

COPPER-GOLD CONCENTRATE SHIPPING CONTAINER

PEBBLE PROJECT EIS

FIGURE 4.27-1

4.27.6.2 Molybdenum Concentrate

Molybdenum concentrate production would comprise approximately 2.5 percent of the project's total concentrate production (PLP 2018-RFI 066). Molybdenum concentrates produced at the mine site would be loaded into flexible intermediate bulk container (FIBC) bulk bags, then into standard 20-foot-long sea shipping containers. Each day, about 107 wet tons of molybdenum concentrate would be transported from the mine site by truck and/or ferry to the port, for a total of 39,300 wet tons each year (PLP 2018-RFI 065). Molybdenum concentrate would be transported by truck and/or ferry for all alternatives; Alternative 3 Concentrate Pipeline Variant would not include a molybdenum concentrate pipeline because the volume of the concentrate is much lower than the copper-gold concentrate. Molybdenum concentrate containers would be unloaded from the trucks and loaded directly onto barges for transport to off-site smelters; no lightering to marine bulk vessels would be required (PLP 2018-RFI 065).

See the "Mitigation" subsection for a summary of avoidance and minimization/design features to reduce the likelihood of concentrate spills.

4.27.6.3 Fate and Behavior of Spilled Concentrate

This section describes the general fate and behavior of spilled concentrate for a wide range of hypothetical releases. Specific impacts from the selected release scenarios are presented below.

Ore concentrates are composed of finely ground naturally occurring rock and mineral material, and their physical characteristics would be like those of very fine sediment (clay- and silt-sized). If spilled into the environment, the immediate physical fate and behavior would be similar to those of other naturally occurring sediments. However, the chemical characteristics of concentrates are both PAG and capable of ML due to the presence of sulfides and other metallic minerals. In the long-term, over years to decades depending on conditions, spilled concentrates would have the potential to produce acid, and leach metals into the environment.

Concentrate Solids versus Concentrate Slurry

If released on land, concentrate solids would behave like typical fine, clay to silty material. Some of the fine particles of dried concentrate could be distributed by wind as fugitive dust. Recovery of spilled concentrate solids from dry land would involve the use of heavy equipment to collect and recover the material and place it back into the containers.

Concentrate solids spilled into flowing water would be dispersed downstream to some degree, depending on the flow conditions. Concentrate spilled into high-energy streams may be difficult to impossible to recover, because concentrate would likely be rapidly flushed downstream. Concentrate spilled into low-energy water such as ponds or very low-volume streams could be recovered relatively easily, requiring in-water recovery efforts such as dredging/excavating).

Under the Alternative 3 Concentrate Pipeline Variant, concentrate would be transported from the mine site to Diamond Point port through a 6.25-inch-diameter steel concentrate slurry pipeline. At the mine site, contact water would be added to the fine-grained concentrate solids to create a slurry (a thick fluid) with a water content of 45 percent, enabling the slurry to flow in the pipeline (PLP 2018-RFI 066). The fate of released concentrate slurry would be the same as that of the fine-grained concentrate solids, but the behavior of the slurry in the short-term would be different than truck-hauled concentrate because of its high water content and fluid nature.

If the slurry pipeline were to rupture where buried, pressure in the pipe could force the slurry into the surrounding material and possibly to the surface. If concentrate is released to a relatively flat land surface, the concentrate slurry could be recovered relatively easily with heavy machinery. If the concentrate slurry were released onto a slope, the slurry could slowly spread out from the release site and flow downhill; potentially into a waterbody or wetland. Concentrate slurry would not likely permeate very deep into subsurface soils due to its viscous properties.

Trucks would haul concentrate solids over water crossings along road corridors. A concentrate pipeline would be attached to bridge infrastructure at major stream crossings. Therefore, there is a possibility that spilled concentrate could reach a waterbody. If either concentrate solids (truck) or slurry (pipeline) were released into a waterbody, both types of concentrate would initially sink to the bottom. Many of the fine particles would subsequently be entrained in the water, especially where current is present, leading to downstream sedimentation and an increase in total suspended solids (TSS).

Chemically, the concentrate solids and the concentrate particles in the slurry would behave the same way, in that they are both PAG and capable of ML over time, depending on conditions. Both concentrate solids and slurry could have residual amounts of chemical reagents. In addition, concentrate slurry would contain 45 percent untreated contact water, which would have elevated concentrations of metals, including copper. Unlike the metals in the concentrate solids, the metals in the aqueous phase of the slurry would be dissolved and bioavailable, to the extent that the slurry could be acutely toxic in a release.

Sedimentation and TSS

Concentrate particles would mostly be clay- and silt-sized, with a very small fraction of fine sand (Knight Piésold 2018p). A spill of these fine particles into a waterbody could cause both sedimentation and an increase in TSS in the water. The amount of material that remains suspended as TSS versus deposited as sediment depends mostly on particle size and the energy of the water/velocity of the current.

Most of the fine clay and silt particles would be entrained in the water and transported downstream by currents. This would create a downstream "plume" of cloudy, turbid water high in TSS. In high-energy/high-velocity streams, even sand particles can remain suspended for a time, contributing to the TSS level. The increased TSS and turbidity would continue until all the upstream concentrate has been recovered, settled, or naturally flushed downstream.

Sand particles are heavier, and would be more likely to remain on the streambed as "bedload." High-energy streams would continue to transport some of the bedload downstream. In lower-energy streams, deposited sediment could remain as stream bedload, especially in areas of weak current such as oxbows. An increase in sedimentation could bury existing substrate, and fill in voids in larger particles of substrate, such as between clasts of gravel, modifying the streambed habitat. Similar impacts could result from a spill of concentrate into a marine environment.

Fugitive Dust Generation

Spilled concentrate that is not recovered could dry out and produce dust. The copper-gold and molybdenum concentrates transported by truck or ferry would have 8 and 5 percent moisture, respectively (PLP 2018d), which would initially cause the particles to flocculate, or stick together. The copper-gold slurry would be wet, with 45 percent moisture; but on drying, could also generate dust. Concentrate dust would be PAG, and have potential for ML over time. Wind-blown fugitive dust could spread the PAG and ML material across a wider area, potentially impacting soils, waterbodies, vegetation, and air quality.

Factors Influencing Acid Generation and Metals Leaching

The following discussion of acid generation and metals leaching is relevant to spills of both concentrate and tailings. Background information on these chemical processes is provided in Section 3.18 and Section 4.18, Water and Sediment Quality, and is addressed in this section as relevant.

Solid particles of concentrate and tailings released into waterbodies can cause initially elevated levels of metals in their *total form*, while the fine particles remain suspended in the water column. Once particles have flushed from the waterbody or settled in the waterbody substrate, total metals levels in the water column decrease. Metals are generally not bioavailable in their total form, and do not become bioavailable until they are dissolved through the process of ML.

A variety of chemical and physical factors determine the potential for acid generation and ML from rock and rock particles/tailings. Major factors are summarized here and include:

- Chemical composition of the material (the amount of sulfur that could generate acid and the amount of leachable metals in the material): The copper-gold concentrate, for example, would contain approximately 27 percent sulfur (as sulfide minerals) and 26 percent copper. In comparison, the pyritic tailings would contain 15 percent sulfur and 0.26 percent copper (PLP 2018-RFI 045).
- Climate/temperature: Acid generation and metals leaching are generally faster chemical reactions at higher temperatures, and slower reactions at lower temperatures. These rates would be lower in the cold climate of the project, where freezing conditions for most of the year slow these chemical processes.
- pH: The leaching of most metals happens more readily at a lower (more acidic) pH; some metals and metalloids, however, leach readily at neutral or higher (more basic) pH. pH is variable in waters across the analysis area.
- Particle size: Smaller particles, such as the ground rock particles that make up concentrate and tailings, have a higher surface area per volume than larger rocks, so that acid generation and metals leaching can occur more readily from small particles. Laboratory testing generally tests very fine silt-sized particles to obtain a conservative estimate of acid generation and leaching rates, while field-based testing uses larger rock samples. Laboratory testing occurs at controlled temperatures, while field testing is subject to local climate conditions. Variation in these data is to be expected. The Applicant provided both field and laboratory data, which are summarized in this section and further addressed in Section 3.18 and Section 4.18, Water and Sediment Quality.
- Buffering capacity: Buffering capacity is the ability of water to resist a change in pH from addition of an acid or a base. Buffering capacity is variable in waters across the analysis area. Alkalinity is generally low in surface waters in the analysis area.
- Dissolved oxygen (DO) content: Water limits the diffusion of oxygen. Still/stagnant water contains essentially no DO, while flowing water (such as in streams) or circulating water (such as in overturning lakes or shoreline areas) can contain variable amounts of DO. The oxidation of sulfides, which can form acid, can potentially occur in flowing or circulating waters, although at a much slower rate than that from air exposure.

This EIS recognizes that potential rates of acid generation and metals leaching would vary in spill scenarios, and has adopted a conservative estimate of “years to decades” to address the potential timing of these processes. It is also recognized that these processes, once initiated, would be ongoing for centuries to millennia, as is constantly occurring in natural rock formations, depending on conditions.

Acid Generation

The copper-gold and molybdenum concentrates would contain approximately 27 and 35 percent sulfur, respectfully, as sulfide minerals (PLP 2018-RFI 045). When exposed to the oxygen gas present in air or oxygenated water, sulfide minerals can oxidize over time, and generate sulfuric acid in the presence of water. Both types of concentrate are PAG (see Section 3.18, Water and Sediment Quality, for discussion of PAG geochemistry). When sulfide minerals are stored sub-aqueously under still or stagnant water, dissolved oxygen is largely absent, so that the minerals cannot be oxidized, and sulfuric acid cannot be formed. Flowing water such as streams contains some dissolved oxygen, so that sulfide minerals in flowing water can be oxidized to generate acid, although at a much slower rate than when exposed to air. Lake water that experiences high circulation/turnover can become well oxygenated, as can shallow intertidal waters. In these environments, sulfide minerals can also be oxidized to generate acid, although at a much slower rate than when exposed to air.

Concentrate that remains on land could oxidize, and later produce sulfuric acid when exposed to water (e.g., rain), which could impact surrounding resources, and potentially be transported into waterbodies, affecting water quality and/or aquatic biota. However, acid generation from sulfide minerals requires years to decades; and during this slow process, any generated acid would be continually diluted by the region's precipitation and surface water recharge.

Metals Leaching

The copper-gold concentrate would contain about 26 percent copper and 1.6 percent molybdenum, and the molybdenum concentrate would contain 50 percent molybdenum and 1.5 percent copper (PLP 2018-RFI 045). Although naturally occurring, metals such as copper can potentially cause long-term impacts when introduced into the environment in elevated concentrations (compared to background levels). Metallic minerals in the concentrate solids would not be immediately soluble in water, and the leaching of metals into the environment would likely require years to decades. Metals present in the aqueous phase of the concentrate slurry would be dissolved and bioavailable, and could cause exceedances of water quality criteria if released in a spill.

As described above for acid generation, particle size is also a factor in potential metals leaching, because metals leaching can happen more quickly from small particles, such as concentrate and tailings. Laboratory testing generally tests very fine silt-sized particles to get the most conservative estimate of metals leaching rates, while field-based testing often uses larger rock samples to determine leaching rates. The Applicant provided both field and laboratory data on leaching rates, so variation in these data is to be expected. This EIS has adopted a conservative estimate of years to decades to address the potential timing for the onset of metals leaching.

4.27.6.4 Historical Data on Concentrate Spills/Spill Frequency and Volume

Operators of various mines across Alaska have reported spills of ore concentrates. Most reported spills are less than 100,000 pounds, and records indicate that most of the spilled material is recovered (ADEC 2018h).

Trucking

The Red Dog zinc and lead mine in northwestern Alaska is an appropriate data analog for the Pebble mine, based on similar transport of ore concentrate from the mine site by truck/trailer to a port. Red Dog concentrate spills data are therefore used in determining spill probabilities for the project. Zinc and lead concentrates are trucked from the Red Dog mine site on a 52-mile-long haul road (DeLong Mountain Transportation System) to shallow water port facilities on the

Chukchi Sea near Kivalina. As of 2005, haul trucks at Red Dog mine hauled 85 tons of concentrate in two side-dump trailers (AECOM 2019a). Note that the Applicant would haul 114 tons of concentrate in three trailers. The risk of a trucking accident from hauling three trailers may be higher than for hauling two trailers. Red Dog operations hauls less concentrate per truck trip, but each trailer at Red Dog would haul more concentrate (approximately 42.5 tons per trailer) than each trailer that would be hauled by the Applicant (approximately 38 tons).

The ADEC Spills Database lists 18 trucking-related reported concentrate spills along the Red Dog haul road between July 1995 and August 2018 (ADEC 2018h). A media report notes the mine operator as having reported approximately 30 trucking-related concentrate spills since the mine opened in 1989 (Alaska Journal 2002). Trucking-related concentrate spills recorded in the database range in size from 10 to 145,000 pounds (from a truck rollover); however, most spills are in the range of 20,000 to 80,000 pounds, with an average of 43,000 pounds. Recovery of spilled concentrate on land is straightforward, simply requiring collection of the material with heavy equipment. Most spills on the Red Dog haul road have been recorded as impacting land only, and report full recovery/recycling of spilled material. Spills into surface water, however, especially into flowing water, can be difficult to impossible to recover. A truck rollover on the Red Dog haul road in 2015 resulted in a spill of 145,000 pounds of concentrate that impacted a freshwater resource. No recovery information is provided for this spill, and the case is not listed as closed.

Generation of fugitive dust from zinc and lead concentrate was a concern at Red Dog Mine after mining operations began in 1989. Concentrate was originally trucked along the road from the mine to the port in trailers covered only by tarps, allowing concentrate dust to escape and be deposited along the roadbed, resulting in adverse impacts. In 2002, Red Dog converted their operations to include hard-covered trailers with lids, and dust generation was subsequently reduced. (Details on the locking capabilities of the concentrate containers currently used at Red Dog are not available.) Areas surrounding the haul road are being monitored as part of the state's contaminated sites cleanup process (ADEC 2018d). Note that the Applicant would haul concentrate in specialized containers with locking lids, so that fugitive dust generation as observed at Red Dog Mine would not be anticipated.

Concentrate Pipelines

Very few concentrate pipelines are in operation, and no published failure rates are available. Most of the available pipeline failure data come from oil and gas pipelines.

Historically, most pipeline failures are due to external corrosion and mechanical damage by excavating equipment or other vehicles (PHMSA 2018). The likelihood of external corrosion (rusting) increases over time. Data specific to corrosion rates of concentrate pipelines are not readily available, but in general for gas transmission, gas gathering, and hazardous liquid pipelines, corrosion accounted for approximately 17 percent of reported pipeline incidents in recent years, based on PHMSA data between 2013-2017 (PHMSA 2018b). The rate of external corrosion of pipelines would depend on climate, and would increase over time. Based on a 20-year operational lifetime of this pipeline, external corrosion leading to failure would be very unlikely. Rates of external corrosion would be expected to increase over time (see the "Cumulative Effects" subsection).

EPA (2014) points out that the potentially corrosive nature of the concentrate slurry could increase pipeline failure rates above historic failure rates due to internal corrosion. As described in the "Mitigation" subsection, the concentrate pipeline would have a full internal liner that would protect against internal corrosion.

Mechanical damage to the pipeline by vehicles would also not be likely during the project due to the remote nature of the project area, the controlled access of the road corridor, and no anticipated excavation equipment activity near the pipeline.

Marine Vessel

US Coast Guard (USCG) and PHMSA databases contain no records of ore concentrate spills from marine vessels (USCG 2018; PHMSA 2018). The ADEC database has no records specific to concentrate spills from marine vessels in Alaska (ADEC 2018h). Spill rates of hazardous materials from marine vessels are extremely low (USCG 2018).

Historically, at ports serving mines around the world, there have been concerns with spills and escape of fugitive dust during overwater transfer of concentrate from containers into bulk cargo vessels. Transfer operations technology has dramatically improved in recent years. At the Red Dog Mine, for example, concentrate is loaded from land-based storage into lightering barges, and then into the holds of deepwater vessels—entirely through a system of enclosed conveyor belts—greatly reducing the potential for spills and/or fugitive dust generation. There are no records of concentrate spills from marine vessels or during overwater operations at Red Dog Mine (ADEC 2018h).

PLP's method of overwater transfer of concentrate into bulk carrier vessels, as described in the "Mitigation" subsection, would also greatly reduce the potential for spills and/or fugitive dust generation. The method would involve opening concentrate containers only once they are deep within the ship's hold, and allowing concentrate to fall no more than 10 feet, so that there would be very limited turbulent rise of concentrate dust.

Iliamna Lake Ferry

There are no historical data available on ore concentrate spills from ferries. Historical data show that spill rates from marine vessels are generally very low (USCG 2018). Spill rates from the ferry would be expected to be comparable to those of marine vessels or even lower, due to the specialized design and operation of the ferry.

4.27.6.5 Existing Response Capacity

There are currently no organizations in Alaska that specialize in response to spills of ore concentrates. PLP would have a spill response plan in place that would address spills of ore concentrate and other hazardous materials.

4.27.6.6 Mitigation

PLP would have a spill response plan in place that would address spills of ore concentrate and other hazardous materials (see mitigation measures in Chapter 5, Mitigation, and additional mitigation discussion in Appendix M1.0, Mitigation Assessment).

Spill-Prevention Measures: Copper-Gold Concentrate

Summary of mitigation measures presented in PLP 2018-RFI 045:

- Bulk cargo containers are designed specifically for transporting ore concentrates from mine sites to marine vessels for the global mining industry.
- Containers are certified in accordance with the International Maritime Dangerous Goods code for transport of dangerous cargo.

- Containers are constructed of heavy steel with removable locking lids. Lids would be locked after loading at the mine site and would not be opened until the container is within the hold of the marine bulk carriers.
- Lids are designed to seal to prevent rainwater entry or release of fugitive dust.
- Containers would be secured to truck trailers by standard ISO container twist-lock system on the corners.
- On the barge and ferry, containers would be positioned on pins to prevent sliding on the deck from vessel motion. A second layer of containers would be stacked up using the same ISO container twist-lock system on the corners.
- Accidental upset of the containers would be contained by the sides of the ferry or the deck of the barges.
- Containers are designed to keep their lids intact in the event of a rollover. Containers have been tested and have demonstrated minimal spillage of product when overturned. If a container were to overturn on land, a forklift or crane would be used to lift and reposition it. Any spilled material would be picked up using a shovel, loader, or vacuum truck as appropriate.
- In the event of a container falling overboard, its recovery would be dependent on water depth and lake/sea conditions.

Fugitive Dust Control Measures: Copper-Gold Concentrate

For Alternative 1a, Alternative 1, Alternative 2, and Alternative 3 base case, copper-gold concentrate containers would be lightered out to moored bulk carriers at one of the lightering locations and emptied into the open hold of the vessel. For Alternative 3 Concentrate Pipeline Variant, concentrate would be transferred by conveyor, lightered out on the decks of barges, scooped up from the decks by wheeled loaders into ship loaders, then loaded into the open hold of the bulk carrier.

These processes have the potential to generate fugitive dust. This potential would be minimized with the following measures:

- For Alternative 1a, Alternative 1, Alternative 2, and Alternative 3 base case:
  - A barge-mounted crane with a specialty spreader unit would lower containers deep into the open hold of the vessel; it is only at that point that the system would unlock the lid and turn the container upside down to release the concentrate into the ship's hold.
  - The crane operator would be responsible for lowering the container deep enough into the hold so that the concentrate falls less than 10 feet, and the discharge elevation is 20 feet or more below the hatch (PLP 2018-RFI 045; PLP 2018c). This prevents falling concentrate from causing turbulent disturbance of concentrate and eliminates any cross-winds from blowing the concentrate out of the ship's hold.
  - The hold would be filled with concentrate to only approximately 50 percent of the maximum capacity of the hold. (The hold could not be filled completely due to the density/weight of the concentrate.) A typical bulk carrier hold is 60 feet in depth. Therefore, the highest discharge elevation of concentrate would be 20 feet below the hatch (PLP 2018-RFI 009c).
  - Copper-gold concentrate is moist (8 percent moisture), which helps to reduce dust generation.

 - If necessary, a water fog system could be installed around the perimeter of the hatch to further moisten the concentrate and capture potential dust.
 - Loading operations would be interrupted when warranted by sea and weather conditions (PLP 2018-RFI 045, RFI 032).
 - After containers have been emptied, lids would be re-installed to avoid any residual material from escaping, and they would be returned to the barge and taken to shore. Each container would then have its exterior cleaned with a vacuum or spray system at the port site prior to being returned to the mine for refilling.
 - Container lids would remain in place until arrival at the mine (PLP 2018-RFI 045).
- For Alternative 3 Concentrate Pipeline Variant:
  - Concentrate would be transferred from the storage building to the barge-loading area by fully enclosed conveyors to contain dust (PLP 2019-RFI 066a).
  - The barge loader would employ an enclosed conveyor boom and telescoping spout to distribute the cargo onto the barge deck with mechanical dust collection (PLP 2019-RFI 066a).
  - The lightering barges would have dust covers to control dust emissions (PLP 2020d).
  - The loading trunk of the ship loader would extend down into the hold of the ship to minimize the potential for generation of fugitive dust, and mist sprays would be used to further control dust (PLP 2020d).
  - The holds of the bulk carriers would not be loaded to the top, further reducing any potential for concentrate dust to escape the hold (PLP 2020d).

Fugitive Dust Control Measures: Molybdenum Concentrate

Molybdenum concentrates would be loaded into FIBC bulk bags and then into standard 20-foot sea containers. The doors at the end of the containers would be sealed for transport, and the bags would not be unloaded until they reached their destination at an off-site smelter (PLP 2018-RFI 045).

Avoidance and Minimization/Design Features of Concentrate Pipeline

The following is a summary of mitigation measures presented in PLP 2018-RFI 066:

- The 6.25-inch steel pipeline would contain an internal high-density polyethylene liner to prevent internal corrosion.
- Cathodic protection system (zinc ribbon or similar) would be used to prevent external corrosion.
- A pressure-based leak detection system would monitor pipeline for leaks.
- Rupture discs and pressure monitoring would protect the pipeline from overpressure events.
- The pipeline would be protected from freezing and buried with approximately 36 inches of cover, or deeper in areas where needed to prevent freezing (Chapter 2, Alternatives). At major stream crossings, the pipeline would be attached to the vehicle bridges and protected from freezing.
- Aboveground sections and pipeline bridge crossings would employ heavy wall pipe or casing for additional protection.
- Manual isolation and drain valves would be located at intervals no greater than 20 miles apart.

- Major river crossings would have isolation valves and pressure and temperature monitoring instrumentation installed.
- Decisions on the appropriate methodology for individual stream crossings would be made in consultation with the ADF&G Habitat Division.

4.27.6.7 Concentrate Spill Scenarios

These scenarios address the probability and consequences of spills of copper-gold concentrate. Molybdenum concentrate is not considered herein, because it would make up only 2.5 percent of the total concentrate produced and would therefore be subject to much lower spill potential. In addition, only copper-gold concentrate has been considered for transport by slurry pipeline as part of the Alternative 3 Concentrate Pipeline Variant.

Concentrate spills from a truck rollover and a concentrate slurry pipeline rupture were analyzed for potential impacts. Spills of copper-gold concentrate from over-water transfer, a marine vessel, and the Iliamna Lake ferry are addressed below, but were ruled out as unrealistic probabilities of occurrence, and not selected for impacts analysis.

Scenario: Concentrate Spill from a Truck Rollover

This scenario addresses the probability and consequences of a spill of 80,000 pounds of copper-gold concentrate into the environment due to a truck rollover along one of the access roads. An 80,000-pound spill was selected for this scenario because it represents the upper range of the average spill size from the Red Dog Mine analog data, presented above. The upper range size was selected to address a broader range of potential impacts.

In this scenario, a truck hauling three trailers, each with a full container of 76,000 pounds of concentrate, rolls over onto the side of the road corridor. The lid-locking mechanisms on two of the containers are damaged, allowing the lids to open, and about half of the concentrate from each container spills out. A total of 80,000 pounds of concentrate is released onto the roadside area. In this scenario, even if the spill were to occur on a bridge over a stream, most of the spilled concentrate would not be likely to end up in the stream. Concentrate would be composed of relatively dense, moist particles. In the event that a container of concentrate overturned, some concentrate would spill out onto the roadway, while some of the material would likely remain in the overturned container. Due to the density and solid nature of the material, the concentrate would not readily mobilize from the roadway into adjacent waterways. The impacts assessment therefore assumes that only a small portion (perhaps 10 percent) of spilled concentrate may spill into a stream. This would equate to approximately 800 pounds of concentrate, or 72 ft^3.

No studies have been identified that analyze trucking-related spill rates on private, controlled-access industrial roads, such as the project access roads (ARCADIS 2013). The probability of this scenario is therefore based on available historic spill data from transport of ore concentrate along the 52-mile haul road used by Red Dog Mine (as discussed above), the most relevant concentrate transport analog in Alaska. Based on the ADEC record of spills at Red Dog Mine, the estimated spill rate per mile for a trucking-related concentrate spill in the project was calculated to be 0.78×10^{-6}, which equates to an average of 0.4 trucking-related concentrate spills per year for 66 miles of road transport. Note that miles of road transport vary by alternative from 53 to 82 miles (Table 4.27-1). Sixty-six miles was used in the original calculation for the Alternative 1 road corridor. This equates to a 33 percent probability of such a spill in any given year, and a 100 percent probability in 10 years or more (i.e., 100 percent probability during the proposed 20-year project); or an average of one spill every 2.5 years (AECOM 2019a). (Note that in the expanded mine scenario, concentrate would be transported by pipeline, not by truck.) As noted above, as of 2005, haul trucks at Red Dog Mine hauled 85 tons (170,000 pounds) of concentrate in two side-dump trailers (AECOM 2019a). Note that the Applicant would haul 114 tons (228,000 pounds) of concentrate in three trailers. Red Dog Mine operations hauls less concentrate per truck trip, but each trailer at Red Dog would haul slightly more concentrate (approximately 42.5 tons/85,000 pounds per trailer) than each trailer that would be hauled by the Applicant (approximately 38 tons/76,000 pounds). The spill size of 80,000 pounds is representative of the range of typical concentrate spills from Red Dog Mine between 1995 and 2017; however, 80,000 pounds are slightly less than would be hauled by one Red Dog trailer, and slightly more than would be hauled by one of the Applicant's trailers.

If the concentrate were to spill into a stream, the bulk of the material would sink to the bottom, while the finer particles of concentrate would become suspended and transported downstream by the current. The remaining fine particles at the spill site would continually become entrained in the current and flushed downstream, and the downstream water would become turbid with elevated levels of TSS. Some of the material would be deposited along the streambed, especially in side-channels or other areas where the current is weak. Some material could be flushed downstream into Iliamna Lake or Iliamna Bay, where some of the particles may eventually settle out as deltaic deposits. There are numerous stream crossings along the road corridors for all alternatives, so there is a reasonable probability of this scenario occurring at a stream crossing.

Spill Response

PLP would have a spill plan in place that would detail the measures to prevent, respond, contain, report, and cleanup spills of concentrate and other potentially hazardous materials. See the "Spill Preparedness, Prevention, and Response Measures" subsection. Drivers would be trained in spill reporting and procedures to minimize and contain low-volume spills, and the driver would be able to conduct an initial response and call for assistance immediately.

If the spill were to occur on dry land, the concentrate would simply accumulate on the roadside. Recovery efforts would be straightforward, with any spilled concentrate recovered back into the containers by heavy equipment. The process would require very thorough cleanup to avoid residual spilled material that could generate fugitive dust.

If the concentrate were to spill into one of the small ponds present along the road corridors, it would sink to the bottom, and create short-lived clouds of turbidity/elevated TSS that would then settle out. Spilled material could be excavated or dredged from the pond, and recovery efforts would likely be effective. Residual amounts of concentrate could remain in the waterbody after cleanup.

The recovery of concentrate spilled into a stream would range from difficult to impossible, depending largely on the strength of the current, which would vary with each stream, and would also vary seasonally. In low-energy streams, much of the spilled concentrate may remain at the spill site for days before being flushed downstream, allowing crews time to dredge/excavate the material from the streambed. Some volume of the concentrate would be transported downstream and deposited along the streambed.

High-energy streams could likely transport most or all of the spilled concentrate downstream of the spill site within 24 hours. By the time crews could mobilize for a response, much of the material would likely be dispersed downstream, making recovery impossible/impractical. Concentrate would become widely dispersed along the streambed, and some of it would remain suspended in the water as long as the current remained strong. Concentrate would settle on the streambed in some areas of lower water velocity, but then would be remobilized by the current during periods of higher stream flow. Depending on the volume that enters the stream, much of the spilled concentrate could naturally flush out of the drainage within weeks to months, while some of the material that settles in low-energy reaches could remain for years to decades. Remaining concentrate would slowly be flushed downstream over ensuing decades, where the material would collect in deltaic deposits at the shoreline of Iliamna Lake or Iliamna Bay.

If the spill occurred during frozen conditions, concentrate would likely collect on top of frozen soil or the surface of frozen waterbodies, facilitating recovery. In some situations, spilled concentrate may penetrate ice on a frozen waterbody, allowing concentrate to spill into the waterbody below. In areas where ice is inconsistent, thin, or fractured, concentrate could enter incompletely frozen waterbodies or flowing water, complicating recovery efforts. Adverse environmental conditions such as heavy rain or snow could also complicate recovery, and strong winds could spread fugitive dust from the spilled concentrate prior to recovery.

Alternatives Analysis

The potential for a concentrate haul truck rollover could vary somewhat by alternative; road corridor lengths and road conditions, such as grade, would vary between alternatives. Alternative 1a would include 72 miles of road transport; Alternative 1 would include 65 miles of road transport; Alternative 2 would include 53 miles; and Alternative 3 would include 82 miles of total road transport. The road corridor for Alternative 3 would be expected to have more road segments with higher grade, based on more steep topography in the southern and eastern portions of the road corridor. Final road design, including grades, has not yet been determined.

Alternative 3 would not involve concentrate transport by ferry, so there would be no potential for concentrate spills from the ferry into Iliamna Lake. The Alternative 3 Concentrate Pipeline Variant is addressed with a spill scenario from the concentrate pipeline, below.

Potential Impacts of a Concentrate Spill from Truck Rollover

This section addresses potential impacts of a copper-gold concentrate spill from the truck rollover scenario described above. Impacts were analyzed in terms of their magnitude, duration, geographic extent, and potential to occur. A concentrate spill would not impact all the resources addressed in this EIS. The following resources were selected for analysis based on their higher potential for impacts.

Soils

Concentrate spilled onto soils would be recovered so that there would be no impact. Historical data from Red Dog Mine show that most concentrate spills that impact land only and do not enter surface water have a nearly 100 percent recovery (ADEC 2018h). Assuming the spill response as described in this scenario, residual concentrate or fugitive dust produced would not be likely to have impacts on soil quality exceeding soil quality criteria.

Water and Sediment Quality

If spilled concentrate does not enter surface water drainages, and recovery of spilled concentrate is prompt and thorough, there would be no anticipated impacts to surface water quality. If concentrate does enter surface waterbodies, depending on the location of the spill and the effectiveness of recovery efforts, the impacts discussed below could occur.

TSS and Turbidity—Fine particles of concentrate (silt and clay-sized) spilled into flowing water would become suspended in the water, creating a large plume of turbid water that would travel downstream. The plume could cause all downstream water in the channel to become turbid, with elevated TSS, until dispersing/settling out in a larger waterbody. The extent of the elevated TSS could be tens of miles downstream, especially where currents are strong. If spilled concentrate is recovered promptly, the duration of the TSS and turbidity would likely last for a few days. If the concentrate is not recovered, the duration of impacts could be weeks to months. If concentrate were to spill into a dry or very low-volume stream, most of the material would likely be recovered. If concentrate spilled into a low-volume stream and was not recovered, the material could be remobilized during periods of higher water levels. This could cause elevated TSS and turbidity to extend for additional months to years.

Sedimentation—If concentrate is released into flowing water, some of the particles would be deposited as sediment downstream, especially in areas where the current slows. Concentrate could bury existing stream-bottom sediments and fill in interstitial spaces between gravel clasts, modifying benthic habitat.

Acid Generation—For a discussion of factors that impact the ability of concentrate particles to generate acid, see "Factors Influencing Acid Generation and Metals Leaching" in the "Concentrate Spills" subsection.

Sulfide minerals in unrecovered concentrate, which would be deposited in limited areas, would slowly dissolve over years to decades. To produce acid, the sulfur needs to be oxidized. A small amount of oxygen can be dissolved in flowing water, and almost no oxygen would be present in still or stagnant water. Circulating water such as in Iliamna Lake can be periodically enriched in oxygen. Mean concentrations of oxygen in project area streams ranged from 10.2 to 10.5 mg/L, and 12.3 mg/L is the theoretical saturation limit for local conditions (Section 3.18, Water and Sediment Quality). The oxygen concentration in flowing water is capable of generating a small amount of acid from spilled concentrate; however, the process of acid generation would be slow, and any acid generated would be constantly diluted by the flowing water. As long as concentrates remain under water, acidic conditions would not be likely to occur. If concentrate were to spill into ponds or non-flowing water, it could be recovered. Any residual concentrate remaining on dry land for multiple years could potentially generate acid. In low-water conditions, or in deltaic environments, additional spilled concentrate could be exposed to air, increasing the potential for acid generation. In addition, concentrate that has settled on streambeds could be resuspended during flooding/storm events and could be further oxidized. The acid could be flushed into surface water, potentially reducing the pH of waterbodies. The rate of acid production is slow, however, and surface water so abundant, that any acid produced would be rapidly diluted, so that in this scenario, no measurable reduction in surface water pH that would exceed WQC would be likely to occur. (Note that "no measurable" change in pH means that any changes would be indistinguishable from natural background variation).

Metals Leaching—For a discussion of factors that impact the ability of concentrate particles to leach metals, see "Factors Influencing Acid Generation and Metals Leaching" in the "Concentrate Spills" subsection.

Downstream waters would be elevated in metals in their *total form,* while concentrate particles remain suspended in the water column. The metallic minerals in the concentrates are not readily soluble in water, so spilled concentrate would not immediately introduce metals in a bioavailable form. If spilled concentrate is promptly removed from the impacted waterbody, there would be no measurable leaching of metals. (Note that "no measurable" leaching means that any changes in metals levels would be indistinguishable from natural background variation.) If concentrate is not recovered, however, some of the metallic minerals would slowly dissolve over years to decades, potentially leaching metals into the water.

If the spill enters flowing water, some of the concentrate would be dispersed downstream. Even after a prompt and thorough spill response, some of this concentrate would not be recovered. However, due to the limited amount of concentrate that could remain in the streams, and the dilution of the slowly leached metals from stream water, the ML would likely not be a measurable impact.

If concentrate were to spill into ponds or non-flowing water, it could be recovered. Concentrate that is not recovered from isolated waterbodies, such as ponds, could leach metals that would not be diluted/flushed out. Water quality in these isolated waterbodies could be impacted by elevated metals levels.

The concentrates may also contain residues of chemical reagents. See the "Reagent Spills" section for a discussion of reagent fate and behavior in the environment.

Assuming the spill response as included in this scenario, any fugitive dust produced would likely not have measurable impacts on water quality.

No impacts to groundwater quality would be expected from this scenario.

If spill recovery involves dredging, BMPs would help to lessen the potential for erosion of streambed and shoreline sediments.

Residual Toxins—Concentrate may also contain residues of chemical reagents, including sodium ethyl xanthate and sodium hydrogen sulfide, both of which can be toxic to fish in low concentrations. See discussion of chemical reagents below under Reagent Spills. The amount of these reagents introduced into the environment in this scenario would be very minor.

Noise

Noise could be generated from spill recovery operations, including increased vehicle traffic, and use of cleanup equipment. If the increase vehicular traffic would be less than double the amount of existing traffic, then the noise level increase would be less than a 3-dBA increase over existing traffic noise levels (generally less than noticeable). Noise from cleanup equipment would depend on the type of equipment used. However, equipment such as pumps, tractors, heavy-haul trucks, and Vac-trucks would have a maximum noise level of approximately 85 dBA or less at 50 feet (FHWA Roadway Construction Noise Model) and would be limited to the cleanup area for the duration of the cleanup and recovery effort.

Air Quality

Concentrate deposited on land that is able to dry out has the potential to become airborne fugitive dust in the form of particulate matter and particulate hazardous pollutants. In the case of a concentrate spill on dry land, recovery of the concentrate would be straightforward, with most of the concentrate likely recovered. Only residual concentrate would likely remain at the spill site, which could dry and out produce potential fugitive dust. Assuming the spill response as included in the scenario, any fugitive dust produced could have localized and temporary impacts on air quality. If spill response was delayed, concentrate could dry out and spread more readily as fugitive dust.

The magnitude and potential of the impacts would depend on the amount of concentrate that deposited on land and meteorological conditions at the time of the spill. A larger spill with strong winds would likely increase the air quality impacts. Concentrations of particulate matter could temporarily exceed the NAAQS concentrations; but over time, the air quality would return to pre-spill conditions. The duration of air quality impacts would be temporary and would return to pre-activity levels at the completion of the activity. The extent of impacts would be limited to discrete portions in the project area, where the spill took place.

Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

Across all alternatives, less than 10 percent of the road corridor passes through wetlands or waterbodies, while the remainder is uplands. This analysis describes the impacts if the spill were to occur in wetlands or waterbodies. A spill into a pond, lake, or stream would impact surface waters as discussed above for Water and Sediment Quality. A spill into vegetated wetlands would primarily affect scrub-shrub and emergent vegetation, because these wetland types represent more than 99 percent of the vegetated wetlands in the transportation corridor.

The magnitude of impact is directly related to the location and timing of the spill. If it occurs during the winter while the waters and wetlands are frozen, then cleanup activities are likely to be more effective, and with a lower magnitude of impact compared to a spill during open-water season, when the spill would be more difficult to clean up, and therefore, more of it would enter waters or wetlands. Vegetation and any wetlands or special aquatic sites that are buried by the concentrate would experience high impacts. Vegetation may also be impacted during cleanup activities.

Concentrate solids would not be expected to affect wetlands through acid generation or ML in the short-term. Over years to decades, any unrecovered concentrate solids in the wetland area could produce acid or metals.

Wetlands and waters could be affected by sedimentation from concentrate solids. Concentrate could bury wetland plants and alter the substrate of exposed waterbodies. As described in the "Water and Sediment Quality" subsection, concentrate released into flowing waters would result in some of the particles being deposited as sediment downstream, especially in areas where the current slows. Adjacent riparian vegetation, including any wetlands or special aquatic sites present, could be covered.

The extent of the area impacted depends on the timing and location of the spill and the effectiveness of the spill response. Spills that occur into flowing water and those that occur in the open-water season are likely to affect a larger area than those that occur during the winter, because concentrate could become entrained in water and be transported. During partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), concentrate may be trapped beneath ice and spread out in flowing water. During frozen conditions with complete ice cover, concentrate is more likely to spill onto frozen surfaces and not spread out as much, and may be easier to clean up.

The duration of impacts is also related to the timing of the spill and the speed of cleanup. Spills that occur during the open-water season may require more time to clean up, and more time for wetlands to recover: possibly several growing seasons. Spills that occur during the winter would be more likely to spill onto frozen surfaces and not spread out as much; therefore, recovery may be faster. During partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), concentrate may be trapped beneath ice, potentially prolonging cleanup and duration of impacts.

Terrestrial Wildlife

Potential impacts from a concentrate spill in upland vegetation communities along the transportation corridor are anticipated to have low-magnitude, localized impacts of temporary duration (from days to weeks depending on cleanup activities) on terrestrial wildlife. Depending on the terrain where the spill occurs, the concentrate may flow downhill until it is stopped by natural topography, vegetation, and gravity. Some dust may be blown into adjacent vegetation; however, most of the concentrate would be removed, thereby reducing impacts on wildlife. It is unlikely that wildlife species would consume the concentrate, because wildlife are anticipated to avoid (and may be hazed from) the area during cleanup activities. There is a low potential that a few small mammals (such as voles, shrews, and lemmings) may be covered by concentrate at the time of the spill.

Historical data from Red Dog Mine show that most concentrate spills that impact land only and do not enter surface water have a nearly 100 percent recovery (ADEC 2018h). Spill duration would last until cleanup activities had removed most of the concentrate, which is anticipated to last a short time (perhaps up to a month); and rain is expected to wash off any remaining concentrate dust from the surrounding vegetation. Under the spill scenario, residual concentrate or minor fugitive dust produced may occur at low levels in a small, localized area around where the spill had occurred.

If a concentrate spill occurs and enters flowing water, concentrate would be carried rapidly downstream and dispersed. Increased TSS/turbidity and sedimentation in a waterbody from a concentrate spill have a potential to smother salmonid eggs in the immediate area of the spill. The smothering of eggs is likely only in the immediate area of the spill (under low-flow conditions or in a small stream), and would only impact eggs in the immediate footprint of the spill.

Leaching of metals from concentrate would likely require years to decades (see the "Fate and Behavior of Spilled Concrete" subsection). Moreover, copper does not bioaccumulate in fish, and therefore does not pose a consumption risk to bears (*Ursus* species), gray wolves (*Canis lupus*), or other terrestrial wildlife that consume salmon (EPA 2014).

Spills that occur during winter months are less likely to impact wildlife species, because many species are hibernating, or have reduced levels of activity and movement. Frozen substrates may allow for more efficient spill response and clean up, and limit the spread of concentrate, although incomplete or broken ice may allow concentrate to spread beneath the ice. Winter spills would be anticipated to have a low impact.

If a spill occurs in a pond, or other stagnant water location, impacts may extend longer, depending on the level of cleanup. If wood frogs occur in the pond, they could be impacted by cleanup activities; and over years to decades, any unrecovered concentrate solids in the wetland area could produce acid or metals.

In summary, a concentrate spill is anticipated to have a small localized impact on a discrete geographic area (while it is cleaned up), with a low magnitude and temporary duration lasting from days to weeks, depending on the amount of time to clean up the spill.

Finally, residual amounts of reagents would be released into the environment with the concentrate in this scenario. The small amount of reagents released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts from these toxins would be localized and of low magnitude.

Birds

Bird species in the immediate vicinity of a spill are likely to initially vacate the area, reducing potential impacts to birds. A spill during spring, summer, and fall may have the greatest magnitude, because migrating and breeding, and young-of-the-year birds are present. Spills that occur during winter months are less likely to impact birds, because most species have migrated south, and frozen substrates permit more efficient spill response and cleanup. For a spill during the summer, there is a low potential for bird species that nest on the ground to be impacted if a spill flows or covers up their nest or young. Species known to occur in the area that nest close to or on the ground include spruce grouse (*Falcipennis canadensis*), ptarmigan species (*Lagopus* species), fox sparrow (*Passerella iliaca*), common redpoll (*Acanthis flammea*), and dark-eyed junco (*Junco hyemalis*), among others. Because the area affected would be small, the number of birds likely to be impacted would be small. In upland terrestrial habitats, the concentrate would be cleaned up, and any fugitive dust or remaining concentrate on vegetation would be washed off during rain events.

If the concentrate spill occurs in a marsh, pond, or other non-flowing waterbody, the concentrate would be cleaned up, and is not expected to result in ML or copper toxicity to fish or invertebrates; and some waterbirds (such as ducks, geese, waterfowl, loons, grebes, mergansers, and others) and shorebird species may temporarily be displaced during cleanup activities. If cleanup activities occur during the summer breeding season near nests, some species may abandon their nests, which may result in breeding failure or loss of clutches. Therefore, impacts are anticipated to have a low magnitude in a localized area with a temporary duration.

Residual amounts of reagents that have not biodegraded would be released into the environment with the concentrate in this scenario. The small amount of the reagents released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts from these toxins would be localized and of low magnitude.

Fish

If released into an enclosed waterbody like a pond or a lake (including in a wetland), the concentrates would sink to the bottom and contribute to sedimentation. The fine particles would bury the natural substrate and could smother benthic organisms or eliminate benthic habitat. Recovery efforts could remove spilled concentrate from pond or lake bottoms where practicable, although the impact to benthic habitat would likely occur prior to recovery efforts. In addition, dredging to remove spilled concentrate could cause further disruption of the aquatic habitat.

A spill of concentrate would introduce fine sediment into the stream that would cause sedimentation and elevated TSS/turbidity downstream, into surface water that has naturally low TSS and turbidity. On large rivers such as the Newhalen, continual flushing and periodic high-flow events (spring break-up and fall floods) would transport the concentrate downstream to Iliamna Lake. The extent of the spill impact would be from the location of the spill downstream to where the concentrate settles out and is eventually incorporated into the streambed substrate as a fraction of the bedload. Some of the concentrate would cover and modify the benthic habitat.

Potential impacts of the spill to fish include decreased success of incubating salmon eggs; reduced food sources for rearing juvenile salmon; modified habitat; and in extreme cases, mortality to eggs and rearing fish. The scope of the potential effects to salmon life stages would depend on the timing and magnitude of the spill. The extent of the impact would depend on the downstream dispersal of a small amount (72 ft^3 in this scenario) of concentrate. Mortality to eggs through smothering would be spatially limited. Future return of an age class could be reduced. However, this impact would likely be very localized and may not be measurable above natural background variation. The duration of impacts would be short-term, or until the concentrate is dispersed and diluted downstream and/or incorporated into the bedload. Suspended solids from turbidity and TSS can injure juvenile salmon and reduce their ability to sight-feed on surface and near-surface invertebrates at higher concentrations of turbidity (USACE 2008b). At lower turbidity, juvenile salmon may use turbid waters as cover to hide from predators. Salmonids can encounter naturally turbid conditions in estuaries and glacial streams, but this does not necessarily mean that salmonids in general can tolerate increases of suspended sediments over time (Bash et al. 2001). Relatively low levels of anthropogenic turbidity may negatively affect salmonid populations that are not naturally exposed to relatively high levels of natural turbidity (Gregory and Levings 1996). The feeding efficiency of juvenile salmonids has been shown to be impaired by turbidity levels exceeding 70 nephelometric turbidity units (NTUs), well below typical; and well below typical and persistent levels in fresh waters of the analysis area (Pentec 2005). Therefore, impacts are anticipated to have a low magnitude in a localized area with a temporary duration.

Residual concentrate particles would be flushed downstream and deposited in low-energy areas, although a fraction of the spilled concentrate may ultimately reach deltaic deposits in Iliamna Lake or Iliamna Bay. Acid generation and metals leaching from these sporadic deposits would occur slowly over years to decades. Any acid produced and metals released would be rapidly and sufficiently diluted by fresh water, so that reduction in stream water pH and increases in metals concentrations relative to the baseline conditions are not likely. Therefore, impacts via metals toxicity to fish would not occur under the concentrate spill scenario being evaluated.

Small amounts of concentrate may be entrained in streambed sediment, and may leach metals slowly over years to decades. This could cause low-magnitude, localized impacts to benthic organisms that are preyed on by fish.

Finally, residual amounts of chemical reagents including xanthate would be released into the environment with the concentrate in this scenario. However, as discussed in EPA 2014, the small amount of xanthate released, coupled with the dilution that would occur in the downstream environment would suggest that impacts from these toxins would be localized and of low magnitude (Xu et al. 1988).

Threatened and Endangered Species

In the analysis area, TES are only found in the marine environment of Cook Inlet (and are described in Section 3.25, Threatened and Endangered Species). There are two creeks that flow east into Cook Inlet that are crossed by the alternative transportation corridors. For Alternative 1a and Alternative 1, one small creek is a tributary to Amakdedori Creek, which is crossed by the port access road just west of Amakdedori port. The potential for a spill to occur directly over this small creek, and then for concentrate to get carried downstream into Cook Inlet, is extremely low. The creek has low flow rates, and even if concentrate reaches Cook Inlet, it takes years to decades for copper to become bioavailable. The majority of the concentrate would be removed from the creek, but small amounts may get carried downstream into Amakdedori Creek. Any copper carried downstream is anticipated to settle down in the various backwater pools and low-flow locations of the creek as it slowly winds towards Cook Inlet. A trace amount may eventually be carried into Cook Inlet; however, continual flushing due to freshwater influx and wave action would disperse any concentrate, and it would have no discernable impact on TES.

There is another small creek (Williams Creek) that flows into Iliamna Bay that is crossed by the Alternative 2 and Alternative 3 transportation corridors. The potential for a spill to occur directly over this creek and the concentrate to be carried downstream into Cook Inlet is extremely low. This creek has low flow rates; therefore, concentrate spilled into Williams Creek would not be rapidly transported into Iliamna Bay, and the majority could be cleaned up before it reaches the marine environment. If a small amount of concentrate were to reach Iliamna Bay, it would be exposed to dilution by fresh water from Williams Creek and wave action.

Exposure to natural substances released into the marine environment is a potential health threat for Cook Inlet beluga whales and their prey; however, Cook Inlet beluga whales generally have lower contaminant loads than do beluga whales from other populations (NMFS 2016b). The Cook Inlet Beluga Whale Recovery Plan concludes that the magnitude of the pollution threat to Cook Inlet beluga whales and the relative concern of known and tested contaminants to Cook Inlet beluga whales are most likely low (NMFS 2016b). Similar to beluga whales, other marine mammal TES could potentially be affected by a concentrate spill, potentially through reduced prey resources. Any loss of prey would be difficult to quantify, given environmental variability in annual salmon numbers.

The potential for a spill along the Alternative 2 and Alternative 3 transportation corridor between Iliamna Bay and Diamond Point port is also low. The majority is likely to spill along the roadway and a small amount may enter the marine environment. Due to wave action, any concentrate that spills into Iliamna Bay is likely to be dispersed throughout the bay and settle out with the other deltaic sediments. In addition, there is a large reduction in copper toxicity that results from copper bonding with dissolved organic matter (EPA 2014). Therefore, there is a low potential that a concentrate spill would impact TES, and the magnitude would be of low intensity, with a temporary duration.

Marine Mammals

Similar to TES, marine mammals that occur in Cook Inlet (detailed in Section 3.23, Wildlife Values) would have a low potential to be impacted by a concentrate spill along the transportation corridor. The potential for impacts to reach Cook Inlet are low. Given the amount of time for copper in the concentrate to dissolve and become bioavailable, continual flushing by wave action, and further reduction in bioavailability due to dissolved organic matter, any concentrate that reaches Cook Inlet is unlikely to produce a noticeable difference in the prey base for marine mammals. Therefore, any impacts are anticipated to not be discernable.

If the concentrate spill were to occur over a stream or river that flows into Iliamna Lake, harbor seals in Iliamna Lake (hereafter Iliamna Lake seal) may be impacted. The extent of impacts that enters a river flowing into Iliamna Lake could reach foraging areas for Iliamna Lake seals. As discussed in Section 3.23, Wildlife Values, Iliamna Lake seals are regularly observed on the eastern side of the lake, in proximity to the Alternative 2 and Alternative 3 transportation corridors. As mentioned above, if the concentrate were to spill into a stream, the bulk of the material would sink to the bottom, while some of the concentrate would immediately be transported downstream by the current. The duration of impacts would be short-term (1 to 12 months), because the remaining fine particles at the spill site would continually become entrained in the current and flushed downstream; and the downstream water would become turbid, with high levels of TSS. Some material could be flushed downstream into Iliamna Lake, where the particles would mostly settle out as deltaic deposits. Increased turbidity of the water entering the eastern portion of the lake may result in temporary impacts to Iliamna Lake seals foraging in the area, and there is a potential for Iliamna Lake seals to be temporarily disturbed while cleanup activities occur. Iliamna Lake seals are anticipated to avoid the area (or be hazed) while cleanup is occurring, and overall impacts are anticipated to be low.

Needs and Welfare—Socioeconomics

It is unlikely that cleanup and remediation activities following a truck release of concentrate would result in increased employment opportunities in the region. Cleanup crews would be small, and likely consist of only PLP employees and specialized contractors. Such a spill would be unlikely to have negative impacts on employment, income, and sales in the region.

Recreation

In the event of a concentrate release from a truck, the spill and response effort would have a temporary effect on recreational resources. The movement of cleanup equipment may be noticeable to recreationists on Iliamna Lake and (seasonally dependent) snowmachine or all-terrain vehicle (ATV) users. The cleanup activities may displace sport fishing or hunting, depending on the area of the spill; however, there are comparable areas available throughout the region for recreation. There would be relatively few recreationists that would be impacted.

Commercial and Recreational Fishing

A truck rollover has an extremely low potential for affecting commercial fishing and the number of returning adult salmon. In any event, the rollover would not affect current-year harvests, because the event would occur upstream of commercial harvest opportunities. Depending on the timing and magnitude of a rollover and spill event, the event could result in the smothering of salmon eggs and reduced feeding success within a limited geographic area. Because salmon impacts are anticipated to be of low magnitude, in a localized area, and short-term, similarly limited effects on commercial salmon harvest values would be expected.

Recreational fishing on the region's rivers and streams is highly seasonal and focused on harvesting returning salmon, and angling for non-salmon salmonids feeding on deposited eggs and salmon carcasses. A rollover event could displace recreational angling efforts if the event or cleanup occurred during the open-water fishing season. The region provides enough angling opportunities for anglers to adjust their fishing locations. However, an event near specific angling locations could affect specific guide companies or angler sub-groups. These effects would be limited in duration and are not expected to extend beyond a single fishing season.

Cultural Resources

Direct impacts to cultural resources from a potential concentrate spill would be similar to the diesel spill scenario discussed above. It would directly impact cultural resources if such a release would occur within the bounds of a cultural resource area or known or potential historic property site. These impacts could include contamination of organic cultural materials and site sediments. Such an event would likely result in direct impacts through loss of integrity for eligibility to the National Register from cleanup activities. These impacts would likely severely damage the site, and resources would not be anticipated to return to previous levels even after actions that caused the impacts were to cease. Indirect impacts could occur to the setting (visual, noise, and olfactory impacts) of cultural resources if the spill were to happen in the vicinity. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Those impacts would be temporary and would cease when response efforts are complete.

Subsistence

A release of concentrate could have localized impacts to subsistence resources and could cause mortality and displacement of fish and wildlife before and during cleanup activities. The concentrate release would likely cause concerns over contamination for local subsistence users that could cause users to avoid the area and alter their harvest patterns. Quick response and cleanup of spills (particularly for spills in water), a system of testing wild foods, and clear and timely communication with nearby communities would help ease concerns about contamination for subsistence users in nearby communities.

Health and Safety

A release of concentrate could cause stress to community members in close proximity from real or perceived risks of contamination, and potentially impact human health. Spills create anxiety about the safety of subsistence foods and water quality. Quick response and containment of spills (particularly for spills in water) and a system of testing wild foods and drinking water for contaminants to give local people complete and understandable information in a timely manner could help alleviate some anxiety, and reduce potential impacts to human health. There would be potential adverse impacts to social determinants of health (HEC 1), with psychosocial stress resulting from community anxiety over a truck release. A truck release may involve a surface transportation accident or injury, but would not likely create increased risks for transportation-related injury or accident (HEC 2). As noted above, a release of concentrate could have localized impacts to subsistence, including avoidance of the area and altering harvest patterns, which in turn could temporarily impact food security and subsistence-level nutrition (HEC 4). The duration of impacts would be short-term (1 to 12 months).

Scenario: Concentrate Slurry Pipeline Rupture

This scenario addresses the probability and consequences of a release of concentrate slurry equal to 900 ft^3 (54,000 pounds; 27 tons) due to rupture of the concentrate slurry pipeline.

Alternative 3, Concentrate Pipeline Variant, would include the transport of copper-gold concentrate in slurry form through a 6.25-inch-diameter steel pipeline that would parallel the north road corridor from the mine site to the port. For most of its length, the pipeline would be buried in the same trench as the natural gas pipeline (PLP 2018-RFI 066). At major stream crossings, the pipeline would be attached to bridge infrastructure; would have additional isolation valves; and would be heavy-walled or cased for extra protection. A pressure-based leak detection system would monitor the pipeline for leaks (PLP 2018-RFI 066). Because the concentrate slurry would be a potentially corrosive material, the pipeline would have an internal high-density polyethylene liner to prevent internal corrosion. See "Avoidance and Minimization/Design Features of Concentrate Pipeline" above for additional spill mitigation features. A concentrate pipeline traversing Iliamna Lake is not being considered (PLP 2018-RFI 032). See Chapter 2, Alternatives, for further details.

In this scenario, the slurry pipeline attached to bridge infrastructure is ruptured during an earthquake, and concentrate slurry begins to flow from the pipe. The automated leak detection system would detect the leak, at which point it would take approximately 1 minute for the pipeline pumps to be shutoff. This would reduce the flow of concentrate slurry in the pipeline, so that the slurry would likely not readily flow out of the pipe for more than approximately 5 minutes. During the initial 5 minutes after rupture, approximately 700 ft^3 of concentrate slurry (42,000 pounds; 21 tons) would be released (PLP 2018-RFI 066). Even after the pumps are shut off, the static head (pressure) in the pipeline would cause additional release of slurry, on the order of 200 ft^3 (12,000 pounds; 6 tons). It would likely require approximately 30 minutes for personnel to respond on the scene and close the manual isolation valves on each side of the bridge, to block any further residual flow from spilling from the pipe. Automatic isolation valves have been suggested as additional mitigation (see Appendix M1.0, Mitigation Assessment). This scenario includes a total release of 900 ft^3 (54,000 pounds; 27 tons) of slurry from the pipeline. Some of the slurry may collect beneath the bridge, while much of it would flow into the stream.

The estimated failure rate for the concentrate pipeline under the Alternative 3 Pipeline Concentrate Variant was based on data compiled by the EPA (2014) and Cunha 2012. As described above, no published failure rates are available specific to concentrate pipelines, so the failure data analyzed come from oil and gas pipelines.

EPA focused their pipeline failure data on pipelines of a similar size (less than 20 centimeters, approximately 8 inches in diameter), run by small operators over similar short distances, and in a cold climate. Data reported by both the EPA and Cunha (2012) include pipeline failure data from urban, suburban, and industrial areas, where accidental or intentional human actions (often involving vehicle collisions) are the principal causes of pipeline failures (AECOM 2019a). Due to the remote nature of the project area and the controlled access of the road corridor, pipeline rupture from human actions is not considered a relevant factor for calculating pipeline failure rates. Cunha (2012) specifically addresses statistics on pipeline failures in Canada (mostly remote areas), which were determined to be more relevant to the project. The estimated failure rate selected for this analysis therefore considered relevant data from both of these data compilations. The heavy-wall pipe or casing for the above-ground sections of the concentrate pipeline (PLP 2018-RFI 066) also decreased the selected pipeline failure rate (AECOM 2019a).

With consideration of the length of the concentrate pipeline in Alternative 3, Concentrate Pipeline Variant, the 20-year operational life, and the heavy wall pipe or casing to be used, the resulting estimated annual failure rate for the concentrate pipeline is 0.013. This equates to a probability of one or more pipeline failures of 1.3 percent in any given year; 23 percent in 20 years; or 64 percent in 78 years (AECOM 2019a). See AECOM 2019a for complete information on failure rate calculations.

A spill of concentrate slurry would introduce fine sediment into the stream that would cause sedimentation and elevated TSS/turbidity downstream, into surface water that has naturally low TSS and turbidity. Some concentrate slurry that is carried downstream would remain suspended in the water, creating a plume of elevated TSS/turbidity downstream, which could extend into Iliamna Lake. Some of the concentrate slurry would be deposited along the streambed, covering the existing substrate and modifying the benthic habitat. Depending on the location of the spill, some of the concentrate slurry would likely be transported into Iliamna Lake, and the solids could be deposited as deltaic deposits where the stream feeds into the lake.

The metals in the copper-gold concentrate slurry solids would not be immediately soluble in water. Over years to decades, metals could leach out of the concentrate slurry into surrounding water, increasing the potential for contamination in water. Concentrate slurry in the stream would not be highly susceptible to acid generation. Stream water in the area can be well oxygenated, so that some oxidation of sulfides could generate small amounts of acid from unrecovered concentrate. Concentrate slurry that may remain unrecovered on the banks of the stream could also generate a small amount of acid (over a time period of years to decades) that could leak into the stream. Any acid produced, however, would be constantly diluted by fresh water, so that a reduction in stream water pH would likely not be measurable compared to background levels.

As noted above, the concentrate slurry would have an aqueous phase of contact water, in addition to the concentrate solids. The contact water would likely be elevated in metals, so that a spill of concentrate slurry would introduce elevated levels of metals into the environment, including copper, that would likely exceed water quality criteria.

Spill Response

PLP would have a spill plan in place that would detail the measures to prevent, respond to, contain, report, and clean up spills of concentrate slurry and other potentially hazardous materials. See the “Spill Preparedness, Prevention, and Response Measures” subsection.

Recovery of the spilled slurry material would be difficult due to its fluid nature. By the time crews would be able to mobilize for a cleanup, much of the slurry could have already been flushed downstream.

Any remaining thick accumulations of concentrate slurry along the stream bank or in the drainage could be excavated or dredged. Excavation or dredging could cause erosion or other damage to the habitat, but the use of BMPs could minimize impacts.

Deposits of concentrate slurry along the streambed could intermingle with existing substrate. This material could be dredged, although it would be difficult to judge which sediment is concentrate and which is naturally occurring, because the concentrate solids would simply look like typical very fine sediment. Dredging could be damaging to the habitat, and may not be justified. Small amounts of concentrate left in the drainage could naturally flush out over years to decades, or longer.

Concentrate suspended in water would be essentially impossible to recover. It would be left to naturally flush out of the system. Small concentrations of suspended concentrate particles could be flushed into Iliamna Lake or Iliamna Bay, where they would eventually settle out.

Alternatives Analysis

Alternative 1a, Alternative 1 and Alternative 2, and the Alternative 3 base case would not use a concentrate pipeline, so there would be no potential spill from a concentrate pipeline rupture for these alternatives. Only the Alternative 3 Concentrate Pipeline Variant would employ a concentrate pipeline to transport concentrate slurry from the mine site to the Diamond Point port.

Concentrate Return Water Pipeline Option

Under the Alternative 3 Concentrate Pipeline Variant, there would be a concentrate return water pipeline option that would involve dewatering the concentrate slurry at the port site, and returning this untreated contact water back to the mine site for treatment through an 8-inch return water pipeline (see Chapter 2, Alternatives.) Under this option, there would be a potential for spills of untreated contact water from the return water pipeline affecting water and sediment quality that would not exist under the other alternatives (addressed in Section 4.18, Water and Sediment Quality, for small spills).

Potential Impacts of a Concentrate Slurry Spill due to Pipeline Rupture

This section addresses potential impacts of a concentrate slurry spill from a rupture in the concentrate slurry pipeline, as described in the scenario above. Impacts are considered in terms of their magnitude, duration, geographic extent, and potential to occur. A concentrate slurry spill would not impact all the resources addressed in this EIS. The following resources were selected for analysis due to the higher potential significance of the impacts.

Soils

Concentrate slurry spilled onto soils in this scenario would be recovered so that there would likely be no impact. A small amount of fluid slurry could seep into the soil to a shallow depth. In the event of such a spill, soils at the spill site could be tested, and contaminated soils could be excavated. Assuming the spill response as described in the scenario, residual concentrate slurry or minor fugitive dust produced would likely not have measurable impacts on soil quality.

Water and Sediment Quality

Impacts to water and sediment quality from this scenario would be similar to those addressed above for the truck rollover release of concentrate solids, but could be of greater magnitude. The volume of release is smaller under this scenario, but this scenario assumes that most of the spilled concentrate slurry enters surface water, so that the probability of impacts to water quality would be almost certain. The geographic extent would likely be larger as well, due to more concentrate being transported a greater distance downstream. The duration of the impacts would likely be longer because the larger volume of concentrate slurry would take longer to clean up and/or to be naturally flushed out of the drainages. In addition, because the concentrate slurry contains an aqueous component of contact water that would be elevated in metals, this scenario causes elevated metals levels in downstream waters that would likely exceed water quality criteria. Contamination of groundwater with elevated metals would also be possible in this scenario.

TSS and Turbidity—Fine particles of concentrate spilled into flowing water would become suspended in the water, causing elevated TSS and turbidity, for an extent of potentially several miles downstream, and possibly into Iliamna Lake. If spilled concentrate slurry is not recovered, the duration of elevated TSS and turbidity in streams could be on the order of weeks, depending on stream energy, as concentrate slurry continues to be flushed out of the drainage. With effective cleanup, the duration of the TSS/turbidity would likely last for multiple days.

Sedimentation—If concentrate slurry is released into flowing water, some of the coarser particles of concentrate would be deposited as sediment downstream, especially in areas where the current slows. Concentrate could bury or intermingle with existing stream-bottom sediments, and fill in void spaces between gravel clasts, temporarily impacting salmonid spawning habitat. The extent of measurable sedimentation would likely be on the order of several miles downstream of the spill site. Because recovery of these dispersed concentrate particles would be impractical, the material would likely have to be naturally flushed out of the stream, which may take weeks to months, depending on the energy of the stream. Depending on the volume and location of the spill, some of the concentrate particles could be transported downstream into Iliamna Lake or Iliamna Bay, where it would settle out as deltaic deposits.

Acid Generation—For a discussion of factors that impact the ability of concentrate particles to generate acid, see “Factors Influencing Acid Generation and Metals Leaching” in the “Concentrate Spills” subsection.

Impacts from acid generation would be the same as those described above for the truck rollover scenario.

Sulfide minerals in the concentrate slurry would slowly dissolve in the subaqueous environment over years to decades. To produce acid, the sulfur would need to be oxidized. Some dissolved oxygen gas can be present in flowing water, and very low levels of oxygen gas may be present in still or stagnant water. Circulating lake water such as that in Iliamna Lake and shallow intertidal waters such as those found in Kamishak Bay can be well oxygenated. Some acid generation from subaqueous concentrates could occur in these environments where spilled concentrate slurry is not recovered. However, due to the long time-scales required for acid generation and the constant dilution from abundance of surface water, acidification of surface water is not likely.

Any residual concentrate slurry remaining on dry land for multiple years could potentially generate acid. In low-water conditions, or in deltaic environments, additional spilled concentrate slurry could be exposed to air, increasing the potential for acid generation. In addition, concentrate particles that have settled on streambeds could be resuspended during flooding/storm events, and could be further oxidized. The acid could be flushed into surface water, potentially reducing the pH of waterbodies. The rate of acid production is so slow, however, and the dilution from fresh water so great, that any acid produced would be rapidly diluted and flushed out of the drainage so that no measurable reduction in surface water pH would be likely.

Metals Leaching—For a discussion of factors that impact the ability of concentrate particles to leach metals, see “Factors Influencing Acid Generation and Metals Leaching” in the “Concentrate Spills” subsection.

Impacts from ML would be the same as those described above for the truck rollover scenario.

The metallic minerals in the concentrate slurry are not readily soluble in water, so spilled concentrate would not immediately introduce metals in a bioavailable form. After years to decades, the minerals in the concentrate slurry would slowly dissolve, potentially leaching metals into the water. Due to the small amount of concentrate that could remain in the streams, however, and the heavy dilution factor from stream water, the ML would likely not be a measurable impact.

In this scenario, the spilled concentrate slurry would contain an aqueous component of 45 percent untreated contact water, which would be elevated in metals. In contrast to the concentrate solids, the metals in the contact water would be dissolved and bioavailable. Therefore, this scenario would impact downstream surface water by elevating the levels of metals, likely exceeding water quality criteria. See Appendix K4.24, Fish Values, for additional discussion on metals toxicity. The effect would be short-term, lasting until the fluid from the slurry has been flushed downstream and/or diluted by stream water. Measurable impacts to downstream water in Iliamna Lake would not be anticipated due to dilution. The scenario assumes that any concentrate slurry spilled on the streambanks would be cleaned up. If not, then that additional concentrate could continue to flush into the stream, prolonging the impact of elevated metals.

Residual Toxins—Ore concentrate slurry may also contain residues of chemical reagents, including sodium ethyl xanthate and sodium hydrogen sulfide, both of which can be toxic to fish in low concentrations. See "Reagent Spills," below for a discussion of reagent fate and behavior in the environment.

Assuming the spill response as included in the scenario, any fugitive dust produced would likely not have measurable impacts on water quality.

If spill recovery involves dredging, BMPs would help to lessen the potential for erosion of streambed and shoreline sediments.

Noise

Noise could be generated from spill recovery operations, including increased vehicle traffic and use of cleanup equipment. If the increased vehicular traffic would be less than double the amount of existing traffic, then the noise level increase would be less than a 3-dBA increase over existing traffic noise levels (generally less than noticeable). Noise from cleanup equipment would depend on the type of equipment used. However, equipment such as pumps, tractors, heavy-haul trucks, and Vac-trucks would have a maximum noise level of approximately 85 dBA or less at 50 feet (FHWA Roadway Construction Noise Model) and would be limited to the cleanup area for the duration of the cleanup and recovery effort.

Air Quality

Concentrate slurry deposited on land that is able to dry out has the potential to become airborne fugitive dust in the form of particulate matter and particulate hazardous pollutants. Concentrate slurry that spills on land may spread out somewhat due to its fluid nature, but could be recovered. Residual concentrate would likely remain at the spill site, and could dry out and produce fugitive dust. Assuming the spill response as included in the scenario, any impacts on air quality from fugitive dust produced would likely be temporary and localized. If spill response was delayed, a larger volume of concentrate slurry could dry out and spread more readily as fugitive dust, increasing the magnitude of impacts.

The magnitude and potential of the impacts would depend on the amount of concentrate slurry that deposited on land, and meteorological conditions at the time of the spill. A larger spill with strong winds would likely increase the air quality impacts. Concentrations of particulate matter could temporarily exceed the NAAQS concentrations; but over time, the air quality would return to pre-spill conditions. The duration of air quality impacts would be temporary, and would return to pre-activity levels at the completion of the activity. The extent of impacts would be limited to discrete portions in the project area, where the spill took place.

Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

This scenario could affect riparian vegetation on the banks of the stream and any adjacent wetlands. Special aquatic sites potentially affected could include vegetated shallows or riffle and pool complexes. The concentrate slurry may pile up beneath the bridge and immediately downstream at volumes high enough to bury the existing riparian vegetation. As the concentrate slurry is carried downstream, smaller amounts of it would likely be deposited along the streambanks, covering the existing vegetation.

Depending on the location of the spill, some of the concentrate slurry may be transported into Iliamna Lake and deposited as deltaic deposits where the stream feeds into the lake. This could affect wetlands, vegetated shallows, and riparian vegetation.

Vegetation and wetlands could be temporarily impacted by deposition of concentrate slurry along streambanks, because these resources are certain to be in the path of the spilled concentrate. Impacts to special aquatic sites may or may not occur depending on the location of the spill.

Concentrate solids would not be expected to affect wetlands through acid generation or ML in the short-term. Over years to decades, any unrecovered concentrate solids in the wetland area could produce acid or metals.

Compared to the concentrate solids release, the slurry release would have the added impact of untreated contact water that would compose 45 percent of the slurry, and would contain elevated levels of dissolved metals, including copper. See the pyritic tailings release scenario below for a discussion of elevated metals impacts to wetlands. Fluid from the slurry could seep into wetland soil to a shallow depth. Vegetation or wetlands could be affected by soils contaminated with elevated levels of metals from the released contact water. Metal-related toxicity could have acute or chronic effects on vegetation or wetlands. The results may be mortality or reduction of growth. In the event of such a spill, soils at the spill site could be tested, and contaminated soils could be excavated. See Appendix K4.24, Fish Values, for additional discussion on metals toxicity.

The magnitude of the impact depends on the season. Dormant vegetation is much less likely to be affected than actively growing plants. If the spill occurs during non-frozen conditions, especially during the growing season, the magnitude of impacts would be increased compared to during frozen conditions. The magnitude of impacts would be highest close to the spill, and would lessen with distance downstream.

The extent of the area impacted depends on the timing and location of the spill and the effectiveness of the spill response. Spills that occur into flowing water and those that occur in the open-water season are likely to affect a larger area than those that occur during the winter, because concentrate could become entrained in water and be transported. During partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), concentrate may be trapped beneath ice and spread out in flowing water. During frozen conditions with complete ice cover, concentrate is more likely to spill onto frozen surfaces and not spread out as much, and may be easier to clean up.

The duration of impacts is also related to the timing of the spill and the speed of cleanup. Spills that occur during the open-water season may require more time to clean up, and more time for wetlands to recover, maybe several growing seasons. Spills that occur during the winter would be more likely to spill onto frozen surfaces and not spread out as much, so that recovery may be faster. During partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), concentrate may be trapped beneath ice, potentially prolonging cleanup and duration of impacts.

Terrestrial Wildlife

Under this scenario, where concentrate slurry enters a flowing river beneath a bridge, the primary impact would be to terrestrial wildlife prey such as salmon and freshwater invertebrates. An immediate release of concentrate slurry could smother fish eggs, and could cause egg mortality in the localized discrete area of the spill. Impacts from elevated TSS and sedimentation would be localized, and last as long as the concentrate covers fish eggs, alevin, and fry in the area; or renders the area unsuitable for spawning. On large rivers such as the Newhalen, continual flushing and periodic high-flow events (spring break-up and fall floods) would transport the concentrate slurry downstream. The extent of the spill impact would be from the location of the spill to downstream, where the concentrate settles out and eventually is incorporated into the substrate. The duration of impacts would not extend longer than 1 year, or until the concentrate slurry is cleaned up or incorporated into the bedload. Because a spill would impact a fraction of the total eggs, alevin, and fry in a discrete reach of river, the impact on terrestrial mammals that feed on salmon would be low, and would not likely be noticeable.

Compared to the concentrate solids release, the slurry release would have the added impact of untreated contact water that would compose 45 percent of the slurry, and would contain elevated levels of dissolved metals, including copper, that would be immediately bioavailable. Wildlife species could be impacted from increased levels of metals entering waterbodies, depending on the amount of untreated contact water entering a given waterbody, and the amount of dilution. Molybdenum, one of the metals with high concentrations in the released contact water, can cause a disease in ruminants called molybdenosis. Other metals in high concentrations that would require more dilution to reach water quality standards include cadmium, copper, lead, manganese, and zinc. The relative toxicity of cadmium to mammals is considered moderate to high, because they have no effective mechanism for elimination of ingested cadmium, and it can accumulate in the liver and kidney. It is well documented that lead can cause various levels of poisoning. Copper toxicity in mammals is considered insignificant, because they possess barriers to copper absorption (Gough et al. 1979). Impacts to wildlife from these metals and others are explained in detail below under potential impacts of untreated contact water release.

A spill in a stream could directly impact small mammals such as voles, shrews, and lemmings, as well as aquatic mustelids such as beaver and muskrat, by altering or destroying feeding and denning habitat. See the pyritic tailings release scenario below for elevated metals impacts to wildlife (see Appendix K4.24, Fish Values, for additional discussion on metals toxicity to salmonid wildlife prey species).

Finally, residual amounts of chemical reagents would be released into the environment with the concentrate slurry in this scenario. The small volume of reagents released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to wildlife from these toxins would be localized and of low magnitude.

Birds

Similar to terrestrial wildlife, bird species that feed on fish and freshwater organisms could be impacted by a reduced prey base in discrete areas of a concentrate slurry spill. The magnitude is anticipated to be low; intensity would be low, because birds can forage in other nearby areas; and the duration would be short, until the concentrate slurry is carried downstream. Birds such as gulls, loons, mergansers, grebes, kingfishers, dippers, and some shorebird species that consume salmon eggs and fry may experience reduced prey availability due to smothering by concentrate at the location of the spill. However, the impact is anticipated to not be discernable, because there is suitable foraging habitat in the surrounding area. In addition, any spills that occur during winter when streams are frozen and most birds have migrated away would be cleaned up, and result in no discernible impact on birds.

Compared to the concentrate solids release, the slurry release would have the added impact of untreated contact water that would compose 45 percent of the slurry, and would contain elevated levels of dissolved metals, including copper, that would be immediately bioavailable. Birds could be impacted from increased levels of metals entering waterbodies, depending on the amount of untreated contact water entering a given waterbody, and the amount of dilution. See the pyritic tailings release scenario and the untreated contact water release scenario below for discussion of elevated metals impacts to birds (see Appendix K4.24, Fish Values, for additional discussion on metals toxicity to salmonid avian prey species).

Finally, residual amounts of chemical reagents would be released into the environment with the concentrate slurry in this scenario. The small amount of reagents released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to birds from these toxins would be localized and of low magnitude.

Fish

Impacts to fish from this scenario would be expected to be similar to those impacts noted above for a release of concentrate solids to a waterbody. Duration of impacts from sedimentation and turbidity could be from weeks to months. Depending on location and seasonality, there could be permanent impacts to an age class of fish due to the increased volume of concentrate slurry spilled. No measurable impacts to fish from acid rock drainage (ARD) or ML would be expected.

Compared to the concentrate solids release, the slurry release would have the added impact of untreated contact water that would compose 45 percent of the slurry, and would contain elevated levels of dissolved metals, including copper. These metals would be immediately bioavailable, compared to the metals present in the concentrate solids. Severall factors are likely to limit metals bioavailability when they are released to surface water, including binding by natural ligands (such as dissolved organic matter) and binding phases on particulates. EPA's recommended aquatic life WQC for copper is based on the Biotic Ligand Model to account for various factors that modify its aquatic toxicity (EPA 2007b). Metals bioavailability in the current evaluations presents uncertainties, but site-specific toxicity tests (as discussed in more detail below under Pyritic Tailings Release) are indicative of limited impacts on fish species. Aquatic toxicity testing was conducted on samples of process water generated during plant water testing by Nautilus Environmental (2012). An undiluted aqueous sample from the mine site used in the toxicity studies (Non-Gold Plant Process Water) is also representative of the contact water that would make up the concentrate slurry, although there is uncertainty regarding how well the sample represents untreated contact water. Water samples from this study are further described below for the pyritic tailings release. The toxicity tests did not demonstrate acute and chronic toxicity to fish species, including rainbow trout (*Ochorhynchus mykiss*) and fathead minnow (*Pimephales promelas*). Survival and reproduction of water flea (*C. dubia*) neonates were adversely affected when exposed to the 12.5 percent "Non-Gold Process Water" sample (by volume); or eight times dilution or less. When introduced into flowing water, the metals in the contact water component of the concentrate slurry would be further diluted and flushed downstream. Based on the above considerations, acute toxicity to fish due to metals would not occur. See further discussion of metals toxicity below under the pyritic tailings release scenario, and in Appendix K4.24, Fish Values.

Small amounts of concentrate may be entrained within streambed sediment, and may leach metals slowly over years to decades. This could cause low-magnitude, localized impacts to benthic organisms that are preyed upon by fish.

Finally, residual amounts of chemical reagents would be released into the environment with the concentrate slurry in this scenario. The small amount of reagents released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to fish from these toxins would be localized and of low magnitude.

Threatened and Endangered Species

Impacts to TES are not anticipated, because potential impacts from a concentrate pipeline break would not occur in waters that enter Cook Inlet.

Marine Mammals

Impacts to marine mammals in Cook Inlet are not anticipated, because potential impacts from a concentrate pipeline break would not occur in waters that enter Cook Inlet.

Impacts to Iliamna Lake seals would be of short duration, and the extent of impacts would likely stretch from the spill location into Iliamna Lake. There may be a limited loss of prey species for Iliamna Lake seals where the concentrate covers up and smothers fish eggs. The concentrate slurry would eventually be carried downstream into Iliamna Lake; the seals would not be at risk from bioaccumulation; and the copper would take years to decades to become bioavailable. Even then, copper toxicity is reduced when copper combines with organic matter, and any residual copper in small crevices between gravels and cobbles is not expected to cause mortality for fish. Iliamna Lake seals may temporarily avoid areas where the concentrate slurry is spilled, especially during cleanup activities. Finally, residual amounts of chemical reagents would be released into the environment with the concentrate in this scenario. The small amount of reagents released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to Iliamna Lake seals from these toxins would be localized to the immediate vicinity of the spill, and of low magnitude.

Needs and Welfare of the People—Socioeconomics

It is unlikely that cleanup and remediation activities following a pipeline rupture would result in increased employment opportunities in the region. Cleanup crews would be small, and likely consist of PLP employees or specialized contractors.

Recreation

In the event of a concentrate slurry release from a pipeline rupture, the spill and response effort would have a temporary effect on recreational resources. The movement of cleanup equipment may be noticeable to recreationists on Iliamna Lake, and (seasonally dependent) snowmachine or ATV users. The cleanup activities may displace sport fishing or hunting, depending on the area of the spill; however, there are comparable areas available throughout the region for recreation. Relatively few recreationists would be impacted.

Commercial and Recreational Fishing

A concentrate slurry spill on land or on a frozen waterbody would not be expected to affect commercial or recreational fishing. A spill into a river or stream environment could impact a fraction of the total eggs, alevin, and fry in a discrete reach of river. No immediate effect on commercial fisheries would occur, because the spill would take place outside the geographic area of commercial salmon harvests. A spill could affect the annual value of the commercial fishery to the extent that such a spill reduced the number of returning adult salmon, either in the short-term via the smothering of eggs, or the longer term if the spill lowered the long-term productivity of the system by reducing the amount of spawning habitat. Because impacts to fish are anticipated to be localized, temporary, and of low magnitude, any reduction in the value of the fishery is expected to be extremely limited under this scenario.

Recreational fishing effort could be displaced in the immediate vicinity of a spill to the extent that the spill reduces localized productivity and food availability, or displaces anglers during cleanup operations. Longer-term effects would not be expected after the concentrate slurry has flushed downstream, as long as total salmonid populations are unaffected and food/prey availability returns to pre-spill conditions. A spill could affect individual angling groups or companies disproportionately if they relied heavily on the affected section of river.

Cultural Resources

Under Alternative 3, impacts from a concentrate slurry pipeline release to cultural resources would be dependent on the location of the release, the proximity of cultural resources, and the extent of cleanup activities. The concentrate slurry could accumulate on stream shores, requiring response. In the event that such a response effort occurred in or adjacent to a cultural resource area or known or potential historic property site, direct and indirect impacts to the site would likely result in loss of integrity to the National Register (resulting from the potential for fire, as well as ground disturbance during extensive cleanup activities). The duration of impacts would be such that resources would not be anticipated to return to previous levels even after actions that caused the impacts were to cease. The extent and context of impacts would be related to the number and significance of affected resources; a release that impacted multiple cultural resources could affect resources throughout the EIS analysis area. Indirect impacts could occur to the setting (visual, noise, and olfactory impacts) of cultural resources if the spill were to occur in the vicinity. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Those impacts would be temporary, and would cease when response efforts are complete.

Subsistence

A spill of concentrate slurry over a river could smother eggs and juvenile subsistence fishes in the area of the spill, and last as long as the concentrate covers fish eggs, alevin, and fry in the area. The extent of the spill impact to subsistence resources would be from the location of the spill to the downstream extent of concentrate deposition. The duration of impacts would not extend longer than 1 year, or until the concentrate slurry is cleaned up or incorporated into the bedload. Wildlife would also be hazed from the impacted area during cleanup activities. The concentrate slurry release would likely cause concerns over contamination for subsistence users that harvest in areas near or downstream from the rupture, and could cause users to avoid the area and alter their harvest patterns. Quick response and containment of spills (particularly for spills in water) and a system of testing wild foods and communicating the results to local people in a timely manner could help mitigate these concerns.

Health and Safety

A release of concentrate slurry could cause stress to community members in close proximity from real or perceived risks of contamination, and potentially impact human health. Spills create anxiety about the safety of subsistence foods and water quality. Quick response and containment of spills (particularly for releases in water), and a system of testing wild foods and drinking water for contaminants to give local people complete and understandable information in a timely manner could help alleviate some anxiety, and reduce potential impacts to human health. There would be potential adverse impacts to social determinants of health (HEC 1), with psychosocial stress resulting from community anxiety over a truck release. As noted above, a release of concentrate slurry could have impacts to subsistence, including avoidance of the area and altering harvest patterns, which in turn could temporarily impact food security and subsistence-level nutrition (HEC 4). The duration of impacts would be short-term (1 to 12 months).

4.27.6.8 Over-Water Transfer Spill

Concentrate would be transferred between lightering vessels and bulk carriers as an over-water operation at lightering locations. Procedures for reducing the potential for spills and release of fugitive dust for the over-water transfers, as described in the previous “Mitigation” subsection, are considered robust. The probability of a large-volume release from over-water transfer is so low as to rule out the scenario as extremely unlikely. The potential impacts of fugitive dust are addressed above for the truck rollover and concentrate pipeline release scenarios.

4.27.6.9 Marine Vessel Concentrate Release

The probability of a spill of concentrate from a marine vessel would be very low.

Copper-gold concentrate would be transferred from dock facilities onto lightering vessels, and then transported to the waiting bulk carriers at a lightering location (see Chapter 2, Alternatives, for lightering locations for the different alternatives). Operations would be put on hold during periods of high seas.

A spill of concentrate from a lightering vessel (barge) could occur if an entire container of concentrate were to fall overboard. A concentrate spill from a bulk vessel would be very unlikely, because concentrate would be held deep within the hold of the ship. Fugitive concentrate dust could also be released during transfer operations over marine waters, although extensive mitigation measures would be in place to reduce the probability of occurrence and extent of release (see the previous “Mitigation” subsection).

A large spill of concentrate into Kamishak Bay between the port and the lightering locations would sink to the seafloor, and could be partially recoverable, due to the shallow (diveable) water depths. Extreme tides, currents, winds, and waves, however, would immediately begin to mobilize the fine-grained material, so that any recovery would be a partial recovery only. Small spills of concentrate, including fugitive dust, would be rapidly dispersed by waves, tides, and currents, and would not be recoverable. If a concentrate container were to fall overboard in shallow water, the container would likely be recovered, potentially with concentrate still remaining inside the container. Recovery of concentrate from deeper water could create too great of a safety risk involved in salvaging the spilled material, and the action may not be justified. In the event of a spill of concentrate from a marine vessel, either a lightering barge or a bulk vessel, the clay- and silt-sized material would contribute to a localized, short-term increased in TSS and sedimentation in Kamishak Bay. The fine-grained particles of spilled concentrate would be quickly deposited, and/or dispersed by waves, tides, and currents.

The metals in the copper-gold concentrate are not immediately soluble in water. Over years to decades, metals could leach out of the concentrate into surrounding water, increasing the potential for contamination in water. Due to extreme tidal fluctuations and strong currents in lower Cook Inlet, however, any potential contamination would be constantly diluted, and it is unlikely that there would be any measurable impacts. Some oxygen gas would likely be present in well-circulated tidal waters, to the extent that sulfide minerals could be oxidized in the marine environment, and produce a small amount of acid. However, again, due to the time required for acid generation and constant dilution, no measurable impacts would be expected.

4.27.6.10 Iliamna Lake Ferry Rupture

The probability of a spill of concentrate from the ferry is similar to or less than that of a marine vessel, and is therefore very low. There are historically low rates of spills of any type from ferries. The risk was considered very low probability, and relatively low consequence, should it occur.

As described above under Diesel Spills, the ferry would be custom-built specifically for Iliamna Lake conditions, and for hauling diesel, concentrate, and other mine materials. One-inch-thick heavy-steel shell (required for ice-breaking) would result in very low potential for damage to the ferry from grounding or a collision. Operation would include a stowage plan designed to ensure no movement of cargo at a list (tilt) of 8 degrees (e.g., in the extreme case of loss of one of the engine rooms) (PLP 2018-RFI 052).

A spill of concentrate into Iliamna Lake would introduce fine particles that would contribute to sedimentation and elevated TSS/turbidity in the lake. TSS levels are naturally low in Iliamna Lake (see Section 3.16, Surface Water Hydrology), and increased TSS and turbidity could potentially impact fish populations. A sudden increase in sediment could bury benthic organisms or habitat. Depending on the weather and time of year, natural dilution and dispersal of particles of spilled concentrate could take days to weeks.

As described above for the marine spill, metals could slowly leach out of the concentrate into surrounding water over years to decades, but any leached metals would be strongly diluted, and it is unlikely that water quality criteria for metals would be exceeded. Sulfide minerals would not be readily oxygenated in the subaqueous lake environment. Iliamna Lake does experience periodic overturning, which oxygenates the water, so a small amount of acid generation from unrecovered concentrate would be possible, over years to decades. Due to the strong dilution from abundant lake water, however, any acid generated would not be expected to cause an exceedance of water quality criteria.

Diving crews could recover spilled concentrate where practicable. Depending on the time of year and the depth of the water, such a recovery operation could be a safety risk to personnel, and could take days to weeks of logistics to mobilize.

4.27.7 Reagent Spills

Reagents are chemicals that promote or restrict certain chemical reactions in the process of separating metals from crushed ore. Most of the reagents would be added to crushed ore slurry during various phases of the flotation process.

Reagents would be transported to the mine site by marine barge, truck, and ferry in 20-ton shipping containers. They would be stored in a secure bulk reagent storage area and segregated according to compatible characteristics. The reagent storage area would be sufficient to maintain a 2-month supply at the mine site. As needed, reagents would be loaded onto a truck and delivered to the appropriate reagent receiving area in the mine site.

Reagents would be used in low concentrations for mineral processing and are primarily consumed in the process; low residual reagent quantities would remain in the tailings stream, and would be disposed of in the tailings storage facility (TSF), where they would be diluted and decompose.

The metallurgical and assay laboratories would also use small amounts of reagents. “Any hazardous reagents imported for testing would be transported, handled, stored, reported, and disposed of as required by law, in accordance with manufacturers’ instructions, and consistent with industry best practices” (PLP 2018d).

A complete list of potential reagents for the project is provided in Table 4.27-2 (PLP 2018d).

Table 4.27-2: Processing Reagents and Materials

Reagent	Use	Shipping/Preparation
Calcium Oxide (quick lime)	pH modifier; depresses pyrite in the copper-molybdenum flotation process.	Calcium oxide pebbles (80%) shipped in specially adapted shipping containers. Pebbles would be crushed and mixed with water to form lime slurry at the lime plant.
Sodium Ethyl Xanthate	Copper collector; used in the rougher flotation circuit.	Pelletized reagent shipped in 1-ton bags. Mixed with process water to form 20% solution and stored in collector storage tank. Mix and storage tanks vented externally with fans.
Fuel Oil (Diesel)	Used in the flotation process.	Shipped in tanker trucks and stored in the main head tank in the copper-molybdenum concentrator area.
Sodium Hydrogen Sulfide	Copper depressant used in the copper-molybdenum separation processes.	Pelletized reagent shipped in 1-ton bags. Mixed with process water to form 20% solution and stored in the NaHS storage tank.
Carboxy Methyl Cellulose	Depressant; anionic polymer used to depress clay and related gangue material in the bulk cleaner flotation circuit.	Pelletized reagent shipped in 1-ton bags. Mixed with process water in the agitated dispersant tank to form 20% solution and stored in dispersant storage tank.
Methyl Isobutyl Carbinol	Frother; maintains air bubbles in the flotation circuits.	Shipped in 20-foot specialized International Standards Organization containers and stored in the frother storage tank.
Depressant (sodium silicate)	Clay or silica gangue mineral depressant used in the copper-molybdenum separation process.	Pelletized reagent shipped in 1-ton bags. Mixed with process water to form 20% solution and stored in the sodium silicate storage tank.
Anionic Polyacrylamide	Thickener aid.	Pelletized reagent shipped in 1-ton bags. Vendor package preparation system composed of a bag-breaking enclosure to contain dust, dry flocculent metering, and a wet jet system to combine treated water with the powdered flocculent in an agitated tank for maturation. Prepared in small batches and transferred to a flocculent storage tank.
Polyacrylic Acid	Anti-scalant for the lime production process.	Viscous pale amber liquid shipped in 35-cubic-foot specialized container tanks in protected rectangular framework.
Nitrogen	Nitrogen used in the molybdenum flotation circuit to depress copper sulfides.	Nitrogen would be provided by a vendor-supplied pressure swing adsorption nitrogen plant. This equipment separates nitrogen from air for use in the mineral-process plant.

Note:
NaHS = sodium hydrogen sulfide
Source: PLP 2018d

Note that no mercury or cyanide would be used for the project. Mercury is naturally present at low levels in some rock formations in the project area.

Reagents would be shipped in both solid and liquid form, and would be housed and transported in secondary containment (PLP 2018-RFI 071).

4.27.7.1 Fate and Behavior of Spilled Reagents

This section briefly reviews the function and general properties of each reagent, and describes the general fate and behavior of spilled reagents. Detailed impact analyses of potential scenarios for reagent spills are not included in this section because there is effective secondary containment for reagents, so that the probability of a reagent being released into the environment would be extremely unlikely.

Many of the reagents would be shipped in pellet form. If spilled on dry land, the pellets would be recovered and placed back into containment. If spilled into water, pellets would sink. Solubility of reagents varies, and is further described below. Soluble reagents would dissolve if spilled into water, and could become bioavailable for a limited time, and potentially toxic to aquatic resources. Reagents that are insoluble or not immediately soluble could have long-term impacts to aquatic resources if not removed from water (PLP 2018-RFI 052). Scoping comments have noted the potential hazards of xanthates in particular (i.e., the sodium ethyl xanthate proposed by PLP).

Calcium Oxide

Calcium oxide (also known as “quick lime”) is a strong base used to increase the pH and remove pyrite in the copper-molybdenum flotation process. It would be used and transported in pellet form, with pellets crushed and mixed with water to form lime slurry (PLP 2018d). Due to its very high pH (strong base), it is considered caustic, and therefore can be hazardous to human health (e.g., skin, eye, and respiratory irritant) (Graymont 2012).

Calcium oxide is water-reactive and leads to an exothermic reaction, forming high-pH (corrosive) calcium hydroxide with much heat released before dissipating and neutralizing. If spilled in water, there would be an acute hazard to adjacent aquatic resources during the initial reaction. There are no hazardous thermal or decomposition products from the reaction (PLP 2018-RFI 052).

Sodium Ethyl Xanthate

Sodium ethyl xanthate is used for copper collection in the froth flotation process. It would be shipped in pellet form, then mixed with water and stored on site as a liquid.

Sodium ethyl xanthate is relatively soluble and highly toxic, especially to aquatic life (PLP 2018-RFI 052; Australian Government Publishing Service 1995). If spilled in water, the pellets would likely persist for some days before degrading by hydrolysis, and could create acute toxic conditions in the aquatic environment. It is biodegradable and is not expected to bioaccumulate in view of its ionic character (PLP 2018-RFI 052).

Sodium ethyl xanthate gives off carbon disulfide gas as a by-product, which can occur from contact with water. Carbon disulfide gas is both toxic and flammable (Redox MSDS 2015). Spills in Australia have included illness and hospitalization of workers and nearby residents who were exposed to the fumes; evacuation of some 100 people from a leak at a railway station; and fires. Sodium ethyl xanthate is classified as a Priority Existing Chemical in Australia due to adverse health or environmental impacts. Australian mine workers performing high-risk handling of sodium ethyl xanthate are now required by Australian regulations to use full-face respirators or self-contained breathing apparatus (Australian Government Publishing Service 1995).The EPA reports that the presence of xanthate would render the tailings slurries toxic; but that in the event of seepage from the TSF, degradation and dilution in the TSF would likely render the downstream waters non-toxic (EPA 2014). EPA notes that this would depend on xanthate’s ability to break down in the tailings facility.

Fuel Oil (Diesel)

Diesel is also used in the flotation process, and could be hazardous to human health and the environment if a release were to occur. Fuel oils are complex and variable mixtures that can impact the respiratory system at high concentrations. In addition, marine diesel fuel is considered possibly carcinogenic to humans, while the carcinogenicity of lighter diesel fuels has not been determined (ATSDR 1995). The potential impacts of small diesel spills are addressed in Section 4.18, Water and Sediment Quality; and large diesel spills, which may pose the greatest risk to human health and the environment, are addressed under Diesel Spills.

Sodium Hydrogen Sulfide

Sodium hydrogen sulfide (NaHS) would be shipped as pellets. If spilled on land, it would be recovered and placed back into containment. NaHS is very soluble, and if spilled into water, it would dissolve. Decomposition products include sodium oxides and sulfur oxides (PLP 2018-RFI 052). NaHS would be mixed with water and stored as a liquid in the NaHS storage tank. Aqueous NaHS is strongly alkaline (pH 11 to 12) and very corrosive. NaHS breaks down into hydrogen sulfide (H_2S) at below neutral pH and in the presence of heat. H_2S is highly toxic to fish (EPA 2014).

Carboxy Methyl Cellulose

Carboxy methyl cellulose would be shipped as pellets. This reagent is soluble and inherently biodegradable. No hazardous by-products or reactions are known to occur under typical conditions (PLP 2018-RFI 052). Sodium carboxy methyl cellulose, otherwise known as cellulose gum, naturally occurs in edible plants (e.g., fruits, legumes, nuts) and is an FDA-approved food additive stabilizer that is generally recognized as safe, and is permitted as an optional ingredient in standardized food (FDA 2018).

Methyl Isobutyl Carbinol

Methyl isobutyl carbinol (also known as MIBC) is a solvent that would be used as a frother to maintain air bubbles in the flotation circuits. It is a flammable liquid, with flammable vapor. It is classified as Dangerous Goods by the International Maritime Dangerous Goods Code (IXOM 2017). The MIBC would be shipped as a liquid in specialized ISO containers (PLP 2018-RFI 052). This liquid has limited solubility; and if spilled into water, it would float. MIBC is readily biodegradable (PLP 2018-RFI 052).

MIBC is considered hazardous, can cause eye and respiratory irritation, is a kidney toxin, and a carcinogen (IXOM 2017). The Material Safety Data Sheet (MSDS) recommends use only outdoors or in a well-ventilated area, and to avoid breathing mist, vapor, or spray (IXOM 2017).

Sodium Silicate

Sodium silicate would be shipped as pellets in 1-ton bags. If spilled in water, the pellets would sink. Rate of dissolution depends on the amount of water used as solvent (less soluble in large amounts of water) and temperature (less soluble in cold water). This material is inorganic and not subject to biodegradation (PLP 2018-RFI 052).

Anionic Polyacrylamide

Anionic polyacrylamide would be shipped as pellets. It is a polymer formed from acrylamide subunits and is soluble. Acrylamide is considered hazardous to the human nervous system, and is likely to be a carcinogen (IRIS 2010). At a pH greater than 6, the polymer degrades due to hydrolysis to more than 70 percent in 28 days (PLP 2018-RFI 052).

Polyacrylic Acid

Polyacrylic acid would be shipped as a liquid. It is a dense, viscous liquid that would sink if spilled into water, and would flow slowly if spilled on land (PLP 2018-RFI 052). It is considered hazardous if released into water (Owl Ridge 2018b). Exposure to acrylic acid is considered hazardous to human development and to nervous and respiratory systems, and carcinogenicity has not yet been assessed (IRIS 1994).

Nitrogen

Nitrogen would be produced on site and would not be transported.

4.27.7.2 Historical Data and Probability of Reagent Spills

The ADEC spills database has no records specific to spills of reagents from trucking, marine, or ferry transport. Spill rates of hazardous materials in general are lower than spills of substances such as diesel fuel or gasoline, because they are not often handled by the general public. From 1995 to 2017, only 3 percent of spills in Alaska released hazardous or very hazardous substances besides fuel oil (ADEC 2018h).

USCG and ADOT&PF/PHMSA databases contain no records of marine vessel spills specific to reagents (USCG 2018; PHMSA 2018). The NMFS Biological Assessment reports that no chemical spill risk data for Cook Inlet vessel traffic are available (Owl Ridge 2018b). The Biological Assessment also states that spills of hazardous waste have a lower probability than oil spills due to the way the goods are transported. Because reagents would be transported in relatively small volumes in secondary containment, the probability of a marine spill of reagents in lower Cook Inlet is very low. The statistical probability of such a release from the ferry into Iliamna Lake is even lower than that of a marine spill, as described above for diesel spills.

4.27.7.3 Existing Response Capacity

There are currently no organizations in Alaska that specialize in response to spills of reagents or other hazardous chemicals, besides fuels. PLP would have a spill response plan in place that would address spills of reagents and other hazardous materials. The Mine Safety and Health Administration establishes mine emergency management requirements for mine operators, including designation and training for responsible persons and the development of mine emergency response plans. PLP would have trained personnel and resources to respond to chemical reagent spills. Response plans would involve coordination and cooperation with Local Emergency Planning Committees (LEPC) and Local Emergency Planning Districts (LEPD) for the Kenai and Lake and Peninsula boroughs. See also the “Spill Preparedness, Prevention, and Response Measures” subsection for the actions that the Applicant has committed to.

4.27.7.4 Mitigation Measures

Reagents would be shipped in their original, approved-for-shipping, containers. These original containers would be placed inside steel shipping containers (secondary containment) and shipped to the mine site prior to unloading from the steel shipping containers (PLP 2018-RFI 071).

Sodium ethyl xanthate mix and storage tanks would be vented externally with fans (PLP 2018d). The ventilation is presumably provided to allow for dispersion of the toxic and flammable gas carbon disulfide, a by-product of sodium ethyl xanthate.

Alternatives Analysis

Because reagents would be transported by truck, the potential for a reagent spill could vary slightly by alternative. Road corridor lengths and road conditions, such as grade, would vary between alternatives. Alternative 1a would include 72 miles of road transport to haul reagents; Alternative 1 would include 66 miles of total road transport; Alternative 2 would include 53 miles of road transport; and Alternative 3 would include 82 miles of total road transport. The road corridor for Alternative 3 would be expected to have more road segments with higher grade, based on steeper topography in the southern and eastern portions of the road corridor. Final road design, including grades, has not yet been determined. Alternative 3 would not involve reagent transport by ferry, so there would be no potential for reagent spills from the ferry into Iliamna Lake.

4.27.8 Tailings Release

Tailings are the finely ground particles of rock material that remain after economic minerals have been extracted through ore processing. Tailings generally contain contact water, which may be elevated in metals and other constituents. Tailings could also contain residual chemical reagents, residual blasting agents, residues from the Water Treatment Plant (WTP), or other chemicals from ore processing. Reagents to be used in the project are addressed under the “Reagent Spills” section, above. Chemical reactions can take place in tailings that produce other chemicals that were not originally in the tailings. A “failure” of a TSF refers to the unintended release of tailings fluid and/or solids, and could result in impacts to the downstream environment.

Historically, mine tailings have been stored in large impoundments that were commonly referred to as tailings ponds, but are now generally referred to as tailings storage facilities (TSFs). Some TSFs maintain a full water cover over their entire surface to provide subaqueous storage of the tailings in order to prevent oxidation of sulfide minerals and generation of ARD. Other TSFs, where such oxidation is not a concern, remove much of the supernatant water for reuse in the milling process, or for treatment and discharge, and just retain smaller ponds of water that cover only part of the tailings, typically referred to as supernatant ponds. TSFs with a full water cover are more susceptible to large tailings releases. See Appendix K4.27 for additional discussion.

PLP is proposing a method of tailings storage that would eliminate the need for a TSF with a full water cover. PLP is proposing to separate mine tailings into bulk tailings, which have a relatively low potential for ARD and ML; and pyritic tailings, which have higher potential to produce acid and leach metals. The bulk and pyritic tailings would compose approximately 88 and 12 percent, respectively, of the total tailings (PLP 2018d). The two types of tailings would be stored in two separate TSFs and would have distinct fates during post-closure. During operations, the bulk TSF would have a minimal supernatant pond and the pyritic TSF would have a full water cover. As part of closure, the bulk TSF surface would be drained of water and maintained as a “dry” landform; the pyritic TSF would be dismantled, and its contents relocated to the open pit. Below is a description of the two types of tailings and their TSFs. Chapter 2, Alternatives, provides more detail on the construction and operation of the facilities. Section 4.15, Geohazards and Seismic Conditions, addresses the geotechnical aspects of the TSFs and their embankments.

4.27.8.1 Bulk Tailings and the Bulk TSF

Bulk tailings would contain the finely ground particles of rock material that remain after most metallic and sulfide minerals have been removed from the raw ore during the bulk rougher flotation, the first phase of mineral separation. Because the process of mineral separation is inherently imperfect, a small percentage of unrecoverable sulfide minerals and other metals would remain in the bulk tailings, so that bulk tailings would contain a small percentage of PAG material and have a relatively low potential for ARD and ML compared to pyritic tailings. The grain size of the bulk tailings would vary from clay- to sand-sized particles (60 percent clay and silt; 40 percent fine sand) (Knight Piésold 2018o).

The bulk TSF would provide storage capacity for 1.1 billion tons of bulk tailings, the operating supernatant pond, and additional freeboard for the required Inflow Design Flood (IDF; equal to the probable maximum flood). The main (north) embankment would be constructed by the centerline method, and the south embankment would be constructed by the downstream method. Data on dam failures around the world demonstrate that dams built by downstream or centerline construction methods are safer than dams built with upstream construction methods, especially under seismic shaking (ICOLD 2001; Rico et.al 2007a; Azam and Li 2010). Both of the bulk TSF embankments would be constructed out of earthfill and rockfill materials on bedrock foundations. See Chapter 2, Alternatives, for general descriptions of centerline and downstream dams. See Section 4.15, Geohazards and Seismic Conditions, for geotechnical aspects of both centerline and downstream dam designs.

Bulk tailings would be thickened and pumped into the bulk TSF by two pipelines as a thick slurry of 55 percent solid rock and mineral particles, and 45 percent fluid (PLP 2018d). The tailings would be deposited by spigots around the perimeter of the facility, so that the level of tailings would be higher along the TSF at the perimeter and lower towards the center of the TSF. Water that drains out of the slurry would accumulate at the low spot towards the center in a supernatant pond. Tailings higher than the level of the supernatant pond are considered the tailings “beach.” Because bulk tailings have a low concentration of PAG material, they would not require subaqueous storage in a typical water-inundated TSF. Higher water content in TSFs can increase the probability of significant tailings spills. Best available technology (BAT) principles established following the Mount Polley dam failure (Morgenstern et al. 2015) include eliminating or minimizing surface water in impoundments, and promoting unsaturated conditions in tailings through drainage provisions. Best available practice (BAP) principles developed following the Mount Polley dam failure (Morgenstern et al. 2015) have been further advanced (Morgenstern 2018; Cobb 2019). The Applicant has a mine site design and layout that would reduce the amount of fluid stored in the bulk TSF by continually pumping the excess fluid to the main WMP.

The main (north) embankment of the bulk TSF would have a maximum height of 545 feet, and would operate as a flow-through zoned rockfill and earthfill embankment that would allow excess fluid in the tailings to drain out through the seepage collection system, and then either be re-used in the mill process, or treated and released. The main embankment and the adjacent tailings would therefore have a depressed or relatively low fluid level (phreatic surface) (see Figure K4.15-3 for a cross section of the predicted phreatic surface at the close of operations). The south embankment would have a maximum height of 300 feet and would be lined, and therefore would not be pervious, so that the phreatic surface would be higher on the southern end of the TSF. The majority of the tailings in the southern portion of the facility would be fluid-saturated. If the supernatant pond level were to rise, fluid could be pumped out of the TSF into the main WMP. Tailings in the beach area, especially on the northern side of the TSF, would be well-drained and relatively dry; while tailings deeper within the TSF would remain fluid-saturated. The bulk TSF would remain as a pervious structure, so that the bulk tailings would be in “relatively dry” storage and not subaqueous.

The bulk tailings that are drained and not fluid-saturated would have a consistency that would flow similar to molasses. These tailings would be quite viscous, and would not readily flow if spilled (MEND 2017). Tailings deeper in the facility that would be fluid-saturated would exhibit more fluid behavior, and would flow more readily as a slurry if spilled.

There remains some uncertainty regarding the ability of bulk tailings to drain sufficiently at the current conceptual level of design. It is uncertain whether the thickened tailings at 55 percent solids would segregate enough, with coarse tailings forming the tailings beach near the spigots and finer tailings in the middle of the TSF, to promote reduction of the phreatic surface near the bulk TSF main embankment (AECOM 2019n). Although the design is intended to promote unsaturated conditions, the majority of tailings may remain saturated throughout operations, and potentially into post-closure.

Appendix K4.27 provides additional background information on the difference between many historic subaqueous TSFs and the Applicant's "flow-through" TSF design.

Aqueous chemistry of the bulk tailings supernatant fluid is expected to be dominated by metals. Modeling results indicate that the concentrations of the following metals would exceed applicable WQC (as defined by Alaska Water Quality Standards [WQS], 18 AAC 70): antimony, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, selenium (a metalloid), and zinc (Knight Piésold 2018a) (see Appendix K4.18, Table K4.18-3). Water quality parameters, including total dissolved solids (TDS), alkalinity, hardness and sulfate in the bulk tailings supernatant, are also not expected to meet the respective WQC.

The contact water used to make up the thickened bulk tailings slurry would also likely contain elevated concentrations of some metals and other constituents relative to WQC.

4.27.8.2 Pyritic Tailings and the Pyritic TSF

The pyritic tailings would be chemically and physically distinct from the bulk tailings. The processing of the raw ore to separate minerals would leave the pyritic tailings with approximately 15 percent sulfur as sulfide minerals, so that the tailings would be PAG material. Therefore, the pyritic tailings would require subaqueous storage throughout the 20 years of mine operations, to prevent oxidation of the sulfide minerals and subsequent generation of acid (PLP 2018-RFI 045). Their potential to generate acid would be similar to that of the copper-gold concentrate. The pyritic tailings would have a much lower level of copper and molybdenum than the concentrates, but would still contain enough metallic elements to have ML potential (PLP 2018-RFI 045).

The pyritic tailings would go through a regrind process, so that the grain size of pyritic tailings would be smaller than that of the bulk tailings. Particle sizes would be mostly clay- to silt-sized, with only 2 percent fine sand sized (Knight Piésold 2018p). The pyritic tailings would be thickened and pumped in a pipeline as a thick slurry into the pyritic TSF for storage (PLP 2018d).

The pyritic TSF would be fully lined and would store approximately 155 million tons of pyritic tailings, up to 93 million tons of PAG waste rock, and an operating supernatant pond that would fully cover the tailings, with additional storage capacity for the required IDF (equal to the probable maximum flood) and additional freeboard (Knight Piésold 2018p; PLP 2020d). There would be three embankments, north, east, and south, that would be zoned rockfill and earthfill structures constructed with the downstream method on a foundation of bedrock. These embankments would form a "ring" embankment around three sides of the TSF, and would have maximum heights of 335, 225, and 215 feet, respectively. As noted above, data on dam failures around the world demonstrate that dams built by downstream or centerline construction methods are safer than dams built with upstream construction methods, especially under seismic shaking (ICOLD 2001; Rico et al. 2007a; Azam and Li 2010). See Chapter 2, Alternatives, for a description of the downstream dam construction; and Section 4.15, Geohazards and Seismic Conditions, for geotechnical aspects of the dam design.

The PAG pyritic tailings would require subaqueous storage with a minimum 5-foot depth of full supernatant water cover to be maintained on top of the tailings during operations. The predicted pH of pyritic TSF supernatant fluid at the close of operations would be 7 to 8 (Knight Piésold 2018a). The pyritic TSF would be a fully lined facility, with the liner extending up the upstream faces of the embankments. Several years after the close of mine operations, the pyritic tailings would be pumped into the open pit, which would then be allowed to fill with water, so that the pyritic tailings would be permanently stored sub-aqueously. Perpetual storage in the pit would reduce the potential for a spill of pyritic tailings after the close of operations.

Because the pyritic tailings would be submerged under water in the pyritic TSF, they would be entirely fluid-saturated. In the event of a release, the fluid stored above the pyritic tailings could entrain the fine tailings particles and release the fluid (non-thickened) tailings slurry. Such tailings slurries could exhibit fluid behavior and readily flow like water (MEND 2017).

Modeling results indicate that the pyritic supernatant would have elevated concentrations of the following metals relative to the applicable WQC: antimony, arsenic, beryllium, cadmium, cobalt, copper, lead, manganese, mercury, molybdenum, selenium, silver, and zinc (Knight Piésold 2018a) (Table K4.18-3). Other parameters, including TDS, alkalinity, hardness, and sulfate in the pyritic tailings supernatant, would fail to meet respective WQC.

The contact water used to make up the pyritic tailings slurry is also likely to contain elevated concentrations of some metals and other constituents. In addition, residuals from water treatment, including selenium sulfide, would be added to the pyritic tailings and placed in the pyritic TSF. See Section 4.18, Water and Sediment Quality, for details on water treatment. In the event of a spill, these materials could be released into the environment. See Appendix K4.24, Fish Values, for additional discussion of metals toxicity.

4.27.8.3 Fate and Behavior of Released Tailings

This section describes the general fate and behavior of released tailings for a wide range of hypothetical releases. Specific impacts from the selected release scenarios are presented below.

An unplanned release of tailings from one of the TSF facilities could cause a flood of water and/or tailings slurry downstream of the facility. Solid tailings particles could be deposited on uplands, wetlands, or in stream drainages. A flood of tailings-laden water could erode streambanks and associated habitat and modify stream morphology. Streamflow would transport some of the spilled tailings downstream, where further deposition could occur, potentially burying stream substrate and altering benthic habitats. Entrained tailings would create turbid water conditions and sedimentation downstream, which would impact downstream habitat until the tailings are completely recovered or naturally flushed from the drainage. Upstream erosion could contribute to ongoing downstream turbidity and sedimentation. Metals could leach from unrecovered tailings on a timescale of years to decades. Unrecovered tailings that are exposed to oxygen could generate acid on a timescale of years to decades or more. Acid and metals flushed into the watershed would be diluted by stream water, while acid and heavy metals that accumulate in streambed sediments, wetland soils, or isolated waterbodies could impact water quality on a timescale of decades.

The fate and behavior of tailings released into the environment would depend on several factors, including: 1) location of release (e.g., dry land, water); 2) type of tailings (bulk or pyritic tailings); 3) water content of the release (proportion of solid tailings versus fluid); 4) volume of the release (tailings and fluid); 5) speed/duration of the release; 6) downstream topography; 7) seasonality; and 8) mode of release.

1. **Location of Release**—A spill of tailings onto dry land could be recovered relatively easily with excavation, although recovery of tailings that enter flowing water would likely not be practicable.
2. **Type of Tailings**—Both bulk and pyritic tailings have the potential to generate acid and leach metals into the environment over time. Due to the low percentage of sulfides

and other metals in the bulk tailings, however, the risk of acid generation and ML from a spill of bulk tailings is low (compared to pyritic tailings). Any acid or metals generated from the bulk tailings would be produced on such a slow timescale (years to decades based on ARD and ML rates), and would be so diluted by precipitation and surface water, that impacts may not be measurable (see discussion of ARD and ML in Section 3.18, Water and Sediment Quality). The pyritic tailings, however, are elevated in metals, and would be more capable of producing acid and leaching metals, depending on conditions. Both bulk and pyritic tailings would cause elevated TSS, turbidity, and sedimentation if released into the environment.

3. **Water Content in the TSF**—Under otherwise normal operating conditions, a spill from the well-drained tailings beach of the bulk TSF would be considered a relatively dry spill scenario, in which the tailings would remain a viscous mass, not capable of flowing great distances. Based on the height of the highest (northern) bulk TSF embankment of 545 feet, the tailings would be expected to flow no more than about 2.2 miles downslope (MEND 2017). If deeper fluid-saturated tailings were to be released, they could flow readily as a liquid slurry, depending on the level of compaction. Likewise, if a water management failure led to overfilling of the bulk TSF and overtopping of an embankment, a bulk tailings release could become a wet scenario, in which the bulk tailings would become fluid-saturated, and converted into a tailings slurry. In this situation, the initial release would be a flood of water, followed by tailings slurry.

   Any release from the pyritic TSF would be a wet spill scenario, with a slurry of supernatant fluid and entrained pyritic tailings expected to flow like water (MEND 2017).
4. **Volume of Release**—A small-volume release of tailings would have less environmental impacts than a massive release. Recovery of a small spill could be relatively simple, while recovery of a massive release, especially one that reaches flowing water, would be extremely difficult.
5. **Speed/Duration of Release**—If a spill of tailings were to occur slowly, such as a slow leak through one of the embankments, personnel would have time to respond, contain the spill, and repair the leak. If response is prompt and the duration of the spill is brief, the spilled tailings would likely be of relatively low volume and would not travel far. A long-duration spill could allow a large volume of tailings to be released; and to travel downslope and into waterbodies.
6. **Downstream Topography**—Local topographical features (slope, terrain, and vicinity to waterbodies) determine the direction and speed of spilled tailings and their fate. Site-specific topographical features were incorporated in modeling the fate of spilled tailings in the scenarios presented below.
7. **Seasonality**—Frozen rivers would not transport spilled tailings downstream. Tailings spilled during frozen conditions would therefore accumulate closer to the TSF and would be easier to recover. Frozen soils would not be permeable, so that tailings slurry would not be able to percolate downward into soils and frozen sediments. During summer/non--frozen conditions, flowing water would mobilize spilled tailings downstream, so that the impacted area would be larger and recovery more complicated. A spill during partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), could potentially trap tailings beneath ice, presenting additional challenges to cleanup.
8. **Mode of Failure**—The behavior of spilled materials is dependent on the way in which a spill occurs. The most common modes of failure include overfilling with fluid leading to overtopping; slope instability leading to dam deformation; earthquake damage;

unstable foundation; excessive seepage leading to a dam breach; and structural failure from poor design/construction (ICOLD 2018). See Section 4.15, Geohazards and Seismic Conditions, for a discussion of TSF engineering design concept, including seismic design parameters. The failure modes for the scenarios presented below were determined by a panel of experts in a project-specific risk assessment, as described below under Risk Assessment for the Proposed Embankments.

Tailings Fluid Release

A release of tailings fluid from the TSFs could include untreated process water ranging in volume from excess seepage of pore water that could overwhelm the seepage control pond to a flood of supernatant fluid. In the event of overfilling of an embankment, supernatant could overtop the dam and spill downslope. A flood of supernatant fluid would flow downstream of the TSF. The speed and distance traveled by the released material would depend on the volume of fluid, the duration of the release, topography, and other factors addressed above. In the event of embankment overtopping, the resulting release could overwhelm downstream drainages and cause downstream erosion.

Elevated levels of metals and other constituents in the tailings fluids would impact water quality downstream. Released fluids would be immediately diluted by stream water, but stream water could fail to meet applicable WQC for many miles downstream.

Tailings Solids Release

In the event of a release of the thickened bulk tailings from the bulk TSF, the mass of thickened tailings could flow only a limited distance downslope on land. Previous studies suggest that thickened tailings are capable of flowing approximately 20 times the length of the height of the embankment (MEND 2017), depending on topography. In the case of a release from the bulk TSF main embankment, this distance would be about 2.2 miles. This distance does not take into account that the tailings would slump into waterbodies. Depending on the volume of the release, the area downstream of the bulk TSF could be covered by fine tailings, and the tailings could enter downstream drainages.

If the tailings reached a flowing stream, solid tailings particles would become entrained in the water and would be carried downstream, causing downstream sedimentation and elevated TSS/turbidity, as described below.

Tailings Slurry Release

If a high-volume release of pyritic tailings or release of wet bulk tailings occurred, a flood of fluid and tailings slurry would readily flow downslope. Some of the solid particles from the tailings slurry would settle out on land, while particles that reached flowing water would mostly be carried downstream as suspended sediment. Some tailings particles would settle on the streambed in areas of low water velocity. The flood waters would recede in a matter of hours to days, leaving behind deposits of the solid tailings material where flooding overtopped stream banks. Depending on the volume of release and other factors, the tailings could cover or bury the existing streambeds and/or stream banks. Further flow down the altered watershed could erode new channels into the soft tailings sediment. Downstream sedimentation and elevated TSS and turbidity would continue until spilled tailings are recovered, naturally flushed out of the drainage, or incorporated into the bedload. If no tailings were recovered or if the volume of release was extremely high, decades to centuries may be required to naturally flush tailings out of the drainages.

Elevated metals from the fluid would affect water quality in the short-term, until all the fluid is flushed downstream and diluted, as previously described. The EPA reports that this type of tailings slurry would be toxic due to the presence of xanthate (a reagent); but that if released in a spill, degradation and dilution would render the downstream waters non-toxic (EPA 2014). Xanthate and other reagents are addressed above.

Sedimentation and TSS

A spill of tailings into a waterbody would cause both sedimentation and an increase in TSS in the water. The amount of material that remains suspended as TSS versus deposited as sediment depends mostly on particle size and the energy of the water/velocity of the current.

The finest particles, including clay and silt, are so light that they would generally remain suspended in flowing water for an extended time, and be transported downstream by currents. In high-energy/high-velocity streams, even sand particles can remain suspended for a time, contributing to the TSS level. Downstream water would appear turbid, or cloudy, if the TSS remained elevated. Even in a small to moderate release of tailings, elevated TSS would extend all the way to the Nushagak River Estuary where it enters Nushagak Bay, part of the greater Bristol Bay (Knight Piésold 2018o). Stream water in and near the project area has naturally very low levels of TSS (Appendix K3.18, Water and Sediment Quality), and an increase in these levels above baseline conditions (pre-development levels) could impact aquatic habitat. Elevated TSS would continue until all spilled tailings upstream are recovered or naturally flushed downstream.

Sand-sized particles are heavier, and are more likely to sink in a waterbody, to be deposited as "bedload," or sediment on the bottom of the waterbody. High-energy streams continually transport bedload downstream. In a lower-energy stream, even clay- and silt-sized particles could be deposited as bedload, especially in areas of weak current, such as oxbows or sloughs. An increase in sedimentation could bury existing substrate, potentially smothering benthic organisms. Spilled tailings could also fill in voids between larger particles of substrate, such as between clasts of gravel, modifying the benthic habitat, and particularly reducing spawning habitat for salmonids.

Acid

Tailings Fluids

Supernatant fluids in the TSFs are predicted to be relatively neutral, with a pH of 7 to 8 (Knight Piésold 2018a). The release of these untreated fluids would therefore not be expected to create acidic conditions in the downstream environment.

Tailings Solids

In the event of a release of bulk or pyritic tailings into the environment, acid could be generated from unrecovered tailings solids, if tailings remain exposed to air over a period of years to decades. The potential for tailings to generate acid would continue until spilled tailings are recovered. Acid would be generated in amounts inversely proportional to tailings recovered. If tailings are recovered, no acid would be generated that would impact the downstream environment.

Both bulk and pyritic tailings would contain sulfide minerals (mostly pyrite, [FeS_2]) that chemically react with oxygen gas (O_2) and water to produce sulfuric acid (H_2SO_4), a strong acid. Pyritic tailings would contain a high level of sulfide minerals, and are classified as PAG. Bulk tailings would be primarily composed of non-acid generating materials, but would contain low concentrations of sulfides (PAG materials). Acid generation from oxidation of PAG materials occurs on various timescales, depending on factors including the rock type, mineralogy, local climate conditions, etc. (see “Factors Influencing Acid Generation and Metals Leaching” in the “Concentrate Spills” subsection). Geochemical studies on rocks from the mine site indicate that PAG material present in the tailings may require years to decades under local conditions to generate acid, depending on oxygen exposure (SRK 2018a) (see Section 3.18, Water and Sediment Quality, for discussion of PAG geochemistry.)

Stagnant water, such as that in small lakes, ponds, and TSFs, contains very low levels of dissolved oxygen (DO). Therefore, when PAG materials are stored sub-aqueously (submerged under water) in a quiescent environment, limited or no sulfur oxidation can occur to generate acid. Larger lakes may have increased circulation, which introduces higher levels of oxygen into the lake water. Iliamna Lake overturns (has significant circulation) twice every year (dimictic), and therefore has higher DO levels than standing/stagnant water.

Flowing water such as streams also contains limited DO, so that a small amount of oxidation can occur from exposed PAG materials in streams over timescales of decades to centuries. Streams in the analysis area contain an average DO level of 10.2 to 10.5 mg/L, and 12 mg/L is considered the saturation limit for local conditions. The DO in flowing water is capable of generating a small amount of acid from spilled concentrate; however, the process of acid generation would be slow, and any acid generated would be constantly diluted by the flowing water.

ARD generated from oxidized tailings could be flushed by surface runoff into waterbodies, potentially reducing the pH of the water in the vicinity. Due to the small amount of acid that would be generated, and the years to decades required for acid generation, it is likely that the acid would be progressively neutralized (diluted) as it moves downstream, due to the natural buffering capacity of the surface water. If generated ARD were flushed into an isolated waterbody, or collected in soil or in a wetland environment, however, the acid could measurably reduce the pH of the water or soil.

Metals

Tailings Fluids

Fluids held in tailings (pore water) and above the tailings (supernatant fluid) would have elevated concentrations of dissolved metals, as described above. Dissolved metals would be bioavailable, and could have toxic effects on aquatic biota. In the event of an unplanned release, these metals would be introduced into the downstream waters, and would cause downstream waters to exceed applicable WQC. The released fluid would be diluted by stream water, and flushed downstream. Depending on the volume and the rate of release, the downstream water quality would be in exceedance of WQC for an unknown length of time and an unknown distance before the released fluid is sufficiently diluted below water quality exceedance. See Appendix K4.24, Fish Values, for additional discussion on metals toxicity.

Tailings Solids

A release of tailings solids into downstream waters would cause elevated levels of metals in their *total form*; that is, the metals would not be dissolved, and therefore not bioavailable. Dissolution of the metals in tailings solids would require years to decades of weathering, depending on local conditions. See “Factors Influencing Acid Generation and Metals Leaching” in the “Concentrate Spills” subsection.

Tailings solids could contribute to elevated dissolved metal concentrations downstream over a period of decades if they are not recovered. The potential for tailings to leach metals would continue until spilled tailings are recovered. Complete recovery of spilled tailings would not be possible, because tailings spilled in flowing water would be widely dispersed. However, timely and effective recovery of spilled tailings would reduce impacts from ML. Impacts would depend on the volume of the spilled tailings solids, and the effectiveness of recovery.

ML is a natural process in which metallic minerals dissolve through chemical weathering, releasing the metals into the water. However, most metallic minerals are not readily soluble in water, especially those associated with sulfide minerals; and the ML process occurs very slowly over years to decades, depending on the metal and local conditions.

At the mine site, natural ML from copper-rich rocks has been occurring for millennia, so that some streams in the area have naturally elevated concentrations of copper and other metals. This is often how mineral deposits are initially discovered. In some streams near the mine site, baseline metal concentrations naturally exceed WQC (SLR et al. 2011a).

In neutral pH waters, ML would be a very slow process. Copper present in the tailings, for example, would not readily leach into surface waters. In acidic water, ML of copper and other metals is accelerated. Some stretches of the NFK and SFK are naturally acidic (see Appendix K3.18, Water and Sediment Quality). The potential for ML would depend on acid generation from the tailings, as well as the natural pH of the waterbody. In a tailings release, however, the slow rate of acid generation from PAG materials on dry land and the high level of environmental dilution would mean that no single body of water would likely become acidic enough to accelerate ML from spilled tailings.

Residual Toxins

In the past, public concern has been expressed regarding mining-related spills of mercury and cyanide, which have led to mortality of fish and other aquatic organisms. Use of mercury or cyanide in the project area is not included for the project. Potential cyanide use in the Pebble Project expansion scenario is addressed in the “Cumulative Effects,” subsection.

Process chemicals that would be used for the project include the reagents described under “Reagent Spills,” above. Most of the reagents are consumed during the process of froth flotation, and residual reagents mostly remain adhered to the metals in the ore concentrate. The small amount of residual reagents in the tailings is anticipated to degrade naturally. See the “Reagent Spills” section above for information on fate and behavior of spilled reagents.

The bulk tailings could have residual amounts of Ammonium Nitrate and Fuel Oil (ANFO), an emulsion-based blasting agent (explosive). ANFO may cause long-term adverse effects to the aquatic environment (Orica 2015). Ammonium Nitrate is widely used as a fertilizer, and applied to the soil in agricultural areas. Ammonium nitrate may be hazardous to water quality, but is biodegradable (New Jersey Dept. of Health 2016). Pyritic tailings would go through additional processing after separation from bulk tailings, and would not be expected to contain residual ANFO.

Residuals from the WTP, including selenium sulfide, would be added to the pyritic tailings and placed in the pyritic TSF. See Appendix K4.24, Fish Values, for a detailed discussion of metals toxicity.

4.27.8.4 Historical Examples of Tailings Releases

The number of tailings dams in the world is estimated at over 3,500 (ICOLD 2018). The International Commission on Large Dams (ICOLD) published a database of 221 tailings dam incidents, including 135 failures that occurred between 1917 and 2000 (ICOLD 2001). Numerous other tailings dam failures have occurred in the last 2 decades as well (WISE 2020).

From 1987 to 2007, there was an average of 1.7 tailings dam failures per year (Peck 2007, as reported in EPA 2014); from 1995 to 2001, the rate of major incidents was two per year (ICOLD 2001); while another source cites two to five major tailings dam failures per year between 1970 and 2001 (Davies 2002). Between 1999 and 2018, the failure rate has averaged 2.4 failures per year. The number of tailings dams increases every year as new mines are constructed, and the failure rate in recent years has risen, with a failure rate of 3.2 failures per year between 2014 and 2018 (WISE 2018). New data from WISE show six TSF failures around the world in 2019, and one failure to date in 2020 (WISE 2020). It is also worth noting that reporting of these failures has improved in recent years, and many failures likely went unreported in the past.

Most tailings dams around the world have been constructed by the upstream method, in which dams are sequentially raised by placement of fill on top of stored tailings in the upstream direction. Upstream dams are often used because they are less expensive to construct, and require a smaller footprint than downstream and centerline dams. Rico et. al. (2007a) estimated that 76 percent of global TSF failures involved upstream dams. Published failure data are therefore based on failures of mostly upstream dams. The Applicant is not proposing to construct any upstream dams.

Downstream dams, in contrast, are raised in the downstream direction by placement of fill on top of the crest and downstream slope of the previous raise. Centerline dams are raised by placement of fill on top of both stored tailings and fill materials of the previous raise. Data on dam failures around the world demonstrate that dams built by downstream or centerline construction methods are much safer than dams built with upstream construction methods, especially under seismic shaking, although downstream and centerline dams have still failed (ICOLD 2001; WISE 2020). The Applicant has proposed downstream and centerline construction for all 13 embankments. See Section 4.15, Geohazards and Seismic Conditions, for technical details on the proposed dam construction methods.

Historical failures of tailings dams have caused damage, including human casualties, destruction of homes and property, economic loss, and environmental impacts, especially impairment of aquatic habitat in drainages beneath the failed embankments.

Appendix K4.27 provides a detailed discussion of recent tailings dam failures that have occurred in British Columbia (Mount Polley 2014), Brazil (Fundão 2015; Feijão 2019), and Australia (Cadia 2018). Morgenstern (2018) and Marr (2019) discuss some of these, along with a select set of other high-profile failures and releases. Examples of some additional earlier high-profile historic failures include:

- November 1974, Bafokeng, South Africa: 3 million cubic meters (m^3) of tailings slurry flowed 45 kilometers.
- July 1985, Stava, Italy: Tailings flowed up to 8 kilometers.
- April 1998, Aznalcóllar, Spain: 4 to 5 million m^3 of toxic water and tailings slurry were released.
- October 2010, Kolontar, Hungary: Approximately 900,000 cubic yards of tailings slurry flowed downstream, and some of that amount reached the Danube River.

It is considered state-of-the-practice to design modern tailings dams to high industry standards; subject them to multi-phase risk analysis; and apply strict regulations on their design, construction, and operation. Modern dam designs include extensive site investigation, consideration of rock and soil strength, climatic variability, flood conditions, seismic potential, etc. Because recently constructed dams have relatively short performance records, there are limited data available on their rates of failure. However, investigations have found that modern dams that have experienced failures have been attributed to human error in design, construction, operations and regulation, or some combination thereof.

A recent example of a modern tailings dam failure is the August 2014 release from the Mt. Polley copper and gold mine in British Columbia, Canada. An estimated 7.3 million cubic meters of tailings solids and 17.1 million cubic meters of fluid were released during a breach of the tailings facility embankment and flowed into downstream waterways (WISE 2018). Investigations (Morgenstern et al. 2015) point to a combination of factors leading to failure, including an initial geotechnical oversight, a steeper-than-designed downstream slope, a lack of foresight in planning for dam raising, improper/insufficient observation (surveillance), and a higher-than-planned supernatant pond on the TSF surface.

Fluids released during tailings dam failures, including supernatant, seepage water, contact water and entrained water, often contain elevated levels of metals that can impact downstream water and habitat. However, these fluids are rapidly diluted and flushed out of drainages. Tailings solids that were never recovered and have been left in place for decades, however, have been shown to be a long-term source of contamination. Downstream sedimentation and increased TSS can cause immediate and long-term impacts to aquatic habitats. Over time, periods of years to decades, ARD and ML can be sources of toxicity from unrecovered tailings.

Three well-studied historic examples of unrecovered mine tailings from the United States demonstrate the potential long-term impact to water quality and aquatic habitats that can result. A tailings dam failure in the New World mining district in Montana in 1950 released 41 million m^3 of tailings with high levels of copper, gold, and other metals into Soda Butte Creek. ML from the spilled solid tailings has impaired biota in the river, and copper levels in the streambed sediments are still elevated today (Marcus et al. 2011). In the Coeur d'Alene River, Idaho, from the turn of the twentieth century until the late 1960s, multiple tailings dams failures and then state-of-the-practice dumping released about 62 million tons of tailings with high concentrations of copper, lead, silver, zinc, and other metals. ML from unrecovered tailings led to toxic levels of metals in both river water and sediment, and the loss of some fish species from the area (EPA 2014). Mining practices common around the turn of the twentieth century led to the uncontrolled dumping of tailings, which contained heavy metals, including copper, on the floodplains of the Clark Fork River, Montana. Generation of acid and ML killed vegetation in some areas; and killed most of the fish in the river for a period of several decades. Periodic rainstorms flushed leached metals into the river and caused subsequent fish kills. Sedimentation also likely contributed to low fish numbers (EPA 2014). All three sites are now Superfund sites (EPA 2014).

Due to improved modern TSF management practices, environmental regulations, and public demand, tailings spills are now more routinely recovered and cleaned up, so that the potential for severe long-term impacts from unrecovered tailings is likely lower now than in the past century. Small- to moderate-volume tailings spills from the project would likely be recovered to conditions in compliance with state regulations.

The Mount Polley dam failure is a recent example in which tailings considered "recoverable" were recovered. Timely recovery of spilled tailings and stabilization of impacted waterways have been shown to limit chemical impacts to downstream waterways (Byrne et al. 2018).

The main water quality impact of the Mount Polley release was elevated TSS and turbidity (Nikl et al. 2016). Metals in their total form (not dissolved or bioavailable) were also elevated after the release due to the suspended tailings particles. Initial water quality impacts also included elevated temperature and conductivity (Petticrew et al. 2015). Water quality downstream of the Mount Polley release was reduced for approximately 6 to 9 months, after which time the water quality returned to baseline (Nikl et al. 2016).

Geochemical predictions were that metal release potential and bioavailability of tailings would be low, which is supported by data showing that tailings have not been toxic, and copper levels were shown to be decreasing after the release (Nikl et al. 2016). Salmon in the Quesnel Lake watershed downstream of the Mount Polley release returned to spawn in high numbers in 2018, 4 years after the spill (Williams Lake Tribune, 2018).

4.27.8.5 Probability of Failure

Determining the probability of failure of tailings dams is difficult, because historic failures represent a wide range of engineering, construction, and operations quality from across the world, and include TSFs constructed over a span of more than a century. Numerous tailings releases that occurred throughout the twentieth century were likely constructed with what would be considered poor-quality engineering compared to modern state-of-the-practice standards, and many experts therefore do not believe that historical dam failure data are relevant when calculating the risk posed by modern dams.

Published tailings dam failure rates are based on historical failures, which have mostly been failures of upstream constructed dams. As noted above, Rico et al. (2007a) estimated that 76 percent of global TSF failures involved upstream dams. Published failure data presented here are therefore based on failures of mostly upstream dams. Centerline or downstream dams, like those proposed by the Applicant, have a much lower failure rate, as described above (ICOLD 2001; Rico 2007a). See Appendix K4.27 for a discussion of dam failures relevant to the proposed project.

Estimates of the probability of failure of tailings dams include: one failure for every 2,000 dam-years (one dam-year is the existence of one dam for one year) (Chambers and Higman 2011); one failure for every 2,041 dam-years (Peck 2007); one failure every 714 to 1,754 dam-years (Davies et al. 2000 as reported in EPA 2014); and one failure every 2,500 to 250,000 dam-years (EPA 2014). These leading estimates all indicate that the probabilities of failure are very low.

Another way to describe the probability of dam failure is the annual probability of failure. The historical average failure rate of tailings dams is 1 in 1,000 per year (0.001 annual failure rate) compared to 1 in 10,000 per year (0.0001 annual failure rate) for water retention dams (Marr 2019). The rate of failure of tailings dams is higher than that of water supply reservoir dams, possibly due in part to the sequential raising of tailings dams, as opposed to reservoir dams, which are constructed all at once (Chambers and Higman 2011). Regarding dam failure rates and height of dams, higher dams (such as dams higher than 300 feet) have historically *not* failed more than lower dams, but spills from higher dams are more likely to be reported by the media because the consequences of such spills can be more severe than spills from smaller dams (with lower-volume containment). In addition, historically, the numbers of higher dams in existence was fewer. One study demonstrates that dam height has an inverse correlation with the frequency of dam failure; only about 1 percent of 147 tailings dam failures documented worldwide by Rico et al. (2007a) have occurred at large dams, greater than 300 feet high. This may be due to higher levels of engineering and safety considerations required for large dams compared to smaller ones. However, this study includes a relatively small database, and other analysts do not agree that there is a demonstrated inverse correlation between dam height and failure (EPA 2014).

Some authors have noted that released volumes from recent tailings dam failures are larger than in past decades, reflecting the larger size of modern TSFs. This may be due to the mining of lower-grade ores, which necessitates storing a higher volume of tailings (Armstrong et al. 2019).

Evaluation of historical data shows that the probability of TSF failures depends on many factors, including the quantity and quality of the geological and geotechnical investigations, dam engineering and design, construction procurement and methods, construction quality control and quality assurance, site soil, rock and groundwater conditions, control of fluid levels in the facility (water management), and accordance with regular inspections and regulatory protocols, tailings gradation and strength characteristics, and tailings segregation and permeability. As noted above, most historic dam failures have been from upstream-constructed dams.

The only common factor in all major TSF failures has been human error, including errors in design, construction, operations, maintenance, and regulatory oversight. ICOLD (2001) stated "the majority of TSF failures were avoidable and a matter of control and diligence by mine owners and operators" and "…the technical knowledge exists to allow tailings dams to be built and operated at low risk, but that accidents occur frequently because of lapses in the consistent application of expertise over the full life of the facility and because of lack of attention to detail."

Those TSFs that have been shown to be the most robust and to *not* experience failures are those that have periodic technical review by qualified engineers throughout the design, construction, and operational lifetime. The Alaska Dam Safety Program (ADSP) would require periodic technical review by an Independent Engineering Review Board (IERB) throughout the life of the facilities (ADNR 2017a). ADSP also requires third-party audits of embankment projects, as deemed necessary by ADSP (ADNR 2017a).

A review of ICOLD data reveals a clear trend in the higher probability of dam failure during active dam operations. Ninety percent of tailings dam failures have occurred in active dams during operations, as opposed to dams in closure (ICOLD 2001, 2018). Data also show that failures of tailings embankments under dry storage conditions (with no ponded water above tailings) after mine closure are small compared to dams in active operations with ponded water (USACE 2018d). Therefore, the probability of a failure of the bulk TSF in closure would be expected to be even lower than the estimates above, as provided by Rico et al. 2007a and discussed in EPA 2014.

Risk assessment for individual embankments considers all of these factors, and the assessment is unique to each dam. For the purposes of this EIS, the probability of a spill from the bulk TSF and pyritic TSF (as well as the main WMP) were therefore considered in a risk assessment specific to the project.

4.27.8.6 Risk Assessment for the Proposed Embankments

A Failure Modes and Effects Analysis (FMEA) is a risk assessment tool commonly used as a preliminary step in assessment of failure risk of large dams. A typical FMEA workshop uses a facilitated group of multi-discipline experts in TSF and dam design, construction, and operations to assess the probability of failure and level of consequences for an embankment. The FMEA process can be used to strengthen engineering design, inform subsequent stages of site investigation, and provide input for the dam permitting process. The FMEA process can also provide guidance on embankment construction and operations, including evolving designs for embankment raises during the life of the mine, and for maintenance and surveillance during closure and post-closure. FMEAs are used as one step of a risk analysis to inform a higher level of risk assessment. FMEAs are subjective and can be prone to bias.

The current level of embankment design for the project is at a very early phase, considered a *conceptual* phase. Site investigation and engineering plans are still ongoing. The ADSP would require additional risk assessment prior to issuing a *Certificate of Approval to Construct a Dam* (ADNR 2017a).

In October of 2018, the US Army Corps of Engineers (USACE) hosted an EIS-Phase FMEA workshop to assess the likelihood of a spill and the severity of potential environmental impacts from the major embankments in the bulk TSF, pyritic TSF, and main WMP. The EIS-Phase FMEA recognized the early-phase conceptual-level design of the embankments, and focused on the impacts assessment of hypothetical releases for EIS purposes. See the EIS-Phase FMEA Report (AECOM 2018l).

Note that the proposed project would include 13 separate embankments as part of 10 facilities, ranging in height from 30 feet to 545 feet (see Appendix K4.15, Geohazards and Seismic Conditions). In addition to the three embankments analyzed for failure impacts herein, there would be several other substantial embankments at the mine site. The bulk TSF main seepage collection pond dam, for example, is currently designed to be 120 feet tall, with a maximum crest length of 3,400 feet, and a maximum impoundment volume of 3,000 acre-feet (Table K4.15-1). It is beyond the scope of the National Environmental Policy Act (NEPA) to address potential impacts from failures of every proposed embankment. This document addresses failures from embankments at the three largest facilities, to cover the widest range of potential impacts.

FMEA participants evaluated the design of each embankment, and assessed the likelihood of a wide range of potential failure modes, which are situations that could lead to a failure of the embankment. These included potential design errors, construction deficiencies, operations mishaps, maintenance and surveillance oversights, foundation condition underestimates, materials weaknesses such as in construction fill or liners, severe weather, earthquakes, human interference, changed conditions, etc. Potential failures in the closure/post-closure phases were considered for the bulk TSF because it would exist in perpetuity. It should be noted that the potential failure modes analyzed did not reflect any specific weakness in the design, but were developed for estimating potential release volumes to analyze impacts of a hypothetical release. See the EIS-Phase FMEA Report for a full discussion of potential failure mode evaluation (AECOM 2018l).

In accordance with NEPA guidelines, failure scenarios selected for analysis in the EIS were of relatively low probability and a comparatively high level of consequence. Minor failures that result in small releases (such as increased seepage that would exceed the capacity of the water treatment plant) have a relatively high probability of occurrence, but can be easily corrected, and therefore typically have a low impact on the downstream population and ecosystem. Massive catastrophic failures, or “worst-case scenarios,” (such as a full embankment breach) would have substantial consequences, but are extremely unlikely. The FMEA considered large-scale catastrophic releases, such as that caused by a full breach of one of the embankments. The probability of a full breach of the bulk or pyritic TSF tailings embankments was assessed to be extremely low (i.e., worst-case). (Note that due to the unique design and construction of individual embankments, probabilities of failure of the proposed embankments were determined by the FMEA process, not by statistical analysis as was completed for trucking accidents, etc.)

In assessing the level of risk during the FMEA workshop, it was assumed, per USACE guidelines, that BMPs and full operational/regulatory procedures would be followed (AECOM 2018k).

For each failure mode, the FMEA participants rated the potential environmental impacts for their severity. The panel then identified those failure scenarios that have a relatively low probability of occurrence, and comparatively high level of consequence (AECOM 2018l). For each facility, one scenario was selected for impacts analysis in the EIS, included below. Selected scenarios were based on end of mine-sized dams because that represents the phase with the highest spill risk. Changes in operations were not explicitly considered during the FMEA process. See the EIS-Phase FMEA Report for a full discussion of scenario selection (AECOM 2018l).

4.27.8.7 Existing Response Capacity

An Emergency Action Plan (EAP) is required by the State of Alaska Dam Safety Program for all Class I and Class II regulated dams. The embankments constructed for both TSFs would be designed and regulated as Class I dams (AECOM 2018k). The EAP is required to be available to direct appropriate response measures in the event of a failure, or in anticipation of such failure. The EAP is to include response measures to adequately protect life and property, and provide coordination of emergency responders in the community (including mine personnel and downstream residents).

In the event of a tailings release, recovery efforts depend on the volume of the release and the distribution of tailings. A small, localized release at or near the mine site could be recovered with relatively little additional impact. If a tailings release were to occur during active mine operations, personnel would be present on site, but not necessarily have training to respond to such a release. If the tailings are actively being flushed downstream by natural waterflow, full recovery efforts may not be practical or possible.

In the event of a very large release, spill response, recovery of tailings, and remediation would be difficult. Recovery of spilled tailings would be challenging, based on the logistics of transporting large volumes of rocky material in a remote, roadless area. Winter recovery could be easier if trucks are able to operate over frozen streams/wetlands, but the impact of such vehicle traffic could be damaging to soils and vegetation, and cause increased erosion into waterways.

Impacts from tailings recovery could include damage to streambeds and riverbank environments from heavy equipment. Recovered tailings would have to be permanently stored somewhere. If it was decided to put the tailings back in the respective TSF, extensive repairs may have to be completed first. If the release occurred after mine closure, personnel would have to be mobilized to the site to respond.

4.27.8.8 Mitigation

- Tailings dam safety is regulated by ADNR Dam Safety Program under Alaska Statute (AS) 46.17 “Supervision of Safety of Dams and Reservoirs” and Title 11, Chapter 93, Article 3 (11 AAC 93), Dam Safety. Note that ADSP has provided updated draft guidelines (ADNR 2017a) referred to throughout the EIS. These draft guidelines have not yet been adopted under Alaska Statutes.
- ADNR approval is required at multiple stages of an embankment development to “construct, enlarge, repair, alter, remove, maintain, operate or abandon” a dam.
- The major embankments discussed herein would all be constructed to the Class I hazard classification (highest potential hazard), requiring that PLP and their engineering consultant provide a high level of technical risk assessment prior to request for and issuance of Certificates of Approval to Construct a Dam.
- Each raise of each dam would require pre-approval from ADNR Dam Safety Program in the form of a Certificate of Approval to Modify a Dam.
- Available storage capacity (freeboard) would always be maintained in the TSFs to account for the IDF and seismic settlement (PLP 2018d).
- Both TSFs would be constructed on bedrock, which is considered to increase the stability of tailings embankments. All surficial soils and other unconsolidated materials would be removed prior to construction.
- As per ADSP draft guidelines (ADNR 2017a), two levels of design earthquake must be established for Class I dams: an *Operating Basis Earthquake* (OBE) that has a reasonable probability of occurring during the project life (return period of 150 to more

than 250 years); and a *Maximum Design Earthquake* (MDE) that represents the most severe ground shaking expected at the site (return period from 2,500 years up to that of the Maximum Credible Earthquake [MCE]). These design earthquakes cannot be represented by a single magnitude value. Rather, impacts would vary with not only magnitude, but also with the type of earthquake, epicenter location, depth, duration of shaking, etc. A range of earthquake magnitudes and characteristics is used to represent each level of design earthquake (see Section 3.15 and Section 4.15, Geohazards and Seismic Conditions).

- Both the bulk and pyritic TSFs would be designed and constructed with acceptable static and seismic Factors of Safety (FoS) commensurate with the confidence in the available data and underlying assumptions, and in accordance with the standard-of-practice for embankment design.
- See Section 4.15, Geohazards and Seismic Conditions, for more details on FoS.
- The ADSP would require periodic technical review by an IERB throughout the life of the facilities (ADNR 2017a). ADSP also requires third-party audits of embankment projects, as deemed necessary by ADSP (ADNR 2017a).

See Section 4.15 and Appendix K4.15, Geohazards and Seismic Conditions, for further discussion of seismic stability design for TSFs.

Bulk TSF

A modified centerline construction method was selected for the bulk TSF main (north) embankment to limit the footprint and volume of materials required for construction (PLP 2018-RFI 075; Figure 2-8). The initial starter dam would be downstream-constructed to a height of 265 feet, followed by centerline construction of the upper 280 feet of the dam to reduce the footprint, with a buttressed downstream slope to enhance stability. The total height of the main embankment would be 545 feet.

Alternative 2—North Road and Ferry with Downstream Dams, considers downstream construction for the bulk TSF main embankment (Figure 2-66). The Factor of Safety (FoS) would be 1.9 to 2.0 for both downstream and centerline designs. The south embankment would be constructed with the downstream method for all alternatives. See Chapter 2, Alternatives, for a description of the downstream dam alternative; and Section 4.15, Geohazards and Seismic Conditions, for geotechnical comparisons of centerline and downstream dam designs.

Bulk TSF Design Features

- The main embankment of the bulk TSF is planned to be an unlined pervious structure, so that excess fluid from precipitation or added process water would constantly seep through and out of the TSF and depress the phreatic surface in the main embankment and nearby tailings. The upper portions of the bulk tailings would therefore be moist, but not fluid–saturated; while deeper in the tailings pile and towards the southern lined embankment, the tailings would be fluid-saturated. Bulk tailings that are not water-saturated are resistant to flow, while fluid-saturated would flow more readily in the event of a dam failure. The south embankment would be lined.
- Supernatant fluid would be maintained throughout operations in a minimal supernatant pond away from the edges of both embankments, and would be maintained at a low volume. Excess fluid would be pumped to either the seepage control pond or the main WMP.
- Precipitation events would temporarily increase the volume of the supernatant pond, but the seepage control system would be designed to maintain the fluid within specified

levels. The bulk TSF is designed to have additional capacity (freeboard) for a volume of water equal to the IDF precipitation event.

- Predicted pH of the bulk tailings supernatant fluid at the end of the 20-year operational life of the mine is 7 to 8 (Knight Piésold 2018a).
- At the close of operations, the TSF would remain in place under “dry storage” conditions in perpetuity. The TSF would be drained of excess fluid, and the tailings would be contoured into a permanent landform. Data show that failures of tailings embankments under dry storage conditions (with no ponded water above tailings) after mine closure are small compared to dams in active operations with ponded water (IEEIRP 2015). New seepage modeling results confirm that the phreatic surface, or the ”water table” in the TSF would be expected to decline in early closure, resulting in more stable embankment conditions in post-closure (PLP 2019-RFI-006b, h, 130). See Section 4.15, Geohazards and Seismic Conditions, for more information on TSF drainage. The stability benefits to a dry surface cover are summarized by Cobb (2019) as follows: “At the end of the operating life the risk is immediately reduced if the operational pond can be removed, resulting in a ‘dry’ closure. After that, the risk is dependent on the nature of the design and the post-closure maintenance requirements.” The bulk TSF post-closure maintenance requirements would be developed as part of the closure design and post-closure objectives.

Pyritic TSF

Pyritic TSF Design Features

- The pyritic TSF would be bounded on its northern, eastern, and southern sides by geomembrane-lined rockfill and earthfill embankments with maximum heights of 335, 225, and 215 feet, respectively.
- The geomembrane liner would extend over the full basin area to reduce seepage out of the TSF, and also reduce the risk of embankment failure due to seepage and piping.
- The geomembrane liner would be protected with processed materials to protect liner from punctures or damage during PAG waste rock material placement (PLP 2018-RFI 055).
- Pyritic tailings would be stored sub-aqueously so that supernatant fluid would not become acidic. Predicted pH of the pyritic tailings supernatant fluid at the end of the 20-year operational life of the mine is 7 to 8 (Knight Piésold 2018a).
- Pyritic tailings are PAG and capable of ML, and have the potential for downstream impacts from spills during the 20 to 30 years of operational life. During closure, the pyritic tailings would be permanently moved to the open pit, reducing the risk of downstream contamination.

4.27.8.9 Tailings Release Scenarios

The following scenarios were developed during the FMEA workshop described above. Workshop participants reviewed the conceptual designs of the bulk and pyritic TSFs and assessed the likelihood of a release; and the severity of resulting consequences for each facility. Minor releases that would have relatively minor impacts were not selected as scenarios for analysis in the EIS, because the associated impacts would be within the range of the selected scenarios. Massive, catastrophic releases that were deemed extremely unlikely were also ruled out for analysis in the EIS. The two scenarios analyzed below were therefore chosen based on their relatively low probability of occurrence, and relatively high environmental impacts. For each scenario, a reasonable volume and duration of release were also selected to evaluate potential impacts to physical, biological, and social resources (see the EIS-Phase FMEA Report [AECOM 2018l]).

The potential for tailings releases as described in the scenarios below would be the same across all alternatives; downstream versus centerline construction of the bulk TSF main embankment would not affect the selected bulk TSF release scenario.

Modeling the Release Scenarios

Information on the selected scenarios from the FMEA workshop was used as input for modeling the two release scenarios described below, to analyze potential impacts on physical, biological, and social resources. Modeling of the tailings releases in the two scenarios below provides an estimate on the extent of flooding, water quality impacts, and potential tailings deposition from the scenarios.

Modeling of the downstream routing of flows was conducted using a two-dimensional inundation model, developed by USACE for modeling open-channel flows, including flood wave propagation. The Hydrologic Engineering Center's River Analysis System (HEC-RAS) is a FEMA-approved two-dimensional hydraulic model. The HEC-RAS model accounts for attenuation of flood waves as they propagate downstream.

Hydrodynamic modeling tools were used for modeling of the propagation of the flood wave and associated inundation for the pyritic tailings release scenario. Hydrodynamic modeling was not required for inundation mapping in the bulk tailings failure scenario; however, it was used to assess the propagation and attenuation of flows from the failed pipelines.

Both types of modeling require inputs of topographic and hydrologic data from the downstream drainages. The topography used in the HEC-RAS, and hydrodynamic models was defined using a digital elevation model (DEM) for the project site. US Geological Survey (USGS) and PLP streamflow-gaging stations in the Nushagak and Koktuli river drainage basins were used to characterize hydrological conditions, and provide the necessary hydrologic data for the modeling.

The mixing of the tailings solid particles in the tailings slurries with natural stream flow was modeled using a two-dimensional analytical model for diffusion analysis. See complete details on modeling methodology and results in Knight Piésold Failure Model Bulk TSF (Knight Piésold 2018o) and Knight Piésold Failure Model Pyritic TSF (Knight Piésold 2018p). As with any modeling exercise, there are uncertainties involved in the modeling inputs, assumptions, and outcomes. See the complete Knight Piésold Failure Model reports for full details (Knight Piésold 2018o, p, q).

Knight Piésold modeling extended as far as the entrance to the 19-mile-long Nushagak Estuary, and not all the way to Bristol Bay.

Scenario: Bulk Tailings Delivery Pipeline Rupture

In this scenario, an earthquake (greater than the OBE) causes shearing of the two tailings delivery pipelines along the northwestern corner of the bulk TSF main embankment. The full pumped flow rate of 70 cfs of bulk tailings slurry would begin to spill into the NFK by way of Tributary NFK 1.130 (Figure 4.27-2). The tailings slurry, with 55 percent tailings solids and 45 percent contact water, would be expected to flow readily (as a Newtonian fluid). See Knight Piésold 2018o for details on how flow parameters were calculated. The slurry would flow downslope as a turbulent flow, with the fine particles of tailings solids remaining in suspension.

In this scenario, it is assumed that it would take 6 hours for the leak to be detected and for the tailings slurry delivery pumps to be shut off. By this time, 1.5 million ft^3 of tailings slurry would have been released. The pipeline would continue to drain an additional 60,000 ft^3 of slurry after the pumps have been shut off. The total volume of 1.56 million ft^3 of bulk tailings slurry would flow down Tributary NFK 1.130 beneath the northwestern corner of the bulk TSF in the north/northeast direction towards the NFK drainage. The total volume of solid tailings released would be 0.5 million ft^3 (40,000 tons), and the total volume of contact water released would be 1.0 million ft^3 (Knight Piésold 2018o).

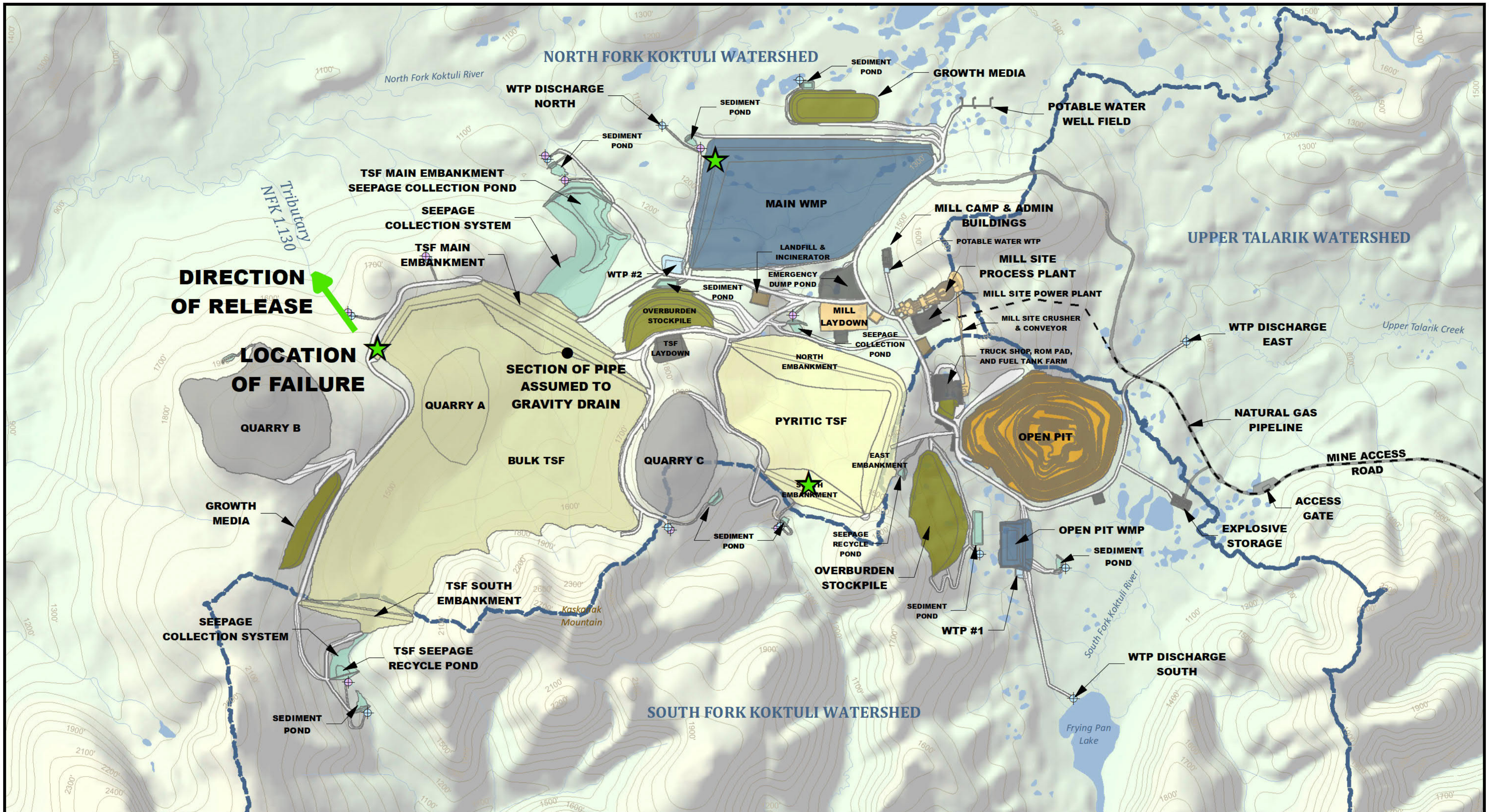
Tributary NFK 1.130 is just under 2 miles in length (about 10,000 feet) between the northwestern corner of the bulk TSF and the mainstem NFK. The upper portions of the tributary are somewhat steep, with a slope of about 15 percent. As the slurry flows out of the sheared pipelines, it would flow down into the steep upper portion of the tributary, which would accelerate the flow. At the bottom of the steep slope the land flattens out, and the slope diminishes to about 2 percent above the confluence with the NFK.

The volume of the released slurry would far exceed the MAD and the natural floods in Tributary NFK 1.130 (Knight Piésold 2018o), so that the slurry release would cause overbank flooding along the tributary's banks, and some limited deposition of tailings solids on the banks (less than 46 acres). The release would cause streambed erosion in the upper portions of the tributary drainage. In the lower stretches of the tributary and at the confluence with the NFK, the slurry release would slow down somewhat; and there would be additional deposition of tailings solids in the drainage and along the banks as the slurry flows recede. In total, solid tailings particles would be deposited on about 46 acres, mostly surrounding the confluence of Tributary NFK 1.130 with the NFK (Knight Piésold 2018o).

At the confluence of Tributary NFK 1.130 with the NFK, the flow of slurry would be comparable to flows in the NFK. The addition of 70 cfs from the bulk TSF tailings failure scenario is relatively small compared to the natural floods in the NFK and downstream drainages. This release scenario would not exceed the 2-year flood flows (bankfull condition) for the NFK, Koktuli River, Mulchatna River, or the Nushagak River. Therefore, no overbank flow and no deposition of solid tailings would be expected outside of the river channel along these downstream drainages (Knight Piésold 2018o).

The duration of increased flows along the downstream drainages would vary from 9 hours at the confluence of Tributary NFK 1.130 and the NFK, to 36 hours near the confluence of the Koktuli and the Swan rivers (Figure 4.27-3). See "Surface Water Hydrology," below, for full details on flow attenuation, arrival time, and duration of increased failure flows.

Note that the EPA (2014) and Lynker (2019) have put forth models of larger bulk tailings spill scenarios. See Appendix K4.27 for a review of these models.



Sources: KP 2018o; PLP 2019-RFI153

US Army Corps of Engineers®

0.5 0 0.5 1
Miles

- Location of Failure
- Section of Pipe Assumed to Gravity Drain
- Direction of Release

Alternative 1a

- GW Quality Monitoring and Pump Back
- Water Quality Monitoring Point
- Natural Gas Pipeline
- Bulk Tailing Storage Facility
- Mine Site Infrastructure
- Mineral Processing Facilities
- Onsite Access Roads
- Open Pit
- Pyritic Tailings Storage Facility
- Quarries
- Sediment/Seepage Collection Systems
- Stockpiles
- Waste Management Facilities
- Water Management Ponds
- Water Treatment Plants

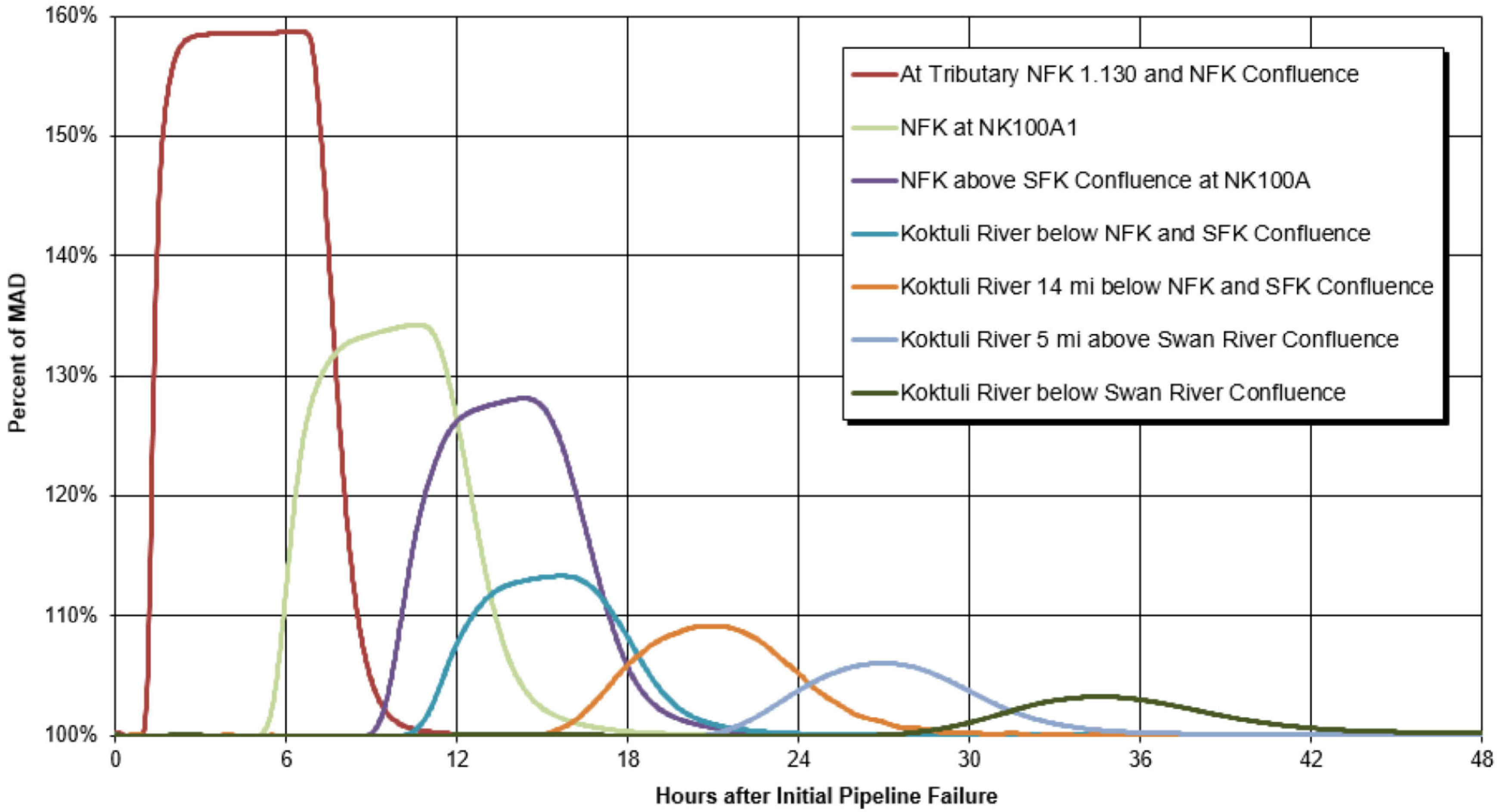
Other Features

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

BULK TAILINGS RELEASE LOCATION

PEBBLE PROJECT EIS

FIGURE 4.27-2



Sources: KP 2018o

US Army Corps of Engineers

HYDROGRAPHS DOWNSTREAM OF BULK TAILINGS RELEASE

PEBBLE PROJECT EIS

FIGURE 4.27-3

Suspended Tailings Solids

The tailings slurry would include a mixture of fine particles suspended in fluid. The finest particles of clays and silts, which make up about 60 percent of the bulk tailings solids, are light; and would stay suspended in the water and be transported downstream. Most of this material would be flushed downstream during the initial peak flows.

The solid particles would mix with the natural stream flow of the downstream drainages, creating elevated TSS downstream. Full mixing of the slurry with natural stream water would be anticipated within about 0.5 mile or less downstream. After the pumps are shut down and the flow of slurry ceases, natural dilution of stream water would begin to decrease the turbidity.

Water in these drainages is naturally low in TSS, with average measured TSS values of 1.19 mg/L in the NFK (see Section 3.18, Water and Sediment Quality, and Appendix K3.18). The most stringent water quality criterion requires TSS to be no more than 20 mg/L. The release scenario would elevate the TSS (and turbidity) of the drainages well above the most stringent WQC all the way downstream to the Nushagak River Estuary at the mouth of Nushagak Bay, part of the greater Bristol Bay. See Water and Sediment Quality impacts, below, for complete data on TSS level across the downstream watershed.

Deposition of Tailings Solids

The fine sand-sized particles that make up about 40 percent of the bulk tailings solids may remain suspended in the water where the stream energy is high, but would likely settle out and deposit on the streambed in areas where the current is weak, especially in side-channels and backwaters. After the initial wave of increased flow has passed, some sand-sized particles could remain in these areas, covering and intermingling with the natural stream substrate. These particles would eventually be naturally flushed out of the drainage, likely when stream flows naturally peak, such as during a storm event or during the spring thaw. Sand-sized particles would be flushed downstream, largely along the streambed itself as bedload. Some of the particles would intermingle with natural bedload sediments, and may remain in the drainages for months to years; while some of the particles would eventually reach Nushagak Bay, part of the greater Bristol Bay, where they would be deposited as sediments in the bay.

Spill Response

The State of Alaska does not have specific requirements for cleanup of spilled mine tailings. As per Alaska Statute 27.19.02, the mine site must be returned to a stable condition, compatible with the post-mining land use (AS 27.19.02).

See the "Spill Preparedness, Prevention, and Response Measures" subsection for the actions that the Applicant has committed to. An EAP would be available to direct the appropriate response measures. Response measures would include ensuring the safety of downstream mine employees; shutting down the tailings pipelines; coordinating emergency responders in the community (including mine personnel and downstream residents); and implementing remedial actions to minimize impacts to affected resources.

The release flood would extend along the banks of Tributary NFK 1.130 as far as the confluence with the NFK. No mine employees would normally be working in this area. Subsequent downstream flows would be so small as to pose no safety concern to downstream residents or recreational users.

Remedial actions would include removing the tailings from the primary depositional area in the upper NFK to the extent practicable. The tailings would be excavated using a combination of heavy equipment and hand tools, and transported back to the TSF or other designated temporary storage area. Any soils impacted by the elevated metals from the contact water could also be removed, and the impacted habitats could be restored.

Access to cleanup areas in the summer would be difficult due to the lack of roads along the NFK, and would likely involve use of helicopters. Access in the winter could be simplified by travel on packed snow trails, and removal of deposited material may be more effective because the ground and streams would likely be frozen. Cleanup during partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), would present additional challenges, with tailings potentially trapped beneath ice.

Cleanup activities such as excavation or dredging could damage stream habitat, and machinery could cause soil erosion and/or compaction adjacent to streams. Additional habitat restoration could be required after tailings recovery activities.

In the event of a tailings spill, the Applicant has committed to the following remedial actions (from Knight Piésold 2018o):

Remedial actions under this failure scenario would initially include:

- Shutting down the tailings pumping system to the breached location
- Ensuring there are no health and safety concerns resulting from the breach, which may include notification of downstream mine personnel and residents
- Notifying the key individuals and regulatory contacts as per the Emergency Response Plan

Ongoing remedial actions would include:

- Repairing and replacing the damaged tailings pipeline
- Mobilizing mine equipment and staff to clean up discharged tailings where practicable, which would likely include helicopter-supported efforts to support ongoing cleanup activities
- Establishing environmental control measures downstream of the failure to reduce the potential for sediment transport from areas with settled tailings
- Repairing any erosion damage to the embankments, if required
- Repairing erosion damage in the tributary and at the confluence, if required
- Monitoring downstream water for water quality (Knight Piésold 2018o)

Alternatives Analysis

The probability and impacts of a bulk tailings release would be similar across all alternatives, with the only difference being the downstream main embankment design under Alternative 2 versus the centerline embankment design for the other alternatives. See Section 4.15, Geohazards and Seismic Conditions, for a discussion of downstream and centerline dam construction methods.

Potential Impacts of a Bulk Tailings Delivery Pipeline Rupture

This section addresses potential impacts of a release of bulk tailings in the scenario described above. Impacts are considered in terms of their magnitude, duration, geographic extent, and potential to occur. A tailings release would not impact all the resources addressed in this EIS. The following resources were selected for analysis due to the higher potential significance of the impacts.

Soils

Tailings Solids Deposition on Soils

In this scenario, less than 46 acres of soils would be temporarily covered by thin deposits of tailings. No long-term impacts to soils would be expected from this deposition.

The total mass of solid tailings released in the scenario is approximately 0.5 million ft^3, or 40,000 tons. Approximately 60 percent of this material, or 24,000 tons, are composed of fine particles of silts and clays that are expected to remain suspended in the flow, and be flushed downstream within days of the release. The remaining 40 percent of the material, or 16,000 tons, are sand-sized particles that are more likely to initially settle out near the confluence with NFK, both in the streambed and where Tributary NFK 1.130 overtops its banks. Some fraction of this material could be deposited on soils.

In this scenario, soils adjacent to Tributary NFK 1.130 could be covered by a thin layer of bulk tailings solids. Near the confluence with the NFK where the land flattens out, surrounding soils would likely be covered by a greater thickness of tailings. The average thickness of solid tailings deposition in this area could be on the order of 0.1 foot. The maximum extent of solid tailings deposition in this area would likely be on the order of 46 acres, which would include both deposits on soils along the streambanks, and streambeds in backwater channels (Knight Piésold 2018o).

Spill response covered in the scenario includes recovery of spilled tailings. Solid tailings covering soils and any soil impacted by contaminated contact water could be removed so that there would be no long-term impacts to soil. Without any recovery efforts, solid tailings would likely be flushed off of soils into the streams by precipitation, overland flow, or subsequent natural flooding within days to months, to be dispersed downstream. There is potential for the solid tailings to form a crust on top of soils and vegetation that could remain on the soils along Tributary NFK 1.130 riverbanks for months to years, without recovery efforts. No acid generation or ML would occur from the deposited tailings on these timescales under the existing environmental conditions.

Erosion

Modeling calculated the bed shear stress downstream of the release to determine the potential for erosion (Knight Piésold 2018o). The initial flood of fluid and tailings could erode the streambed, riverbanks, and surrounding soils where overbank flooding occurs. Channel erosion would be expected in the upper portion of Tributary NFK 1.130, with a greater degree of channel erosion likely in the downstream portion of the existing channel. Further erosion of fine particles up to fine gravel would be expected along channels near the confluence of Tributary NFK 1.130 with the NFK (Knight Piésold 2018o).

Spill response mitigation would include repair of any erosion damage (stream stabilization), if necessary. Localized erosion and resultant sedimentation and elevated TSS downstream could continue for months to years during stream stabilization efforts.

Erosion downstream of the confluence of Tributary NFK 1.130 with the NFK may not be measurable (i.e., may be indistinguishable from background levels of erosion).

Metals Contamination

Soil could become contaminated with elevated levels of metals from contact water in the tailings slurry. Where tailings slurry spills onto soils beneath the point of release at the bulk TSF, contact water could potentially percolate into the soil column; and metals in the contact water would adsorb onto surficial soil. Similarly, where overbank flooding occurs along Tributary NFK 1.130, bank soils would come in contact with metals in the contact water, although the contact water would be diluted by stream water in these instances. Where metals in soils exceed ADEC soil cleanup level guidelines, soils could be excavated to the extent practicable and the impacted habitats could be restored. If contaminated soil is not fully recovered, some contaminated soil would remain at the site of the release. Ongoing monitoring could detect remaining elevated levels of metals, and additional excavation could be carried out as needed.

No measurable dissolved (bioavailable) metals would be leached from deposited tailings solids because the process of ML would require decades (Section 3.18, Water and Sediment Quality). Tailings particles would be flushed off of the land surface and out of the stream drainages within months to years in areas surrounding the impacted drainages.

Surface Water Hydrology

Surface water flow would be increased above the 2-year flood level (bankfull conditions) on Tributary NFK 1.130 and would likely cause overbank flooding. Peak flows would be less than the natural 2-year flood on the NFK and other downstream drainages, and would not cause additional overbank flooding. Peak flows, arrival time, and duration of increased failure flows for downstream drainages would be as follows (from Knight Piésold 2018o):

- The exact MAD of Tributary NFK 1.130 is unknown because there has been no hydrologic monitoring in this stream. MAD and monthly flows were therefore estimated based on drainage area proration, with flows measured in nearby Tributary NFK 1.190, which has a similar aspect and topography (Knight Piésold 2018o). The estimated MAD is 5 cfs. During the release scenario, modeling predicts the peak flows at this location would exceed the natural 2-year flood during the initial flooding event, causing overbank flooding.
- Just downstream from the confluence of the NFK and Tributary NFK 1.130, the MAD of the river is about 120 cfs. During the release scenario, modeling predicts the peak flows at this location to increase to 190 cfs. The increased flow would arrive about 1 hour after the initial release, and last for approximately 9 hours (Figure 4.27-3).
- Downstream of the confluence of the NFK and SFK, the MAD of the drainage is 510 cfs. During the release scenario, modeling predicts the peak flows at this location to increase to 570 cfs; about a 13 percent increase. The increased flow would arrive about 9 hours after the initial release, and last for approximately 13 hours.
- Just downstream of the confluence of the Koktuli and the Swan rivers, the MAD of the river is about 1,430 cfs. During the release scenario, modeling predicts the peak flows at this location to increase only about 3 percent to 1,470 cfs. The increased flow would arrive about 28 hours after the initial release, and last over 20 hours.
- Modeling did not extend beyond the confluence with the Swan River, but the duration of increased flows at the Mulchatna and Nushagak river confluences can be estimated (by extrapolation of modeling results) to be about 24 hours and 36 hours, respectively. The duration of increased flows at the Nushagak River Estuary would last about 50 hours.

Water and Sediment Quality

Surface Water Quality

TSS—An increase in TSS from the released bulk tailings slurry would be a water quality impact across approximately 230 miles of drainages; from below the bulk TSF, all the way to the Nushagak Estuary at the entrance of Nushagak Bay—part of the greater Bristol Bay. TSS levels in Tributary NFK 1.130, the NFK, the mainstem Koktuli, the Mulchatna, and the Nushagak River would exceed WQC for 1 to a few days initially, and then intermittently after that for weeks to months to years, depending on the speed and effectiveness of recovery efforts.

The concentration of solid tailings in the downstream drainages is expressed herein as percent solids, and as TSS in mg/L (that is, the mass of the solid particles per volume of water). Water in these drainages is naturally low in TSS, with average measured TSS values of 1.19 mg/L in the NFK (see Section 3.18, Water and Sediment Quality, and Appendix K3.18). The most stringent WQC require TSS to be no more than 20 mg/L. Modeled peak TSS values during the initial period of peak flow are as follows (from Knight Piésold 2018o):

- At the confluence of the Tributary NFK 1.130 and the NFK, the percent solids in the water were modeled to be 13 percent. The TSS was modeled to be 171,000 mg/L during peak flow. The natural levels of TSS in the NFK average about 1.19 mg/L.
- Below the confluence of the NFK and SFK, the percent solids in the water would drop to 3 percent, with a TSS of 30,000 mg/L during peak flow.
- Below the confluence of the Koktuli and the Swan rivers, the percent solids in the water would drop to less than 1 percent, with a TSS of 6,900 mg/L.
- Downstream of the Koktuli River confluence with the Mulchatna River, the dilution of natural stream water would be very strong, so that the percent solids in the water were modeled to drop to less than 1 percent, with a TSS of 1,300 mg/L during peak flow.
- At the Nushagak River Estuary, at the mouth of Nushagak Bay, part of the greater Bristol Bay, the solids content would be less than 1 percent, but the water would still have elevated TSS, with a TSS of 320 mg/L.

Note that the modeled TSS values account for the tailings solids only, and do not consider the additional TSS from ongoing erosion near the release site.

The initial duration of the elevated TSS levels would be similar to the duration of the elevated flows, as detailed above. TSS in the downstream drainages near the mine site would initially be elevated above WQC for at least half a day; while TSS in the lower Nushagak near Bristol Bay would initially be elevated for 2 to 3 days (Knight Piésold 2018o). As residual tailings solids continue to flush into the watershed over ensuing days to weeks, there would be intermittent increases in TSS for weeks to months, depending on the speed and effectiveness of recovery efforts. It is unknown if the intermittent increases in TSS would be below the WQC.

In addition to the tailings solids, increased TSS would be introduced into downstream drainages due to erosion in Tributary NFK 1.130 during the release. After the elevated flows have diminished and most tailings solids have been flushed downstream, ongoing sedimentation and elevated TSS could continue from the unstable streambed and streambanks. Depending on the severity of the erosion, this could be a localized impact directly downstream of the release site. Spill response mitigation would include repair of any erosion damage (stream stabilization), if necessary. Erosion could continue to elevate TSS in the immediate downstream area for months to years during stream stabilization.

Acid—For a discussion of factors that impact the ability of tailings particles to generate acid, see "Factors Influencing Acid Generation and Metals Leaching" in the "Concentrate Spills" subsection.

This bulk tailings release scenario would not be expected to impact water quality due to acid. The released fluid would have a relatively neutral pH (Knight Piésold 2018a). Note that the NFK has naturally acidic water in some reaches (see Appendix K3.18, Water and Sediment Quality).

ARD from the bulk tailings solids would not be likely due to the low concentration of PAG materials in the bulk tailings, the long time periods required for acid generation, and the high level of dilution from surface water. Bulk tailings deposited along floodplains that remain exposed to air could generate acid over a period of years to decades if not recovered. Precipitation and seasonal flood waters would flush any generated acid into surface water. Any acid produced would be produced very slowly, and would be constantly diluted by surface water and flushed downstream so that measurable decreases in water pH would not be expected.

The Nushagak estuary extends for the last 19 miles of the lower Nushagak River before it feeds into Bristol Bay. This area contains abundant mud flats, which are periodically exposed during levels of lower tides. It is possible that a small amount of tailings could be deposited on the mud flats, and exposed to the air, which could increase the potential for ARD. However, the deposited tailings would likely be flushed back into the main channels by high tides and rain, and deposited in Bristol Bay prior to generating measurable amounts of acid.

Metals—For a discussion of factors that impact the ability of tailings particles to leach metals, see "Factors Influencing Acid Generation and Metals Leaching" in the "Concentrate Spills" subsection.

Under this scenario, metals in contact water used to mix the bulk tailings slurry would be introduced to Tributary NFK 1.130 and transported downstream. The contact water used to mix the bulk tailings slurry is predicted to contain the following metals above the most stringent WQC: antimony, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, selenium (a metalloid), and zinc (Knight Piésold 2018a; Appendix K4.18, Table K4.18-3).

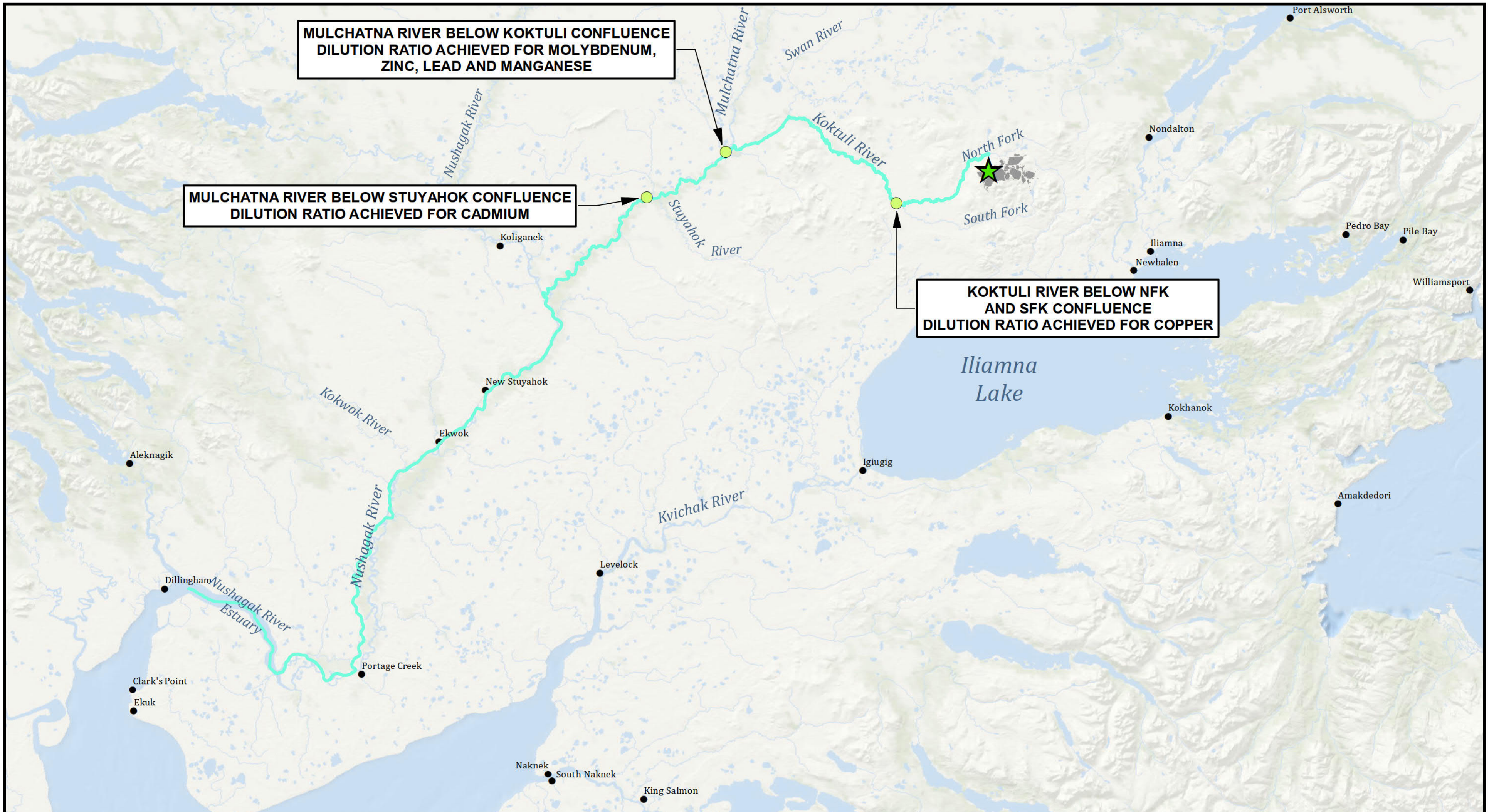
Metals concentrations resulting from the spill would be diluted progressively downstream by the stream flow. More rapid downstream dilution would occur during higher stream flow in the summer months; while during the winter, there would be less streamflow to dilute the elevated metals. Modeled downstream metals levels assumed MAD stream levels in the downstream drainages.

Note that the NFK has naturally acidic water in some reaches (see Appendix K3.18, Water and Sediment Quality). Unrecovered tailings that remained in more acidic waters would be more susceptible to dissolution, and could potentially leach metals at an increased rate.

As summarized below and on Figure 4.27-4, modeling results indicate that concentrations of several metals would exceed applicable WQC in the downstream drainages following the spill (Knight Piésold 2018o). In Figure 4.27-4, the points along the drainages labeled "Dilution Ratio Achieved" indicate the point at which those metals would be diluted to within WQC. The metals that would be present in the highest concentration would be cadmium, lead, manganese, molybdenum, and zinc (Knight Piésold 2018o). Copper was also considered in the modeling due to the abundance of copper in the area (Knight Piésold 2018o).

- Copper concentrations would exceed the most stringent WQC to the Koktuli River below the NFK and SFK confluence, about 23 miles downstream from the mine site.
- Lead, manganese, molybdenum, and zinc concentrations would exceed the most stringent WQC until the Mulchatna River below the Koktuli River confluence, about 62 miles downstream.
- Cadmium concentrations would exceed the most stringent WQC until the Mulchatna River below the Stuyahok River confluence, about 78 miles downstream from the mine site.

These metals would remain at elevated levels above WQC for several days, likely no more than a week, while the flows are flushed downstream.



Sources: KP 2018o; PLP 2019-RFI153

US Army Corps of Engineers

Location of Release

Dilution Ratio Achieved

Modeled Rivers

Mine Site

10 0 10 20

Miles

MODELED EXTENT OF ELEVATED METALS DOWNSTREAM OF BULK TAILINGS RELEASE

PEBBLE PROJECT EIS

FIGURE 4.27-4

The bulk tailings solids would not be expected to impact water quality from ML due to the low concentration of metals, the long time periods required for dissolution of metals, and the high level of dilution from surface water. Metals present in the solid tailings require a decade or more to leach into the water and become bioavailable. If tailings are recovered, there would likely be no measurable ML, and therefore, no additional levels of elevated metals. Tailings solids that are not recovered could leach metals into surface water over a timescale of decades. However, due to the relatively small volume of solid tailings that would be deposited in this scenario, and the constant dilution and continual flushing of tailings from the watershed, this impact would likely not be measurable.

The formation of secondary metal salts is not likely from this scenario, due to the limited amounts of metals that could be leached from the tailings, the strong amount of dilution from downstream waters, and the anticipated recovery efforts. The formation of secondary metal salts would require years. Impacts to water quality from dissolution of secondary metal salts would be the same as those noted above for other leached metals.

Residual Toxins—Bulk tailings may also contain minor residues from ore-processing reagents that could be released into the watershed in the event of a spill. Most of the reagents are consumed during the process of froth flotation, and residual reagents mostly remain adhered to the metals in the ore concentrate. The small amount of residual reagents in the tailings is anticipated to degrade naturally in the TSF. However, in this scenario, the release occurs from the delivery pipelines, so that residues of reagents such as xanthate would not have time to biodegrade prior to release. The EPA reports that these types of tailings slurries would be toxic due to the presence of xanthate (EPA 2014). Tailings slurry with residual xanthate that are released into downstream waters could create toxic conditions in downstream waters, although the concentration of xanthate would be low, and would be diluted in downstream waters.

As described above, bulk tailings would also contain residues of the blasting agent ANFO. ANFO is biodegradable; however, in this scenario, the release occurs from the delivery pipelines, so that the residues of ANFO would not have biodegraded prior to release.

Sediments—Some streambed sediments/substrate could be partially buried by deposited tailings particles, especially in the low-energy side channels near the confluence of Tributary NFK 1.130 and the NFK. The maximum extent of tailings solids deposition in this area would likely be on the order of 46 acres, which would include both streambeds and floodplain soils (Knight Piésold 2018o). The average thickness of deposition could be on the order of 0.1 foot (Knight Piésold 2018o). The fine-tailings particles could fill in interstitial spaces between clasts of gravel, modifying streambed habitat.

A small volume of tailings could potentially intermingle with and become incorporated into deposits of naturally occurring sediments (the bedload), particularly in low-energy drainage areas. These tailings may remain in the drainage for months to years prior to being flushed downstream. If the small volume of tailings was to remain in the drainage long enough to leach metals (years to decades), the constant dilution of stream water and the slow process of metals leaching would likely result in no measurable levels of metals.

Erosion of upstream streambed sediments from the release would also cause deposition of sediments near the confluence of Tributary NFK 1.130 and the NFK (Knight Piésold 2018o).

Trace amounts of metals from the released contact water in the bulk tailings slurry could be adsorbed to particles and incorporated into streambed sediments (the bedload). Metals incorporated into the bedload would continue to be flushed downstream and diluted, but trace amounts may remain in the sediment and slowly be released to surface water. Such trace amounts would be unlikely to have a measurable impact on sediment and water quality with respect to metals concentrations.

Groundwater Quality—There is potential for groundwater to be contaminated with elevated levels of metals from contact water in the tailings slurry. There are numerous shallow aquifers throughout the area, and metals present in the fluid portion of the release could permeate through soils into shallow groundwater. However, due to the strong dilution from surface water, it is likely that metals would be diluted to below ADEC groundwater cleanup levels. Measurable impacts to groundwater quality are not likely from this scenario. In the case of a spill resulting in groundwater contamination, the State of Alaska may require ongoing monitoring and reclamation work as it deems necessary. See Section 4.18, Water Quality, for standard monitoring and mitigation that could be implemented.

Any acid and metals generated by tailings solids that may remain in streambed sediments would be so diluted that no measurable impact on groundwater quality would be expected. This is due to the long timescales involved in acid generation and ML, and the small amount of PAG and ML material contained in the bulk tailings.

Noise

Noise could be generated from spill recovery operations, including increased vehicle and/or helicopter traffic, and use of heavy machinery and other cleanup equipment.

Air Quality

Tailings deposited on land that dry out have the potential to become airborne fugitive dust. Considering the small volume of tailings deposition expected on land, and the wet climate, any fugitive dust produced would likely not have measurable impacts on air quality.

Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

The bulk tailings release scenario would cause bank erosion and limited burial of low-lying vegetation, wetlands, and any other special aquatic sites immediately downstream of the spill. Riparian vegetation along the banks of Tributary NFK 1.130 (Knight Piésold 2018o), as well as some adjacent upland vegetation, could be buried by tailings solids up to 0.1 foot in thickness over less than 46 acres. It is unlikely that the flood flows would remove the dense vegetation growing on the valley side slopes, or scour the substrate of the Tributary NKF 1.130 (Knight Piésold 2018o).

The magnitude of the impact would be high regardless of the timing, because this type of spill would affect both dormant and actively growing vegetation through physical removal from erosion or burial. Eventually, solid tailings particles would be flushed off of the land surface and out of the stream drainages within months to years in areas surrounding the impacted drainages.

The extent of the impacts would be limited to the area covered by the solid tailings particles, estimated to be less than 46 acres, mostly surrounding the confluence of Tributary NFK 1.130 with the NFK, and areas where contact water with elevated metals and residual toxins may permeate wetland soils (Knight Piésold 2018o).

Assuming the spill response as described for the scenario, the majority of spilled tailings would be removed, and the duration of impacts to the 46 acres of wetlands could range from one to several growing seasons. Contaminated soils could be sampled and excavated if necessary. If tailings and contaminated soil are not recovered, the duration of impacts could range from a few growing seasons (for vegetation to grow on the tailings) to permanent (if wetlands are buried and not restored).

Terrestrial Wildlife

Impacts to terrestrial wildlife species would vary depending on the time of year that a spill occurs. If the spill occurred during winter, the magnitude, duration, geographic extent, and intensity would be lower, because many of the terrestrial wildlife species have reduced activity levels, and some are in hibernation. Any species that are hibernating in the area directly impacted by the spill (approximately 46 acres) may be disturbed during cleanup activities. If the NFK and surrounding streams are frozen, spill response and cleanup would be more effective and the geographic extent would be greatly reduced, because no water would be diluting the tailings or transporting them downstream. Impacts of a spill during winter would generally be low for most wildlife species, because cleanup would be more effective; there would be less environmental damage associated with the cleanup (due to frozen surfaces and snowpack); and wildlife would likely avoid the area during activities around the spill. Impacts from a spill during frozen conditions are not expected to last longer that a few weeks to months, until all material is cleaned up.

If the spill occurred during the open-water season, the geographic extent of impacts would likely extend further. The magnitude and intensity would be increased, and more species would be affected. Impacts would be greatest during the summer and fall, when wildlife are raising young and putting on fat reserves for winter. Any terrestrial wildlife in the immediate vicinity during the spill has a potential to be covered, smothered, or have habitat altered by the tailings. Up to 46 acres of vegetation and wildlife habitat may be directly affected. This is a relatively small amount of habitat given the abundance of nearby suitable habitat; and although some small mammal species (shrews, lemmings, voles, ground squirrels, hares) may suffer direct mortality from smothering during the spill, most species are expected to vacate the area. Wildlife may be indirectly impacted through reduced prey availability and altered forage. Vegetation that is covered by tailings would not be available for consumption until it grows through the tailings, or until it is washed off by rainfall.

The tailings may smother salmonid eggs and alevins, and reduce the quality of spawning habitat in the direct footprint of the spill in the NFK, and to some extent further downstream. A reduction in the NFK spawning biomass that reduced the number of returning adults would have a measurable, but small, impact on the overall number of salmon. This would impact species that feed on these life stages of salmonids, and may cause lower salmon numbers in subsequent years, depending on the extent of the spill. In addition, contact water in the tailings slurry may cause acute toxicity in fish. Any impacts to fish, detailed in the fish section below, would directly impact terrestrial species that prey on fish, such as brown bears (*Ursus arctos*) and gray wolves (*Canis lupus*). In addition, several other carnivore and omnivore species may occasionally forage on salmon, such as river otters (*Lontra canadensis*).

The cycling of marine-derived nutrients as part of the salmon cycle promotes healthy ecosystems. Fish that are fed on by terrestrial wildlife are distributed in the environment by transportation of salmon carcasses and excretion of feces and urine. This promotes healthy ecosystems that benefit wildlife; increase vegetation productivity; and promote the production of periphyton, aquatic macroinvertebrates, resident freshwater fish, and juvenile salmon (Brna and Verbrugge 2013). Impacts to salmon in the NFK may disrupt local cycling of nutrients temporarily in the immediate vicinity of the spill. Only localized mortality of eggs, alevins, fry, smolt, and freshwater invertebrates may occur in the direct footprint of the spill (depending on the time of year). This localized impact is not anticipated to cause an appreciable decrease in salmon productivity in the NFK.

Therefore, the scenario would result in a high-magnitude impact on a localized salmon-spawning area in the NFK before sediment is carried downstream, dispersed, and cleaned up. The duration is until the sediment no longer covers up the vegetation, and until salmon are able to use the area for spawning again. Overall impacts are not anticipated to be noticeable in terms of terrestrial wildlife abundance, but most species are anticipated to avoid the area until cleanup activities and rain/snowfall have removed tailings from the vegetation.

Finally, residual amounts of toxic ANFO and sodium ethyl xanthate that have not biodegraded would be released into the environment with the tailings in this scenario. However, the small amount of ANFO and xanthate released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to wildlife from these toxins would be localized and of low magnitude.

Birds

A spill during winter, when migratory birds have vacated the area, would result in low-magnitude impacts of temporary duration on resident bird species. Tailings would be more effectively contained and recovered under frozen conditions. However, if a spill occurred during the open-water season, impacts on avian prey would likely result in increased magnitude, and potentially a greater geographic extent.

According to modeled spill projections, elevated levels of TSS from the bulk tailings could extend as far downstream as the Nushagak River estuary. The Nushagak River estuary extends for the last 19 miles of the lower Nushagak River before it feeds into Bristol Bay. This area contains abundant mud flats, which are periodically exposed during levels of lower tides. It is possible that a small amount of tailings could be deposited on the mud flats. This area is important for a wide variety of avian species during important life stages. Periods of increased avian use include the April through May spring migration period and the August through October fall migration period. Birds that use the area include high numbers of waterfowl such as black scoters, northern pintail, and scaup species (NOAA 2004). Some of the birds that breed at the mouth of the Nushagak River include Aleutian terns, glaucous-winged gulls, mew gulls, herring gulls, and other species (NOAA 2004). Farther from the river mouth, large numbers of shorebirds pass through the area, feeding on exposed mudflats. Ingestion of fish and invertebrates that contain metals could be passed on to the avian species feeding in the area.

A variety of avian species rely on various life stages of salmon as food resources. According to Brna and Verbrugge (2013), of the 24 duck species that occur in the Bristol Bay region (including Nushagak Bay), at least 11 species feed on salmon eggs, parr, or smolts, or scavenge on carcasses. This includes waterbird species such as greater (*Aythya marila*) and lesser (*Aythya affinis*) scaup, harlequin duck (*Histrionicus histrionicus*), bufflehead (*Bucephala albeola*), common (*Bucephala clangula*) and Barrow's goldeneyes (*Bucephala islandica*), and common (*Mergus merganser*) and red-breasted (*M. serrator*) mergansers. Based on data presented in Section 3.23, Wildlife Values, the upper NFK near the location of the spill does not support large numbers of waterbird species.

Bald eagles (*Haliaeetus leucocephalus*) also feed on salmon during a variety of life stages. Salmon abundance can influence bald eagle population size, distribution, breeding, and behavior. Based on data presented in Section 3.23, Wildlife Values, the upper NFK is not a productive bald eagle nesting location. Species like the American dipper (*Cinclus mexicanus*) consume salmon eggs, fry, and small bits of carcasses when available (Brna and Verbrugge 2013). In addition to salmonid species, many shorebirds make use of freshwater invertebrates, and various species of small fish are consumed by yellowlegs and phalaropes.

Under the scenario, some fish life stages may experience acute toxic levels from elevated metals in the tailings slurry contact water. Impacts to birds through localized impacts on salmon may occur (by needing to find other feeding locations). There is an abundance of suitable foraging habitat both above and below the potential spill location into the NFK; although cleanup activities may disturb local breeding species, depending on the time of year. Some ground-nesting birds may have their nests covered by tailings during the initial spill; however, if the spill occurs early in the summer, some birds may be able to re-nest. Overall, impacts to salmon are anticipated to be restricted to the immediate vicinity of the spill, and downstream where eggs and alevin (if present) are smothered by tailings. A tailings release that resulted in smothered eggs or alevin and reduced spawning habitat quality or quantity could affect the prey base for some aquatic avian species. A reduction in the NFK spawning biomass that reduced the number of returning adults would have a measurable, but small, impact on the overall availability of fish prey species for birds. Overall impacts to birds are anticipated to be low-magnitude (this would vary based on extent of clean up and recovery efforts) and short duration (a few weeks to months, but could extend longer depending on impacts to salmon/prey abundance) while cleanup occurs, affected vegetation recovers, and sediment is transported downstream. The geographic extend would stretch from the spill location to the Nushagak River estuary.

Finally, residual amounts of toxic ANFO and sodium ethyl xanthate that have not biodegraded would be released into the environment with the tailings in this scenario. However, the small amount of ANFO and xanthate released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to birds from these toxins would be localized and of low magnitude. They may have acutely toxic effects on avian prey, but due to flushing, are anticipated to be rapidly diluted in the system. Birds that prey on species killed by ANFO and sodium ethyl xanthate may experience sublethal toxicity, but due to system flushing and ingestion of multiple prey items, are unlikely to experience lethal toxicity.

Fish

Under this spill scenario, impacts on stream hydrology and several stream water quality parameters (TSS and metals concentrations) would occur generally simultaneously in similar spatial durations and extents. Therefore, impacts on fish would occur simultaneously, via physical injury, loss of habitat and food, and toxicity of metals.

A tailings spill would introduce fine sediment into the stream, causing sedimentation and elevated TSS/turbidity in downstream surface water that has naturally low TSS and turbidity. Fine sediment could infill void spaces between gravel clasts, altering benthic habitat. Continual flushing and periodic high-flow events (spring break-up and fall floods) would transport the tailings downstream. The spill impact would extend from the spill location about 230 river miles downstream of the mine site.

Potential impacts on fish include decreased success of incubating salmon eggs; reduced food sources for rearing juvenile salmon; modified habitat; and in extreme cases, mortality to eggs and rearing fish. The degree of potential impacts on salmon life stages would depend on the timing and magnitude of the spill. The duration of impacts would not extend longer than 1 year, or until the tailings are cleaned up or incorporated into the bedload. Increased turbidity and TSS could injure juvenile salmon and reduce their ability to sight-feed on surface and near-surface invertebrates (USACE 2008b). At lower turbidity, juvenile salmon may use turbid waters as cover to hide from predators. Salmonids can encounter naturally turbid conditions in estuaries and glacial streams, but this does not mean that salmonids in general can tolerate increases of suspended sediments over time (Bash et al. 2001). Relatively low levels of anthropogenic turbidity may negatively affect salmonid populations that are not naturally exposed to relatively high levels of natural turbidity (Gregory and Levings 1996). The feeding efficiency of juvenile salmonids has been shown to be impaired by turbidity levels exceeding 70 NTU (Pentec 2005). The flows associated with this scenario would not be sufficient to mobilize bedload material as in a large flood. The low-level use of the habitat to be impacted (based on the distribution and densities of juvenile and adult salmon observed in the area) indicates that drainage-wide or generational impacts to salmon from direct habitat losses associated with the scenario would not be expected.

Release of metals from contact water in the tailings slurry is predicted to cause increases in surface water concentrations above the WQC for copper, lead, manganese, molybdenum, and zinc. The magnitude of these exceedances for each metal would decrease with time, and with distance downstream of the spill. In the short-term, and immediately downstream of the spill where relatively lower dilutions occur in the surface water, acute toxicity (lethality) may occur in fish and other sensitive aquatic species. Over days to weeks in downstream locations, sub-lethal effects, such as impairment of olfaction, behavior, and chemo/mechanosensory responses, may also occur in these receptors, specifically due to copper (Meyer and DeForest 2018). The magnitude of specific impacts cannot be known because of the relative sensitivities of the species and the type of effects. However, within days to weeks of potential impacts, toxic effects of metals on fish would be indistinguishable from the concurrent effects due to sedimentation and turbidity described above.

Tailings submerged in the stream could potentially generate small amounts of acid if oxidized by DO in the stream water, but the dilution of the flowing water and the slow rates of acid generation would prevent water from becoming measurably acidic. Tailings that may remain exposed on the stream banks could generate acid over a time period of years to decades that could reach the NFK. Any acid produced, however, would be diluted by fresh water, so that a reduction in stream water pH would likely not be measurable.

The metallic minerals in the tailings are not readily soluble in water, so metals would not immediately be introduced in bioavailable form. If the tailings are promptly removed from the NFK, there would be no measurable leaching of metals. After a number of years, however, if the tailings are not recovered, the minerals would slowly dissolve, leaching metals into the water, some of which could bioaccumulate in the food chain. Due to the small amount of tailings that would likely remain in the NFK, however, and the heavy dilution from stream flow, incremental impacts on fish (via toxicity and bioaccumulation) due to metals leaching would likely not be measurable. See Section 4.24 and Appendix K4.24, Fish Values, for an expanded discussion of metals impacts to aquatic resources.

The WQC exceedances are expected for several days under this scenario. A more detailed discussion of impacts via metals toxicity is provided for the pyritic tailings release scenario, below. As discussed subsequently, the comparison of the predicted concentrations to WQCs assumes that the metals are 100 percent bioavailable. That is not the case, as exemplified by the EPA's recommended WQC for copper, based on the Biotic Ligand Model, which accounts for various factors that modify its aquatic toxicity (EPA 2007b). Metals bioavailability in the current evaluations presents uncertainties. Site-specific toxicity tests (as discussed below) are indicative of limited impacts on fish species. In a study by Nautilus Environmental (2012), aqueous samples from the mine site were used to evaluate aquatic toxicity to fish species and aquatic invertebrates. Two samples were tested: Gold Plant Process Water and Non-Gold Plant Process Water. The bioavailability of metals in the "Non-Gold Plant Process Water" sample, which represents undiluted tailings fluids, would be similar to the contact water portion of the tailings slurry released under this spill scenario, although there is uncertainty as to how well the sample represents the contact water. These toxicity tests are described in detail below for the pyritic tailings release.

The toxicity tests did not demonstrate acute and chronic toxicity to fish species, including rainbow trout and fathead minnow in 4- and 7-day exposures, respectively. Survival of water flea neonates was adversely affected in a 48-hour test at 25 percent (by volume) "Non-Gold Plant Process Water" sample. Reproduction was adversely affected in the 7-day test at 12.5 percent aqueous sample; that is, at eight times dilution or less. These results indicate chronic exposures for 7 days or more to tailings fluid at lower dilutions in the streams could have sub-lethal effects on sensitive aquatic species and to fish indirectly by impacting their diet, but direct toxic impact on fish species is less likely. Under this current spill scenario and assuming 100 percent bioavailability, the WQC exceedances do not extend beyond several days; that is, chronic exposure is not expected. Based on the site-specific toxicity results and the predicted exposure regime (several days), impacts on fish due to metals toxicity would be limited, and likely overshadowed by impacts via physical injury, and loss of habitat and food.

Although predicted mercury concentrations in the tailings are low, even very low amounts of total mercury that may incorporate into anoxic sediments, such as those occurring in wetlands in the project area, could result in methylation to form MeHg, the toxic and bioavailable form of mercury. MeHg is toxic, bioaccumulates, and biomagnifies in fish (see Appendix K4.24, Fish Values, for an expanded discussion of potential impacts from MeHg in fish).

Finally, residual amounts of toxic ANFO and sodium ethyl xanthate that have not biodegraded would be released into the environment with the tailings in this scenario. However, as discussed in EPA (2014), the small amount of ANFO and xanthate released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to fish from these toxins would be localized and of low magnitude (Xu et al. 1988).

Threatened and Endangered Species

There would be no impacts to federally listed TES, because none occur in areas where a tailings release is projected to reach. According to Brna and Verbrugge (2013), based on a preliminary assessment, no breeding or otherwise large occurrences of TES are known to occur in the Nushagak watershed. Although there are TES in Bristol Bay, they are beyond the anticipated area that would be impacted by the bulk tailings release scenario (do not normally occur around the mouth of the Nushagak River) and are not discussed herein. Therefore, no impacts to TES are anticipated.

Marine Mammals

A bulk tailings release may potentially impact the habitat and occurrence of marine mammal prey species that inhabit the NFK. Changes to salmon spawning and rearing habitat and impacts to salmon due to acute and chronic toxicity from the bulk tailings failure may reduce the prey base for several marine mammals. Salmon and other fish in the NFK and downstream would be impacted. The duration would last until affected spawning and rearing habitat is restored and salmon are no longer impacted. The geographic extent would stretch from the spill location in the NFK downstream for tens of miles until metals are diluted, and TSS would be elevated all the way to the Nushagak River estuary. In particular, the non-federally listed Bristol Bay stock of beluga whales are known to swim at least 18 miles up the Nushagak River; occur year-round in Bristol Bay; and may be impacted by a tailings release. Citta et al. (2016) described the annual distribution of beluga whales in Bristol Bay using data from 31 satellite-linked transmitters during 2002-2011. They found that during salmon migrations, beluga whales were restricted to the river entrances in the inner bays that comprise Bristol Bay. In early spring (typically April), beluga whales move up rivers (including the Nushagak) in pursuit of spawning rainbow smelt. As the smelt run ends in late May, beluga whales begin to feed on outmigrating salmon smolt until late June, when they shift their diets again to focus on eating adult salmon returning to spawn (Citta et al. 2016). The study found that beluga whales did not relocate to different river entrances or change bays during peak salmon periods. This suggests that beluga whales were either selecting locations that were good for catching salmon, or there were more salmon than beluga whales needed to supply their nutritional needs. Based on salmon population estimates, there is an abundance of salmon for beluga whales. After the completion of the salmon runs, beluga whales ranged farther beyond the inner bays.

In terms of salmon prey, a tailings release that resulted in smothered eggs or alevin and reduced spawning habitat quality or quantity could result in a reduction in the NFK spawning biomass that reduced the number of returning adult salmon. However, based on current salmon populations, a small reduction in spawning adults in the NFK is unlikely to impact the overall number of salmon available for beluga whales.

There are other marine mammal species that use the Nushagak River for feeding, such as harbor seals. Similar to beluga whales, a minor impact on NKF spawning adults from the bulk tailings scenario is not likely to impact the overall abundance of prey for harbor seals.

Needs and Welfare of the People—Socioeconomics

The cleanup and remediation activities following a bulk tailings delivery pipeline rupture in which a large volume of slurry is released into the environment would briefly increase employment opportunities and expenditures in the Iliamna Lake area, and potentially in the Bristol Bay region. Manpower requirements would be especially high if labor-intensive response efforts such as mechanical recovery and physical removal were used. Employment increases for cleanup activities would likely be brief (less than 1 year).

Over the longer term, the impacts on employment, income, and sales would be negative if commercial and recreational fishing and/or tourism were to suffer due to the real or perceived impacts of the spill. Real or perceived water contamination could also negatively impact local business and consumers.

Environmental Justice

Impacts from a tailings release would impact the socioeconomics, subsistence, and health and safety of those in the region. There could be increased employment for a brief time for cleanup and remediation; however, there could be declines in employment, income, and sales from commercial and recreational fishing and/or tourism if impacted by real or perceived impacts of the spill. A release could impact subsistence harvest quantities and harvest patterns, and there could be impacts to health and safety. Taken as a whole, adverse impacts from the spill event would disproportionately impact minority and low-income communities. There would be interrelated subsistence, health, and socioeconomic impacts to the minority and low-income communities in the area.

Recreation

In the event of a tailings release, impacts to the recreational setting would be acute or obvious. The levels of recreational activities downstream from the mine site are higher than at the mine site itself, but are still estimated to be low. The recreational activities that may be affected could include sport fishing, recreational snowmachining, and sport hunting. A release may cause probable loss or damage to anadromous fisheries, which could impact sport anglers. There would be impacts to recreational sightseeing, because visual resources would be impacted. Sightseeing and flightseeing are typically secondary recreational activities done in conjunction with travel for sport fishing and sport hunting, and would also be impacted from visual impacts.

Commercial and Recreational Fishing

A tailings release that resulted in smothered eggs or alevin and reduced spawning habitat quality or quantity could affect commercial fishery value through lost harvest opportunities. The magnitude and duration of these lost harvest opportunities would be relative magnitude and duration of reduced salmonid productivity. Roughly 1 in 1,000 eggs turns into a returning adult salmon; and historically, the commercial fishery has harvested nearly 70 percent of returning adult sockeye. Therefore, roughly 1 in every 1,400 to 1,500 eggs is harvested as an adult by the commercial fishery; and over the last 20 years, the 10-year average ex-vessel value per harvested sockeye has ranged from $4.75 to $7.62 in 2019 US dollars. A reduction in the NFK spawning biomass that reduced the number of returning adults would have a measurable, but small, impact on the overall value of the fishery.

The commercial fishery has expressed concern that a large-scale spill event would affect the value of the fishery by changing the value of harvested salmon in the open market. Historical experience shows the extent to which large-scale spills tend to affect the value of seafood products. After the *Exxon Valdez* oil spill, the Eshamy District of the Prince William Sound (PWS) Management Area was closed for the duration of the 1989 season, while PWS Management Area districts experienced at least some fishing. That event resulted in direct financial losses associated with lost harvest opportunities. However, post-event statistical analyses found no effect on salmon prices in 1989, 1990, or 1991. An Alaska jury also found no decline in salmon prices for 1990 and 1991, but did make an award for an effect on prices in 1989 (Owen 1995). In 2016, Japanese researchers found statistically significant, but “negligible” effects on seafood prices in the wake of the Fukushima nuclear disaster (Wakamatsu and Miyata 2015). These studies indicate that seafood price effects associated with industrial accidents tend to be very small or undetectable, and of limited duration. At the same time, in the wake of such disasters, a specific name can be associated with lower consumer desirability if the name is firmly connected with the disaster itself. For example, consumer choice research conducted after the Fukushima nuclear disaster found that labeling seafood as being from Fukushima Prefecture resulted in lower willingness-to-pay, compared to unlabeled seafood or labels from other prefectures (Wakamatsu and Miyata 2017). The study notes that preference research associated with an oceanside nuclear disaster where radioactivity entered the food chain may not be applicable to a hypothetical mine disaster, where pollutants would be less likely to accumulate in seafood.

Recreational fishing effort in the NFK is very limited. Not enough returned surveys include the NFK for ADF&G to publish an estimate of recreational angling effort for that waterbody. The NFK is aggregated with the estimate for the entire Mulchatna drainage, which averaged 1,600 to 1,700 angling days per year between 2007 and 2016. ADF&G Freshwater Guide Logbook data estimate that just over 340 guided angling days a year occur in the Mulchatna drainage, including the NFK.

Far more days are spent angling on the Mulchatna River, which has a 10-year estimated effort of 1,700 angler days per year, including roughly 340 guided angler days, and the Nushagak River. Statewide Harvest Survey (SWHS) data indicate that between 2004 and 2016, the Nushagak River averaged just over 12,000 angler days between the Mulchatna confluence and Black Point. In a bulk tailings spill, the released tailings would pass through the Mulchatna River into the Nushagak River. The increased TSS and turbidity associated with the spill could temporarily (on the order of several days to a week) affect anglers’ success rates, because salmonid species feed partially by sight.

The impacts on the recreational fishery would be limited in the Nushagak River by the duration of increased turbidity or TSS affecting the ability of target species to see or smell prey. Fishing packages in the region cost between $600 and $1,000 per night. A spill before or during the peak summer months could result in trip cancellations and associated economic impacts for guide companies, and the business and communities that support them.

Cultural Resources

A bulk tailings delivery pipeline failure would impact cultural resources along the shore of the NFK if tailings were carried to a known or potential historic property site, or response efforts with ground-disturbing activities occurred near cultural resources. Resources may not be anticipated to return to previous levels even after actions that caused the impacts were to cease. The probability of ground-disturbing cleanup activities occurring at historic property sites is low due to the dispersed geographical distribution of sites downstream of the mine site. Impacts would occur in a discrete geographic area, but could affect rare cultural resources in the region. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Clean-up activities would likely require a mitigation plan to limit impacts to known or potential historic properties, and would occur in accordance with the Programmatic Agreement. It is not possible to identify specific cultural resources that could be affected. Indirect impacts could occur to the setting (visual and noise impacts) of cultural resources if the spill were to happen in the vicinity. Those impacts would be temporary, and would cease when response efforts are complete.

Subsistence

A tailings pipeline release would impact subsistence resources, particularly salmon, at and downstream from the release site. The tailings may smother salmonid eggs and alevins, and reduce the quality of spawning habitat in the direct footprint of the spill in the NFK—and to some extent further downstream. Fish could experience acute and chronic toxicity from heavy metals in the released tailings. Wildlife would also be hazed from the area by cleanup efforts. The impacts to subsistence resources would persist until the tailings are cleaned up or incorporated into the bedload. The most persistent and widespread impact of a tailings spill would likely be concern among subsistence users about contamination of subsistence fish resources in the greater watershed. Subsistence users would likely avoid fishing and other subsistence activities downstream from the release, affecting harvest patterns, as well as harvested quantities of highly valued resources.

In the aftermath of the 2014 Mount Polley Mine tailings dam failure, described previously, most of the indigenous communities surveyed by Shandro et al. (2017) reported impacts to personal fishing practices, increased emotional stress, and increased administrative burden on community leaders related to the tailings and tailings water release. Shandro et al. (2017) found that traditional fishing areas were avoided by some communities due to concerns over contamination in the Fraser River system, and that members of these communities reported traveling greater distances to harvest fish. Community leaders (also subsistence users) reported increased administrative workloads to gather credible information about the tailings release, remediation efforts, and the safety of salmon and the Fraser River system (Shandro et al. 2017). Quick response and cleanup of tailings, and a system of testing wild foods and communicating the results to local people in a timely manner, could help mitigate contamination concerns.

Health and Safety

There are no nearby downstream human habitations. The closest village downstream is New Stuyahok, 105 miles downstream from the mine site by way of the NFK. Modeling suggests that at that distance from the potential release, there would be no observable rise in water level.

Residents of the village would likely see an increase in turbidity and TSS in the river for days to weeks after the release (see the Surface Water Hydrology subsection).

Downstream communities rely on groundwater wells for drinking water. No measurable impacts to groundwater would be expected from this scenario, although groundwater contamination could be perceived. Perceived contamination of the environment and subsistence foods (e.g., salmon) may affect community concerns about access to, quantity, and quality of subsistence foods, which can affect the socio-economic status, emotional well-being, food security, and dietary patterns of local communities; this concern may extend throughout the extended spills analysis area. A tailings release in winter could impede snowmachine travel by subsistence hunters. Restricted access to the environment (e.g., due to real or perceived contamination) may result in decreased mental health and increased psychosocial and family stress, substance use, suicidal tendencies, and cardiovascular disease (Dillard et al. 2012; Gibson and Klinck 2005).

There are potential adverse impacts to social determinants of health (HEC 1), with psychosocial stress resulting from community anxiety over a tailings release, particularly in areas of valued subsistence and fishing activities. There could be exposures to potentially hazardous materials, including metals (HEC 3). Subsistence and food security may be impacted, with potential perceptions of subsistence food contamination that extend throughout the area (HEC 4). Reliable and prompt communications about environmental and subsistence food impacts and precautions about both acute and chronic exposures would alleviate psychosocial stress, reduce impacts to subsistence and food security, and allay public health concerns. Impacts would vary in duration; be limited to the area of the spill; and would vary in intensity depending on the season.

Scenario: Pyritic Tailings South Embankment Release into the SFK

In this scenario, operational error(s) and lift construction difficulties result in an overtopping failure, which results in a partial breach (6 feet downcutting/21 feet wide) of the south embankment. The partial breach results in the full release of the supernatant pond of 155 million ft^3, and the upper 1 foot of solid pyritic tailings of 30 million ft^3 (871,200 tons), for a total release of 185 million ft^3 (release volume determined by the FMEA panel) (AECOM 2019l). The full modeled release would take approximately 500 hours, or nearly 21 days, although most of the material would be released in the first 10 days (Knight Piésold 2018p). In this scenario, no additional tailings would slump out of the facility following the release.

The south embankment is at the upper catchment of Tributary SFK 1.240 in the SFK drainage. This hypothetical release from the south embankment would be to the southwest, and would flow directly into Tributary SFK 1.240 (Figure 4.27-5).

The initial release of supernatant pond water would cause a large flood wave to flow down Tributary SK 1.240 at high velocity, up to 1,000 cfs, inundating the complete width of the vegetated valley bottom. The flood wave along Tributary SFK 1.240 would overtop the banks during the first 2 days of the release (inundation maps provided in Knight Piésold 2018p). Tributary SK 1.240 is confined by narrow valley walls, so the flow through the drainage would not slow down substantially until it arrived at the mainstem of the SFK, about 1 mile downstream (Knight Piésold 2018p). This segment of the SFK may be seasonally dry during summer months.

The flooding would cause erosion in the existing stream channel, and potentially on surrounding soils in areas of overbank flooding (Knight Piésold 2018p).

The initial release would begin with supernatant pond fluid only, and essentially no tailings solids. As the release continues and the pond level draws down closer to the level of the tailings (5 feet below the pond surface), more of the solid tailings would become entrained, or mixed into the flow, so that it would become a slurry of fluid and tailings. The slurry would flow as a turbulent flood of water, with the fine particles of tailings solids remaining in suspension. The increase in solid tailings would make the release increasingly more viscous over time[2]. Increased viscosity would slow down the flow, and more of the solids would be likely to be deposited during later stages of the release.

The model cannot predict the exact volume or thickness of solid tailings that would be deposited, but the banks along Tributary SK 1.240 would have at least a thin veneer of solid tailings deposition in areas of overbank flooding.

When the wave reaches the confluence with the mainstem SFK, the flood of water and tailings would overtop the banks and spread out over a large area. The flood wave would still be a high-energy, high-velocity flow at this point, to the extent that modeling predicts some of the flood would even flow upstream on the mainstem SFK (Knight Piésold 2018p). Along the SFK downstream from the confluence of Tributary SFK 1.240, overbank flooding would leave a thin layer of tailings solids on an estimated 220 acres. The high-energy flow continues to flood over the top of the SFK banks as it moves for about 15 miles downstream of the pyritic TSF.

After 15 miles of overbank flooding downstream, the flood wave is able to spread out and attenuate. Stream levels would remain elevated past this point, but the release would be contained in the natural channel for the rest of the downstream drainages, causing no more overbank flooding. Stream levels would remain elevated for at least 52 miles downstream, past the Swan River confluence (Figure 4.27-6).

In this scenario, on-site mine operations teams would be unable to stop the flow of fluid exiting the breach, but would be expected to stop the flow after an approximately 1-foot depth of tailings escapes.

Suspended Tailings

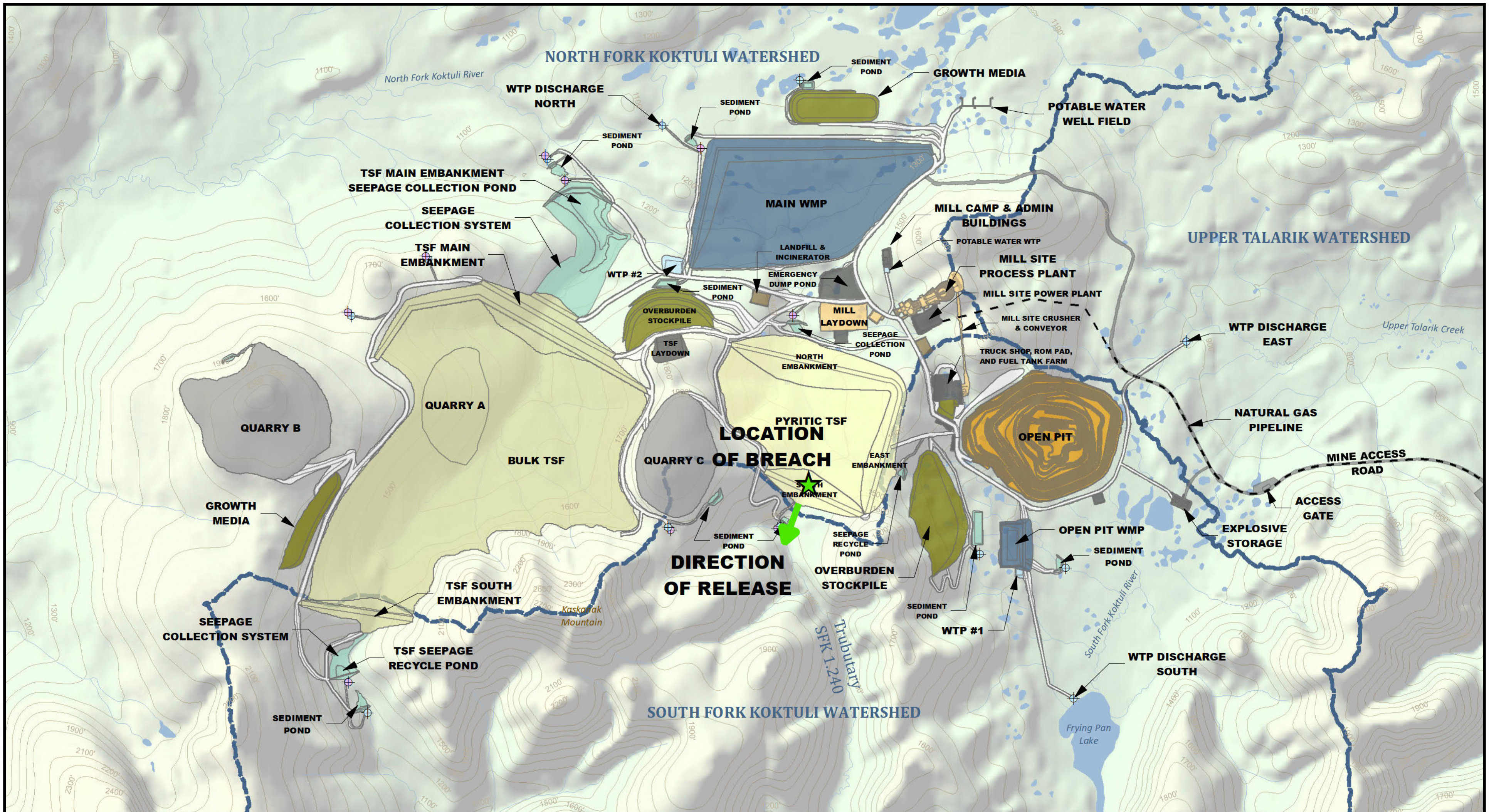
The pyritic tailings would be composed of 98 percent clay- and silt-sized particles, and 2 percent very fine sand (Knight Piésold 2018p). Because the tailings solids are entirely very fine, light particles, most of the solids would stay suspended in the water and be transported downstream, except where overbank flooding occurs and in areas of minimal current, such as low-energy side channels. Most of the released solid material would be flushed downstream during the initial peak flows.

The solid particles would mix with the natural stream flow of the downstream drainages, creating elevated TSS downstream. After all of the tailings solids have been released, natural dilution of stream water would begin to decrease the levels of TSS.

Water in these drainages is naturally low in TSS, with average measured values of 1.69 mg/L in the SFK (see Section 3.18, Water and Sediment Quality, and Appendix K3.18). Applicable WQC require TSS to be no more than 20 mg/L. This release scenario would elevate the TSS and turbidity of the drainages above the WQC downstream for approximately 230 river miles to the Nushagak River Estuary, where it enters Nushagak Bay, part of the greater Bristol Bay.

TSS at the confluence of Tributary SFK 1.240 and the SFK was modeled to be about 241,500 mg/L; while at the Nushagak River Estuary, modeled TSS values are predicted to be about 9,400 mg/L. TSS would remain elevated in the downstream drainages for 3 weeks or more.

[2] The HEC-RAS model cannot model changing solids concentrations throughout a flood event. Due to this limitation in the model, it was assumed for modeling purposes that the released pond water and tailings were fully mixed, so that the released slurry would have a constant solids content of 23 percent (by mass). In reality, flow type would change as the solids concentration in the fluid increases throughout the event, with the flow becoming more viscous, and potentially slowing somewhat over time.



Sources: KP 2018p; PLP 2019-RFI153

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0.5 0 0.5 1

Miles

Location of Breach

Direction of Release

Alternative 1a

GW Quality Monitoring and Pump Back

Water Quality Monitoring Point

Natural Gas Pipeline

Bulk Tailing Storage Facility

Mine Site Infrastructure

Mineral Processing Facilities

Onsite Access Roads

Open Pit

Pyritic Tailings Storage Facility

Quarries

Sediment/Seepage Collection Systems

Stockpiles

Waste Management Facilities

Water Management Ponds

Water Treatment Plants

Other Features

River/Stream

Lake/Pond

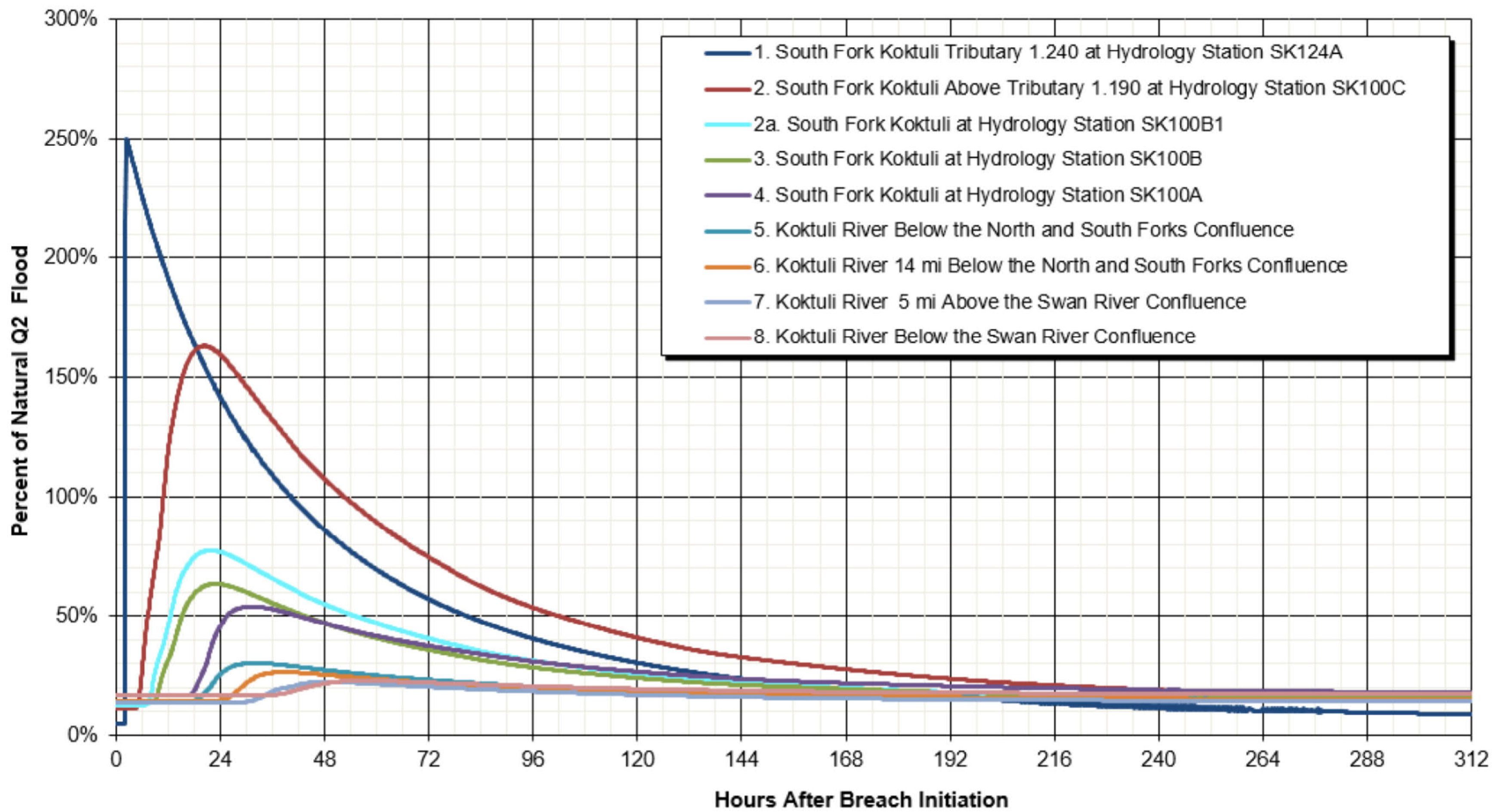
Watershed

100' Contour (Existing)

PYRITIC TAILINGS RELEASE LOCATION

PEBBLE PROJECT EIS

FIGURE 4.27-5



Sources: KP 2018p

US Army Corps of Engineers

HYDROGRAPHS DOWNSTREAM OF PYRITIC TAILINGS RELEASE

PEBBLE PROJECT EIS

FIGURE 4.27-6

Deposition of Tailings Solids

Where overbank flooding occurs, receding floodwaters are likely to deposit a thin layer, or veneer, of the fine solid tailings on the floodplains. Also, where floodwaters enter low-velocity side channels or ponds, the slower water could allow settling of solids.

At the confluence of Tributary SFK 1.240 and the SFK, the floodwaters are modeled to spread out widely, covering about 220 acres. In this area, more widespread deposition of the solid tailings would be expected.

In low-velocity, low-energy areas in the active downstream channels or along the banks, a small volume of solid tailings could potentially settle out and be deposited. Because the particles are so fine, however, they would be re-entrained by subsequent flow and flushed downstream.

As the flow continues down the SFK, there are many areas where the stream channel widens, and many side channels and small ponds where the MAD stream waters do not typically flow (Knight Piésold 2018p). For the first 15 miles downstream from the TSF, overbank flooding could allow the pyritic release to flow into these areas. Once released into these areas, the floodwaters would slow, and deposit the suspended tailings. The fine particles could remain on the surface in these areas until a larger flood event passed through the side channels and flushed the particles back downstream. Depending on conditions, it could take several years to flush out all of the fine material.

Spill Response

As noted above, the State of Alaska does not have specific requirements for cleanup of spilled mine tailings. As per Alaska Statute 27.19.02, the mine site must be returned to a stable condition, compatible with the post-mining land use (AS 27.19.02).

See the “Spill Preparedness, Prevention, and Response Measures” subsection for the actions that the Applicant has committed to. An EAP would be available to direct the appropriate response measures. Response measures would include ensuring the safety of downstream mine employees; shutting down the tailings pipelines; coordinating emergency responders in the community (including mine personnel and downstream residents); and implementing remedial actions to minimize impacts to affected resources.

Overbank flooding would extend down Tributary SFK 1.240 past the confluence with the SFK for a total of about 15 miles downstream of the TSF. No mine employees would normally be working in these areas. Subsequent downstream flows would be so small as to pose no safety concern to downstream residents or recreational users.

Remedial actions could include removing the pyritic tailings from the primary depositional areas at the base of the pyritic TSF, along the margins of Tributary SFK 1.240, and near the confluence of Tributary SFK 1.240 and the SFK, to the extent practicable. The tailings could be excavated using a combination of heavy equipment and hand tools, and transported back to the TSF or other designated temporary storage area.

If the SFK is experiencing dry conditions during a spill, recovery of spilled tailings would be facilitated. Tailings would be less likely to be carried downstream, and would accumulate on the dry riverbed. Tailings could be recovered by excavation.

Depending on the thickness of deposited spilled tailings, recovery of the solid tailings may not be justified in all areas. The amount of solid tailings deposition in most downstream areas would include a very thin layer of clay and silt deposition. Such a thin layer of very fine tailings particles would naturally be dispersed, and flushed downstream by precipitation and/or any naturally elevated streamflow events within months to years. Recovery efforts, including excavation or dredging of spilled tailings, could potentially cause erosion, compaction, and/or damage to vegetation that may exceed the impacts of the tailings remaining in place. Additional habitat restoration could be required after tailings recovery activities.

There would be no immediate risk of acid generation or ML from the spilled tailings.

Any soils impacted by the elevated metals from the supernatant fluid could also be removed, and the impacted habitats could be restored.

Access to cleanup areas in the summer would be difficult due to the lack of roads along the NFK, and would likely involve heavy use of helicopters. Access in the winter could be simplified by travel on packed snow trails, and removal of deposited material may be more effective because the ground and streams would likely be frozen.

Cleanup activities such as excavation or dredging could damage stream habitat, and machinery could cause soil erosion and/or compaction adjacent to streams. Additional habitat restoration could be required after tailings recovery activities.

In the event of a tailings spill, the Applicant has committed to the following remedial actions (from Knight Piésold 2018p):

Remedial action under this failure scenario would include:

- Notification to downstream residents, including individuals and regulatory contacts per the Emergency Response Plan, regarding the incident to minimize the health and safety risks associated with the breach

Ongoing remedial actions would include:

- Mobilizing mine equipment and staff to clean up discharged tailings where practicable, which would likely include helicopter-supported efforts to support ongoing cleanup activities
- Establishing environmental control measures downstream of the breach to reduce the potential for sediment transport from areas of settled tailings, repairing the pyritic TSF south embankment
- Repairing erosion damage in the tributary and at the confluence, if required
- Monitoring downstream water for water quality (Knight Piésold 2018p)

Alternatives Analysis

The probability and impacts of a pyritic tailings release would be the same across all alternatives.

Potential Impacts of a Pyritic Tailings South Embankment Release into the SFK

This section addresses potential impacts of a release of pyritic tailings into the SFK scenario described above. Impacts are considered in terms of their magnitude, duration, geographic extent, and potential to occur. A tailings release would not impact all the resources addressed in this EIS. The following resources were selected for analysis due to the higher potential significance of the impacts.

Soils

Tailings Solids Deposition on Soils—In this scenario, a minimum of 220 acres of soils would be temporarily covered by thin veneers of fine tailings solids. No long-term impacts to soils would be expected from this deposition.

The total mass of tailings solids released in the scenario would be approximately 30 million ft^3 (871,200 tons). Particle sizes would be mostly clay- to silt-sized, with only 2 percent fine sand size. Due to the very fine particle size, most of the tailings solids would remain suspended in the flow, and very little would be expected to settle out.

Soils adjacent to Tributary SFK 1.240 would likely be covered by a thin veneer of tailings solids deposited during overbank flooding. Downstream of the confluence with the SFK where the land flattens out, soils on the banks of the SFK could be covered by a somewhat greater thickness of tailings. Modeling results do not indicate the thickness of solid tailings deposition. The extent of solid tailings deposition in this area would likely be on the order of 220 acres (Knight Piésold 2018p).

Due to the very fine particle size and expected thin layers of deposition, these fine particles would be easily flushed back into the drainage by precipitation, overland flow, or subsequent natural flooding events within days to months. In areas where tailings are deposited in side-channels, future flooding events would naturally flush the tailings back into the drainages within months to years. No acid generation or ML would occur from the deposited tailings on that timescale. The thickest deposits of solid tailings covering soils could be recovered, as needed, although erosion or damage to vegetation from recovery activities could occur.

Erosion—Modeling calculated the bed shear stress downstream of the release to determine the potential for erosion (Knight Piésold 2018p). The flood of fluid and tailings would flow downstream initially at high velocity, up to 1,000 cfs, and would erode the streambed throughout the length of Tributary SFK 1.240. Some sections of the tributary could be eroded/scoured to bedrock, especially immediately downstream of the pyritic TSF. The sudden release of water may cause localized bank erosion that could result in chronic erosion until the banks stabilize. Soils on the banks along Tributary SFK 1.240 could also be eroded somewhat where overbank flooding occurs, especially where vegetation is not present (Knight Piésold 2018p).

Near the confluence of Tributary SFK 1.240 with the SFK, streambed sediments would be eroded, and surrounding soils on the banks of the SFK could be eroded in areas of overbank flooding, especially in areas where no vegetation is present. Some soil erosion could occur for about 13 miles along the mainstem SFK, in areas of overbank flooding. No measurable erosion would be expected farther downstream.

Mitigation would include the repair of erosion damage in the tributary and at the confluence (stream stabilization) if required. Depending on the severity of the erosion, months to years may be required to stabilize the altered stream morphology.

Metals Contamination—Soil could become contaminated with elevated levels of metals from pyritic supernatant fluid in the release. Where supernatant spills onto soils beneath the point of release at the pyritic TSF, it could potentially percolate into the soil column, and metals in the supernatant would adsorb onto surficial soil. Similarly, where overbank flooding flows over soils along the banks of Tributary SFK 1.240, bank soils would come in contact with metals in the supernatant, although the fluid would be diluted by stream water in these instances. Where metals in soils exceed ADEC soil cleanup level guidelines, soils could be excavated to the extent practicable and impacted habitats could be restored.

Metals would not be immediately leached from deposited tailings solids because the process of ML would require years to decades (Section 3.18, Water and Sediment Quality). Tailings particles would be flushed off the land surface and out of the stream drainages within months to years in areas surrounding the impacted drainages.

Surface Water Hydrology

Stream Morphology—The sudden release of supernatant water would result in bed scour and bank erosion throughout the length of Tributary SFK 1.240. The confined reach immediately downstream of the embankment could be scoured to bedrock. The combined volume of tailings slurry and existing bedload could permanently alter the existing geomorphic characteristics of this stream, and result in lateral and vertical instability. This would result in chronic severe bank erosion and increased sediment loads throughout this tributary and the SFK, requiring stream restoration. Ongoing erosion would also contribute to increased TSS downstream for months to years, depending on stream stabilization efforts.

Elevated flows—Surface water flow would be increased above the 2-year flood level on Tributary SFK 1.240, and on the mainstem SFK until the confluence with Tributary SFK 1.190 (Knight Piésold 2018p). This would cause overbank flooding in this area for approximately 2 days (Figure 4.27-6). The sudden release of water and the resulting erosion could potentially modify the stream morphology of Tributary SFK 1.240 and immediate downstream areas of the SFK.

Peak flows would be less than the natural 2-year flood on the remainder of the SFK and other downstream drainages, and there would be no additional overbank flooding. Elevated flows downstream would last for several days to weeks (Figure 4.27-6). Peak flows, arrival time, and duration of elevated flows for downstream drainages are as follows (from Knight Piésold 2018p):

- The MAD of Tributary NFK 1.240 is 18.6 cfs. During the release scenario, modeling predicts the peak flows at this location to increase to 1,004 cfs. This would exceed the natural 2-year flood flow (402 cfs) during the pyritic tailings release event, so that overbank flooding would be expected for the first 2 days of the release.
- Just downstream from the confluence of Tributary SFK 1.240 and the SFK, the MAD of the river is about 47.9 cfs. During the release scenario, peak flows at this location would increase above the natural 2-year flood flow (422 cfs) to 688 cfs, causing overbank flooding in the area. Overbank flooding would persist for approximately 2 days (Figure 4.27-6). Flows would remain elevated for several days to weeks after that, but would be maintained in the stream channel.
- Downstream of the confluence of the NFK and SFK, the MAD of the drainage is 508 cfs. During the release scenario, modeling predicts the peak flows at this location to increase to 1,075 cfs, which would be less than the natural 2-year flood flow of 3,558 cfs. No overbank flooding would occur in this area. The increased flow arrives about 18.3 hours after the initial release and lasts for several days to weeks.
- At the confluence of the NFK and the Swan River, the MAD of the river is 1,431 cfs. During the release scenario, modeling predicts the peak flows at this location to increase to 1,940 cfs. No overbank flooding would occur in this area. The increased flow arrives about 38 hours after the initial release and lasts for several days to weeks.

Water and Sediment Quality

Surface Water Quality

TSS—An increase in TSS from the released pyritic tailings would impact water quality for approximately 230 miles of drainages, from below the pyritic TSF all the way downstream to the Nushagak River Estuary, where it enters Nushagak Bay, part of greater Bristol Bay. The turbidity of the downstream water would be elevated above baseline conditions (pre-development levels) in Tributary SFK 1.240, the SFK, the mainstem Koktuli, the Mulchatna, and the Nushagak River where it feeds into Nushagak Bay, part of the greater Bristol Bay.

Elevated TSS would likely be an intense impact for several weeks while the clay- and silt-sized particles are initially transported downstream.

The concentration of solid tailings in the downstream drainages is expressed herein as percent solids, and as TSS in mg/L (that is, the mass of the solid particles per volume of water). Water in these drainages is naturally low in TSS, with average measured TSS values of 1.69 mg/L in the SFK (see Section 3.18, Water and Sediment Quality, and Appendix K3.18). The most stringent WQC require TSS to be no more than 20 mg/L. Modeled TSS values are somewhat of an overestimate, because the model assumed that all of the solid tailings remained in suspension. Modeled peak TSS values during the initial period of peak flow are as follows (from Knight Piésold 2018p):

- At the confluence of Tributary SFK 1.240 and the SFK, the TSS was modeled to be 241,500 mg/L during peak flow.
- Below the confluence of the SFK with the NFK, the TSS would reach about 71,800 mg/L during peak flow.
- Below the confluence of the Koktuli and the Swan River, the peak TSS would be about 31,200 mg/L.
- Downstream of the Koktuli River confluence with the Mulchatna River, the dilution of natural stream water would be very strong, so that the TSS would be about 17,800 mg/L during the peak flow.
- At the Nushagak River Estuary, which feeds into Nushagak Bay, part of the greater Bristol Bay, the water would still have elevated TSS of 9,400 mg/L, many orders of magnitude above WQC.

Note that the modeled TSS values account for the tailings solids only, and do not consider the additional TSS from ongoing erosion near the release site.

If not recovered, settled tailings would likely flush out of the drainages naturally during subsequent periods of elevated flow. During these periods of elevated flow, deposited tailings would be re-entrained in stream water, and would cause a brief increase in TSS and turbidity in the downstream drainages.

In addition to the tailings solids, additional TSS would be introduced into downstream drainages due to the erosion of the streambed during initial flooding. After the elevated flows have diminished and most tailings solids have been flushed downstream, ongoing sedimentation and elevated TSS would likely continue due to the actively eroding banks of Tributary SRK 1.240 and the SFK near the confluence with the tributary.

Mitigation would include the repair of erosion damage in the tributary and at the confluence (bank stabilization) if required. This would reduce the duration of the elevated TSS. Depending on the severity of the erosion, it could require months to years to stabilize the altered banks.

For this scenario, it could take months to a few years to flush out remaining tailings deposited during the initial flow, depending on climatic conditions. During this time, the re-entrained tailings would cause periodic modest increases in TSS and turbidity as they are flushed downstream. These periodic increases in TSS could exceed WQC.

In addition to tailings solids flushed down the SFK drainage, a small amount of solid tailings would likely enter a large pond near the confluence of Tributary SRK 1.240 and the SFK, due to overbank flooding in this area. The pond would measure approximately 1,000 feet by 1,000 feet (23 acres). Tailings solids in the pond would likely settle to the bottom within days; but due to the fine particle size, they would easily be remobilized and cause periodic increases in TSS in the waterbody. Recovery of these fine particles from the pond may not be practicable.

Acid—For a discussion of factors that impact the ability of tailings particles to generate acid, see “Factors Influencing Acid Generation and Metals Leaching” in the “Concentrate Spills” subsection.

Impacts from acidic conditions would not be expected in this scenario. Supernatant fluid would have a relatively neutral pH of 7 to 8 (Knight Piésold 2018a), and would therefore not contribute to acidic conditions. Note that the SFK has naturally acidic water in some reaches (see Appendix K3.18, Water and Sediment Quality).

Pyritic tailings solids would contain a substantial percentage of sulfide minerals (15 percent sulfur as sulphide; PLP 2018-RFI 045) capable of generating ARD. Deposition of pyritic tailings solids along streambanks that remain exposed to air could generate acid over a period of years to decades if not removed. Precipitation, runoff, and seasonal flood waters could flush any generated ARD into surface water, while some of the acid could percolate into the soil and reach shallow groundwater. Any ARD would be generated very slowly and would be constantly diluted by river water and flushed downstream, so that measurable decreases in water pH may not be observed. Pyritic tailings have a greater potential to impact downstream water quality than bulk tailings due to the higher concentration of PAG materials.

As noted above, the Nushagak River Estuary extends for the last 19 miles of the lower Nushagak River before it feeds into Bristol Bay. This area contains abundant mud flats that are periodically exposed during levels of lower tides. It is possible that a small amount of tailings could be deposited on the mud flats and exposed to the air, which could increase the potential for ARD. However, the deposited tailings would likely be flushed back into the main channels by high tides and rain, and deposited in Bristol Bay prior to generating measurable amounts of acid.

Metals—For a discussion of factors that impact the ability of tailings particles to leach metals, see “Factors Influencing Acid Generation and Metals Leaching” in the “Concentrate Spills” subsection.

Under this scenario, pyritic tailings fluid (the supernatant and pore water) with elevated metals concentrations would be released to Tributary SFK 1.240, and transported downstream (Knight Piésold 2018p). Pyritic tailings fluid is predicted to contain the following metals above the most stringent WQC: antimony, arsenic, beryllium, cadmium, cobalt, copper, lead, manganese, mercury, molybdenum, selenium, silver, and zinc (Knight Piésold 2018a) (see Appendix K3.18, Table K3.18-1, and Table K4.18-3).

Metals concentrations resulting from the spill would be diluted progressively downstream by the stream flow. More rapid downstream dilution would occur during higher stream flow in the summer months; while during the winter, there would be less water to dilute the elevated metals. Modeled downstream metals levels assumed MAD stream levels in the downstream drainages.

Note that the SFK has naturally acidic water in some reaches (see Appendix K3.18, Water and Sediment Quality). Unrecovered tailings that remained in more acidic waters would be more susceptible to dissolution, and could potentially leach metals at an increased rate.

As summarized below and in Figure 4.27-7, modeling results indicate that concentrations of several metals would exceed applicable WQC in the downstream drainages following the spill (Knight Piésold 2018p). Note that in Figure 4.27-7, the points along the drainages labeled “Dilution Ratio Achieved” indicate the point at which those metals would be diluted to within WQC. The metals that would be present in the highest concentration would be cadmium, lead, manganese, molybdenum, and zinc. Copper levels in the released fluid would also be elevated above the most stringent WQC. Due to the large volume of fluid released in this scenario, downstream water quality would be impacted for tens to hundreds of miles downstream (Knight Piésold 2018p):

- Copper would remain at levels exceeding the most stringent WQC until the Mulchatna River below the Koktuli River confluence, about 80 miles downstream of the mine site.

- Lead, manganese, and zinc would remain at levels exceeding the most stringent WQC until the Nushagak River below the Mulchatna River confluence, about 122 miles downstream of the mine site.
- Cadmium and molybdenum would remain at levels exceeding the most stringent WQC as far downstream as the Nushagak River Estuary, approximately 230 miles downstream from the mine site.

These metals would remain at elevated levels above WQC for several weeks while the flows are flushed downstream.

The pyritic tailings solids would not be expected to impact water quality from ML due to the long time periods required for dissolution of metals, and the high level of dilution from surface water. Metals present in the tailings solids (for example, 0.26 percent copper; PLP 2018-RFI 045) would require decades to leach into the water in a bio-available form. If tailings are recovered, there would likely be no measurable ML. Tailings solids that are not recovered could leach metals into surface water over a timescale of decades. However, due to the relatively low percentage of metals in the tailings, the small volume of solid tailings that would be deposited in this scenario, and the constant dilution and continual flushing of tailings from the watershed, this impact would likely not cause water quality exceedances.

The formation of secondary metal salts is not likely from this scenario, due to the limited amounts of metals that could be leached from the tailings, the strong amount of dilution from downstream waters, and the anticipated recovery efforts. The formation of secondary metal salts would require years. Impacts to water quality from dissolution of secondary metal salts would be the same as those noted above for other leached metals.

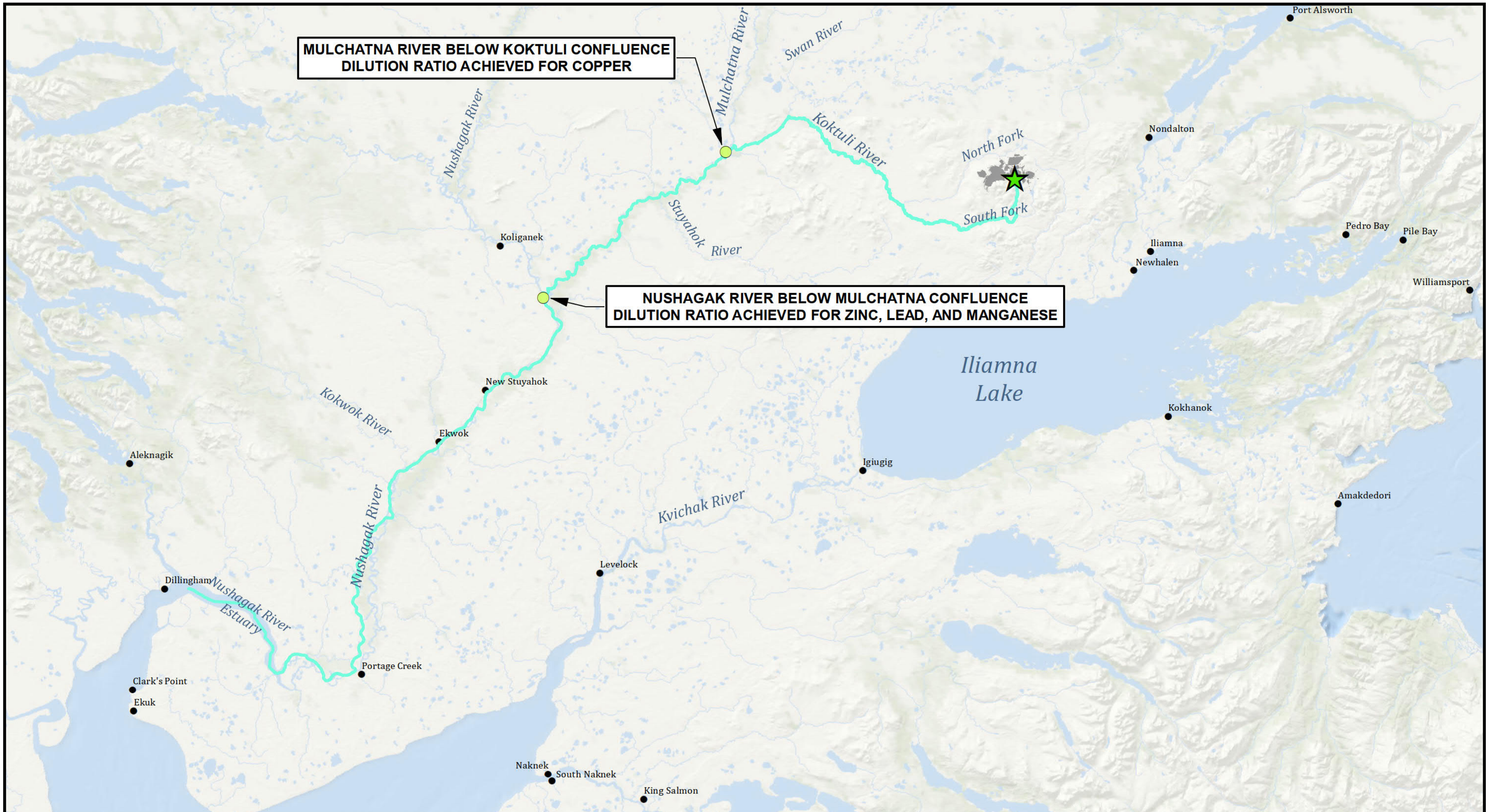
Residual Toxins—Pyritic tailings may contain minor residues from ore-processing reagents that could be released into the watershed in the event of a spill. Most of the reagents are consumed during the process of froth flotation, and residual reagents mostly remain adhered to the metals in the ore concentrate. The small amount of residual reagents in the tailings is anticipated to degrade naturally.

Pyritic tailings would also contain residues from the WTP, which would contain elevated levels of selenium sulfide. See Appendix K4.24, Fish Values, for a discussion of the potential toxicity of selenium and other metals.

Sediment Quality—In low-energy segments of streams, a small volume of tailings could potentially intermingle with and become incorporated into deposits of naturally occurring streambed sediments (substrate). A small volume of tailings could remain in streambed sediments for years to decades, potentially long enough to leach metals. However, the volume of tailings solids would be so low, the ML rate so slow, and the dilution from surface water so strong, that no measurable ML would be anticipated. PAG tailings would not generate measurable acid while under water.

Erosion of upstream streambed sediments from the release would also cause deposition of sediments near the confluence of Tributary SFK 1.240 and the SFK, and for some miles downstream (Knight Piésold 2018p). These redeposited sediments would become part of the bedload, and would continue to migrate downstream and potentially alter the streambed for months to years or more.

Trace amounts of metals from released pyritic supernatant fluid could potentially be incorporated into streambed sediments (the bedload). Metals incorporated into the bedload would continue to be flushed downstream and diluted, but trace amounts could potentially remain held in the sediment and slowly released to surface water. Such trace amounts would be unlikely to have a measurable impact on water quality.



Sources: KP 2018p; PLP 2019-RFI153

US Army Corps of Engineers

10 0 10 20
Miles

Location of Release
Dilution Ratio Achieved
Modeled Rivers
Mine Site

Note: Cadmium and molybdenum do not appear on the map, as their dilution ratios are not achieved before the Nushagak River Estuary.

MODELED EXTENT OF ELEVATED METALS DOWNSTREAM OF PYRITIC TAILINGS RELEASE

PEBBLE PROJECT EIS

FIGURE 4.27-7

Groundwater Quality—Groundwater could become contaminated with elevated levels of metals from the pyritic supernatant fluid. There are numerous shallow aquifers throughout the area. Due to the 3-week duration of the release, metals present in the fluids could permeate through soils into shallow groundwater. Elevated metals in groundwater close to the release site could exceed ADEC groundwater cleanup levels. In the event of a spill, monitoring wells could be installed to assess the extent of contamination. Containment of affected groundwater would be monitored using monitoring/pumpback wells to assess groundwater quality (Knight Piésold 2018a), and the groundwater in the area could be monitored for metals content. Any impacted groundwater would be expected to be detected in these wells. Additional pumpback systems may be installed downstream if necessary, as determined by monitored water quality. No measurable impacts to groundwater would be expected beyond several miles downstream of the mine site. In the case of a spill resulting in groundwater contamination, the State of Alaska may require ongoing monitoring and reclamation work as it deems necessary. See Section 4.18, Water and Sediment Quality, for other standard monitoring and mitigation that could be implemented.

Some surface water flow in the SFK naturally seeps into a shallow groundwater aquifer several miles south of the pyritic TSF. This aquifer releases an estimated annual average of 22 cfs into the Upper Talarik Creek (UTC) basin (Knight Piésold 2018p). There is potential for some fluid with elevated metals from the pyritic release to permeate shallow groundwater aquifers in losing stretches of the SFK watershed. If this were to occur, there is potential for some of this contaminated groundwater to flow into the UTC watershed. Inundation modeling does not model potential seepage of the pyritic tailings release into the shallow aquifer (Knight Piésold 2018p). Due to the strong dilution from surface water and the distance from the release site, however, it is likely that any metals entering groundwater would be diluted to below ADEC groundwater cleanup levels. Measurable impacts to groundwater quality in the UTC drainage basin are not likely from this scenario.

Noise

Noise could be generated from spill recovery operations, including increased vehicle and/or helicopter traffic, and use of heavy machinery and other cleanup equipment.

Air Quality

Tailings deposited on land that are able to dry out have the potential to become airborne fugitive dust. Considering the small volume of tailings deposition expected on land, and the wet climate, any fugitive dust produced would likely not have measurable impacts on air quality.

Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

The impact would be similar to the bulk tailings scenario above, causing a high likelihood of burial and/or erosion of mostly riparian and some adjacent upland vegetation along Tributary SFK 1.240 and the SFK, with additional risk of a metal-related toxic effect from the supernatant. The effects could extend downstream to the Nushagak Estuary.

Burial/erosion—The intensity of physical impacts to wetlands, vegetation, and any special aquatic sites are anticipated to be high intensity as 185 million ft^3 of water, slurry, and material are transported rapidly downstream. The effects would be highest closest to the release, and would diminish with distance downstream. Wetlands and any special aquatic sites present would be buried by a thin veneer of tailings. Vegetation would also be adversely affected by erosion of streambanks and floodplains. The magnitude of the impact would be high, regardless of the timing, because this type of spill would affect both dormant and actively growing vegetation through physical removal from erosion or burial.

The extent of the impacts would be limited to the area covered by the solid tailings particles, estimated to be a minimum of about 220 acres, mostly downstream of the confluence of Tributary SK 1.240 with the SFK (Knight Piésold 2018p).

Toxicity-related impacts—The spill would introduce elevated levels of metals from the supernatant that would temporarily exceed WQC. Some amount of these metals may be bioavailable. See Appendix K4.24, Fish Values, for additional discussion of metals toxicity. Pyritic tailings may also contain residues from reagents and residuals from the WTP, including selenium sulfide. The elevated levels would last for a few weeks while the flows are flushed downstream. Remaining contaminants would then be flushed downstream and released into Nushagak Bay, part of greater Bristol Bay, where they would become heavily diluted. Any changes to the pH, texture, or chemistry of the soil would likely not exceed soil quality criteria.

Assuming the spill response as described for the scenario, spilled tailings would be removed and the duration of initial impacts would be brief, potentially on the order of weeks to months. Mitigation would include the repair of erosion damage in the tributary and at the confluence (bank stabilization) if required. Depending on the severity of the erosion, it could require months to years to stabilize the altered banks, which would delay recovery of the riparian vegetation. For areas affected by burial, re-growth of vegetation may take a few growing seasons.

Terrestrial Wildlife

Impacts to terrestrial wildlife species would be similar to those stated above under the bulk tailings spill scenario, but the magnitude and extent would be greater. Impacts would be in the SFK, and the pyritic tailings pond failure would result in a large pulse of water and tailings downstream into the SFK, causing scouring of material in the SFK, flooding, and habitat loss and alteration (220 acres). This may cause wildlife (particularly small mammals and species that cannot easily avoid flood conditions) to get washed downstream, or be forced to seek higher ground during the initial pass of water. Based on data in Section 3.23, Wildlife Values, and ABR 2011a, the SFK, where the initial release would occur, does not support large numbers of medium to large terrestrial wildlife. There are a few scattered bear dens on slopes above the SFK, which would not be directly impacted. The area does not appear to concentrate moose or caribou, although the occasional brown bear has been detected in the area. Several beaver colonies are in the SFK, and may experience potential damage to their lodges and dams (including potential blow-out) as a result of a pulse of released water. Overall physical impacts to the vegetation and wildlife habitat are anticipated to be high intensity, as 185 million ft^3 of solid and fluid tailings and additional eroded streambed materials are transported rapidly downstream. Sourcing of vegetation, removal of soil, and deposition of sediment into new areas would alter the habitat in the area downstream of the spill.

In addition to vegetation and habitat impacts, fish in the SFK would be impacted. Fish in Tributary SK 1.240 may get flushed downstream, and smothered, crushed, or killed by the force of water and material flowing down the tributary. Some species may be able to seek refuge, but the impacts to salmon and resident fish would be high intensity. Depending on the timing of the pyritic tailings pond release, salmonid spawning habitat, close to 9 river miles downstream of the release location, may be impacted. The portion of the SFK immediately below the pyritic tailings dam is rearing habitat for salmon, but does not provide suitable spawning habitat for several miles. It is possible that large amounts of sediment may be washed far enough downstream to cause egg smothering at spawning locations, and potentially alter spawning substrates.

The released fluid would be elevated in metals and may cause acute toxicity to fish, especially young salmon that are rearing in the upper reaches of the SFK. A discussion of impacts from metals and the various confounding environmental variables to fish (prey for some terrestrial wildlife) is detailed below in the fish section (see Appendix K4.24, Fish Values, for additional discussion of metals toxicity).

Acute toxicity of salmonid species may result in wildlife exposure to fish that have been impacted by increased metals. The magnitude of impacts would be high, because wildlife habitat and salmon in the area would be altered. The duration of initial impacts would likely be short (up to several weeks), because the initial pass of fluids would displace some species, and impacts to salmon would last longer, until enough flushing reduces acute and chronic toxicity levels to permit salmon rearing again. It may take years for the 220 acres of wildlife habitat and salmonid spawning and rearing habitat to be restored. The extent of impacts would stretch from the pyritic TSF downstream in the SKF for many miles until salmon are no longer impacted.

Finally, residual amounts of chemical reagents and WTP residuals, including selenium sulfide, could be released into the environment with this scenario. The small amount of these toxins released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to wildlife from these toxins would be localized and of low magnitude.

Birds

Impacts would be similar to those detailed above for the NFK. The area south of the pyritic TSF adjacent to the SFK does not provide high-quality habitat for many waterbird species, and it does not appear to support large numbers of migrating or resident waterbirds (as detailed in Section 3.23, Wildlife Values and ABR 2011a). Depending on the time of year the spill occurs, if waterbird broods (such as harlequin ducks and mergansers) are present, they may be displaced or pushed downstream during the initial release of fluids. If the spill occurs during winter, impacts to birds would be low, because only resident species would be present. If the spill occurs between spring and fall, birds that forage along the water's edge or broods may be temporarily displaced during the initial pulse of water, and any ground nesters in the immediate vicinity may have nests covered by tailings or washed away. Up to 220 acres of habitat may be impacted.

If metals in the soil and water are not fully cleaned up, there is a potential for metals to accumulate in vegetation. Birds that feed on vegetation (and the surrounding sediment) with elevated metals may experience injury and mortality, depending on the metal loads in the vegetation. This is described in greater detail under "Untreated Contact Water Release," below. The full extent and duration of impacts would depend on cleanup and recovery efforts, but it may take several years for the vegetation and habitat to recover.

Impacts to avian prey (invertebrates, resident fish, and some salmonid life stages) would occur. Some prey would be washed downstream, while others may suffer mortality through smothering. Given the duration and spatial extent of predicted WQC exceedances, chronic aquatic exposures to cadmium, copper, lead, and zinc could have impacts on aquatic invertebrates and fish. Even at low concentrations, cadmium is toxic to aquatic organisms (Gough et al. 1979). Decreased abundance of invertebrates as a food source also could impact juvenile salmon and resident fish, in turn impacting a variety of avian species. It is expected that most invertebrate and fish communities would eventually come back to pre-spill conditions, but this may take several years, depending on the extent of habitat removal from the spill. Overall, impacts are anticipated to be of high magnitude to bird species in the immediate area, and the geographic extent would range from the pyritic tailings pond downstream in the SFK until salmon and avian prey are no longer impacted. This may extend down to the mouth of the Nushagak River, where TSS and metals (such as cadmium and molybdenum) would be elevated following the pyritic tailings release. Impacts to avian species at the mouth of the Nushagak River and estuary were detailed previously under the bulk tailings release scenario. The duration of impacts would last until avian prey return to pre-spill conditions, which may take several years. A more thorough discussion of impacts to fish is detailed below in the following section.

Finally, residual amounts of chemical reagents and WTP residuals, including selenium sulfide, could be released into the environment with this scenario. As detailed in the untreated contact water release scenario, elevated selenium has caused adult avian mortality, reproductive failure, embryonic mortality, and developmental abnormalities in several aquatic bird species (Martinez 1994) in lakes and other ponded waterbodies. Selenium is bioaccumulated in aquatic habitats, and selenium poisoning may persist for several generations and can be passed from parents to offspring through their eggs (Mann et al. 2011). However, the small amount of reagents and selenium sulfide released, coupled with the dilution that would occur in the downstream environment (due to flushing from rain and snow melt), would suggest that impacts to birds from these toxins would be localized and of low magnitude.

Fish

Tributary SFK 1.240—Increased TSS from the release of tailings solids would occur simultaneously with increased sediment loads due to erosion. The increased TSS due to the tailings solids would likely diminish within several weeks. Increased sediment loads due to erosion could continue to impact fisheries habitats and aquatic functions in this tributary for an indeterminate length of time, likely months to 2 years, depending on the effectiveness of stream restoration efforts. Potentially toxic effects of metals would be indistinguishable from the concurrent effects of elevated TSS.

South Fork Koktuli River—The pyritic tailings release would increase the flows above the MAD elevation in the South Fork of the Koktuli River. This reach of the Koktuli is characterized by low width-to-depth ratios with non-cohesive bank materials of silts and clays. The sudden release of water may cause localized bank erosion, which could result in chronic erosion until the banks stabilize. Any sediment from upstream erosion could have acute effects by smothering spawning habitat throughout this reach.

In the SFK River, the majority of salmon adults and spawners were observed in the lower reaches of the rivers (PLP 2011). This suggests the presence of higher-quality habitat, or simply adequate quantities of suitable habitat, readily available to accommodate the numbers of salmon entering the streams without the need to distribute further upstream. Low numbers of spawning coho salmon have been documented in the lower reaches of Tributary SFK 1.240 near the confluence with the SFK. Spawning has not been documented for any other salmon species.

Rearing sockeye salmon have been documented in the tributary of the drainage, although in lower densities (1 to 3 fish per 100 m^2) than in the mainstem SKF, indicating overall lower habitat quality or adequate quantity and quality habitat in other areas of the drainage. Rearing Chinook salmon have been documented in a sub-tributary, but in low numbers. Rearing has not been documented for any other salmon species.

The low-level use of habitat that would be impacted (based on densities of juvenile Chinook and coho salmon captured in these habitats), and the low numbers of coho spawning near the confluence of Tributary SFK 1.240 with the SFK, indicates that drainage-wide or generational impacts to populations of salmon from direct habitat losses associated with the scenario would not be expected.

During initial flooding, the concurrent effects of erosion, scour, and sedimentation would be indistinguishable from metal toxicity. As the water levels recede, potential for metals toxicity would be a concern. As described previously and shown on Figure 4.27-7, concentrations of several metals would exceed their WQC in the downstream areas, including cadmium, copper, lead, manganese, molybdenum, and zinc. The WQC for cadmium, copper, lead, and zinc are associated with the protection of aquatic life, whereas those for manganese and molybdenum are associated with drinking and irrigation water, respectively. Given the spatial extent and duration of predicted WQC exceedances, chronic aquatic exposures to cadmium, copper, lead, and zinc could have impacts on aquatic invertebrates and fish. Decreased abundance of invertebrates as a food source also could impact juvenile salmon and resident fish.

Cadmium is known to accumulate in the liver and kidneys of fish (EPA 2016b). Even at low concentrations, cadmium is toxic to aquatic organisms (Gough et al. 1979). Specifically, cadmium has been documented to cause lesions and necrosis in liver; cellular swelling and congestion of blood vessels; alter the metabolism of essential trace elements; altered blood count; disrupt the endocrine system (interfere with formation of steroids, eggs, and sperm); altered growth rate; and a variety of other toxic effects (Authman et al. 2015).

Copper is an essential micronutrient, but fish exposed to elevated concentrations of copper show alteration in their gills, such as an increased amount of mucus under the gill covers and between gill filaments (edema). Damaged gills result in decreased oxygen consumption (Authman et al. 2015). Low levels of copper/chronic effects can include reproductive effects such as blockage of spawning, reduced egg production in female fish, abnormalities in newly hatched fry, reduced survival of young, poor growth, and decreased immune response, among others (Authman et al. 2015). Impairment of olfaction, behavior, and other sensory responses in aquatic organisms exposed to copper has been observed, sometimes at very low concentrations. Such sub-lethal effects could affect fish life history traits including feeding, reproduction, avoidance of predators, and natal homing. Some water samples collected from streams proximal to the Pebble deposit contained naturally elevated concentrations of copper from local geologic deposits, sometimes exceeding the most stringent WQC (Section 3.18, Water and Sediment Quality).

Lead adversely affects invertebrate reproduction and can be taken up by algae, macrophytes, and benthic organisms (EPA 2016b). Lead is deposited in fish organs such as the liver, kidneys, spleen, digestive tract, and gills, which can lead to disorders in fish (Authman et al. 2015). Acute lead toxicity is characterized by damage to the gill cellular lining, which leads to suffocation. Chronic lead toxicity includes changes in blood parameters, damage to the nervous system, oxidative stress, and adverse effects on fish health and reproduction (Authman et al. 2015).

Zinc is an important element and micronutrient in living organisms; but at increased waterborne levels, may cause direct toxicity in fish. Zinc toxicity affects the gills of fish by disrupting uptake of calcium, which can lead to hypocalcemia and eventually death (Authman et al. 2015). High zinc concentrations/toxicity also leads to growth retardation; respiratory and cardiac changes; inhibition of spawning; gill, liver, kidney, skeletal muscle damage; and mortality (Authman et al. 2015).

Predicted exceedances imply the potential for toxic effects on sensitive aquatic organisms, including adverse effects on fish described in the above paragraphs. However, impacts on a wider range of species are uncertain for the three reasons discussed below.

First, as metals toxicity generally decreases with increasing hardness, hardness correction is applied to establish aquatic life criteria protective of sensitive aquatic organisms. However, the most stringent WQC representing aquatic life criteria for cadmium, copper, lead, and zinc assume a highly conservative hardness correction; the 25th percentile of the baseline hardness of the watershed streams are used to streamline the impact assessment (see Table K3.18-1). This assumed hardness may underestimate the hardness resulting from the spill. Therefore, realistic exceedances of WQC for these metals would be more limited (in extent and duration) than those predicted on Figure 4.27-7. The most stringent WQC for manganese and molybdenum are not associated with aquatic life, and their exceedances do not necessarily reflect the potential impacts to aquatic life.

Second, the predicted downstream concentrations resulting from the tailings fluid spill are assumed to be 100 percent bioavailable. Several factors are likely to limit metals bioavailability when they are released to surface water, including binding by natural ligands (such as dissolved organic matter) and binding phases on particulates. EPA's recommended aquatic life WQC for copper is based on the Biotic Ligand Model to account for various factors that modify its aquatic toxicity (EPA 2007b). Recently, Meyer and DeForest (2018) showed that hardness-based WQC were reasonably protective of the adverse effects of copper on behavior- and chemo/mechanosensory-responses in aquatic organisms, including invertebrates and fish; Biotic Ligand Model-based WQC were more protective. Based on uncertainties regarding metals bioavailability in the current evaluations, the impacts of the predicted exceedances of metals WQC on fish and invertebrates is not known. However, site-specific toxicity tests are indicative of limited impacts on fish species, as described below.

Third, simply comparing predicted metals concentrations to the most stringent WQC misrepresents the potential impacts to a range of aquatic species, including fish. Toxicity tests using undiluted aqueous samples representing the tailings fluid from the mine site did not demonstrate acute and chronic toxicity to fish species, including rainbow trout and fathead minnow. Aquatic toxicity testing was conducted on samples of process water generated during plant water testing by Nautilus Environmental (2012). In this study, test organisms, including juvenile rainbow trout, fathead minnow neonates, and water flea neonates, were exposed to two aqueous samples: "Gold Plant Process Water" and "Non-Gold Plant Process Water." At the laboratory, the test samples were prepared by serial dilution of these aqueous samples using laboratory dilution water. The specifics of how the aqueous samples were generated and their geochemical characterization is not available, so there is some uncertainty about how well the samples represent mine site fluids. It is understood that the "Non-Gold Process Water" sample is representative of contact water in the main WMP and the undiluted (via precipitation) supernatant in the TSFs. Hence, the discussion of the results here is limited to that of the "Non-Gold Plant Process Water" dilution series. Rainbow trout and fathead minnow juveniles were exposed to the test samples for 96 hours to assess acute toxicity (survival) and fathead minnow neonates were exposed for 7 days to assess sub-chronic toxicity (survival and growth). In the acute tests, the "Non-Gold Plant Process Water" did not adversely affect the survival of the juvenile fish, both rainbow trout and fathead minnow in all dilution series, including in 100 percent or undiluted aqueous samples. Similarly, in the sub-chronic test, the "Non-Gold Plant Process Water" did not adversely affect the survival and growth of the fathead minnow neonates (Nautilus Environmental 2012). The study also exposed water flea neonates to the "Non-Gold Plant Process Water" dilution series for 48 hours to assess acute toxicity (survival) and for 7 days separately to assess chronic toxicity (survival and growth). Adverse effects were observed on survival in the acute test and reproduction in the chronic test at 25 percent (by volume) and 12 percent (by volume) of the "Non-Gold Plant Process Water," respectively. These results indicate that adverse effects are not expected at dilutions greater than eight times during tailings release. Unlike the WQCs, which are based on toxicity of individual metals, the results of these toxicity tests represent exposure of the test organisms to a combination of metals in the sample. Therefore, results reflect a combined effect of the mixture of metals and other constituents in the tailings fluid, whether individual metals in a mixture act additively, synergistically, or antagonistically. These results indicate chronic exposures for 7 days or more to tailings fluid at lower dilutions in the streams could have sub-lethal effects on sensitive aquatic species, on which the fish may feed, but direct toxicity is less likely on fish species. See Appendix K4.24, Fish Values, for additional discussion of metals toxicity.

In conclusion, the results of the aquatic toxicity tests on water flea, fathead minnow, and rainbow trout using aqueous samples representative of contact water in the main WMP and undiluted supernatant in the TSFs indicate that acute impacts (lethality) on fish due to metals toxicity would not occur within the predicted time frame and extent of WQC exceedances. Sub-lethal impacts could occur to sensitive aquatic invertebrates in the upstream areas beyond approximately two weeks, where lower dilution to metals concentrations would occur. Sub-lethal impacts on fish are unknown, especially because these sub-lethal impacts, if any, would occur at the longer time frame beyond a week after the initial physical impacts subside. However, chronic exposures to elevated metals above baseline are not predicted beyond several weeks.

Although predicted mercury concentrations in the tailings are low, even very low amounts of total mercury that may incorporate into anoxic sediments, such as those occurring in wetlands in the project area, could result in methylation to form MeHg, the toxic and bioavailable form of mercury. MeHg is toxic, bioaccumulates, and biomagnifies in fish (see Appendix K4.24, Fish Values, for expanded discussion of potential impacts from MeHg in fish).

Small amounts of metals-rich tailings may be entrained in streambed sediment, and may leach metals slowly over years to decades. This could cause low-magnitude, localized impacts to benthic organisms that are preyed on by fish.

Finally, residual amounts of chemical reagents and WTP residuals, including selenium sulfide, could be released into the environment with this scenario. The small volume of reagents and selenium sulfide released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to fish from these toxins would be localized and of low magnitude.

Threatened and Endangered Species

There would be no physical impacts to federally listed TES, because none occur in areas where a tailings release is projected to reach. According to Brna and Verbrugge (2013), based on a preliminary assessment, no breeding or otherwise large occurrences of TES are known to occur in the Nushagak watershed. There are several TES that occur in Bristol Bay (Limpinsel 2013), but physical impacts (and those related to WQC exceedances) are not anticipated to extend that far downstream out into Bristol Bay where they occur. However, any reduction in salmon and other fish populations from the pyritic tailings release scenario could indirectly impact TES. This is expected to be relatively minor because TES feed across a broad range of areas.

Marine Mammals

Impacts would be similar to the bulk tailings scenario but would occur in the SFK and extend further downstream. Elevated TSS and metals (cadmium and molybdenum) would extend to the mouth of the Nushagak River. A tailings release may potentially alter the habitat and occurrence of marine mammal prey species that inhabit the Nushagak River watershed. A potential reduction in salmon due to reduced spawning habitat and toxicity from the pyritic tailings failure would reduce the prey base for several marine mammals. The duration would last until affected spawning and rearing habitat is restored and salmon are no longer impacted; the geographic extent of impacts would extend from the spill location in the SFK downstream until metals are diluted to within WQC. Because TSS and some metals would be elevated all the way to the mouth of the Nushagak River, both the non-federally listed Bristol Bay stock of beluga whales and harbor seals may be impacted. As detailed previously under the bulk tailings release scenario, beluga whales range several miles upstream in the Nushagak River, feeding on a variety of fish at different life stages. Therefore, in terms of salmon prey, a pyritic tailings release that results in smothered eggs or alevin and reduced spawning habitat quality or quantity could result in a reduction in the SFK spawning biomass that alters the number of returning adult salmon.

One of the metals that would exceed WQC all the way to the mouth of the Nushagak River is cadmium; which even at low concentrations, is toxic to aquatic organisms (Gough et al. 1979). Although dilution through flushing would reduce some impacts from elevated levels of cadmium in the Nushagak River, the impacts on salmon that are present in the river during the spill event are difficult to predict. Any impacts to salmon could reduce the overall prey abundance for beluga whales and harbor seals. Although a small reduction in spawning adults in the SFK is unlikely to impact the overall number of salmon available for beluga whales and harbor seals, the impacts of increased cadmium (and other metals) levels in the Nushagak River would be harder to predict (given the metals discussion under the fish section detailed previously). The duration of impacts to marine mammals would extend until impacts to their prey are no longer noticeable.

Finally, residual amounts of chemical reagents and WTP residuals, including selenium sulfide, could be released into the environment with this scenario. The small volume of reagents and selenium sulfide released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to marine mammals from these toxins would be localized and of low magnitude.

Needs and Welfare of the People—Socioeconomics

The cleanup and remediation activities following a bulk tailings delivery pipeline rupture in which a large volume of slurry is released into the environment could briefly increase employment opportunities and expenditures in the Iliamna Lake area, and potentially in the Bristol Bay region. Labor force requirements would be especially high if labor-intensive response efforts such as mechanical recovery and physical removal were used. Employment increases for cleanup activities would be brief (less than 1 year).

Over the longer term, the impacts on employment, income, and sales would be negative if commercial and recreational fishing and/or tourism were to suffer due to the real or perceived impacts of the spill. Real or perceived water contamination could also negatively impact local business and consumers.

Environmental Justice

A tailings release could impact the socioeconomics, subsistence, and health and safety of those in the region. There could be increased employment for a brief time for cleanup and remediation; however, there could be declines in employment, income, and sales from commercial and recreational fishing and/or tourism if impacted by real or perceived impacts of the spill. A release could impact subsistence harvest quantities and harvest patterns, and there could be impacts to health and safety. Taken as a whole, potential adverse impacts from the spill event would disproportionately impact minority and low-income communities. There would be interrelated subsistence, health, and socioeconomic impacts to the minority and low-income communities in the area.

Recreation

Impacts to the recreation setting from this tailings release scenario would be acute or obvious for at least several weeks. The levels of recreational activities downstream from the mine site are higher than at the mine site itself, but are still estimated to be low. The recreational activities that may be affected could include sport fishing, recreational snowmachining, and sport hunting. A release may cause probable loss or damage to anadromous fisheries, which could impact sport anglers. There would be impacts to recreational sightseeing, because visual resources would be impacted (i.e. increased downstream turbidity). Sightseeing and flightseeing are typically secondary recreational activities done in conjunction with travel for sport fishing and sport hunting, and would also be impacted from visual impacts.

Commercial and Recreational Fishing

The sudden release of supernatant water into Tributary SFK 1.240 could impact the ex-vessel and first wholesale value of the Bristol Bay commercial fishery. First, the long-term contribution of Tributary SFK 1.240 and the SFK downstream of SFK 1.240 could be affected for some time, depending on the efficacy of stream rehabilitation efforts. As noted above and in Section 3.6, Commercial and Recreational Fisheries, and over the last 20 years, the 10-year average ex-vessel value per harvested sockeye has ranged from $4.75 to $7.62 in 2019 US dollars. Over the last 20 years the Nushagak District, which includes the Nushagak, Mulchatna, Wood, Igushik, Snake, and Nuyakuk rivers, has averaged a total inshore sockeye run of 8.5 million fish, with spawning escapement of 2.6 million fish. In addition, the Chinook salmon run in the district averages 180,000 fish per year. Under this scenario, the productivity of the Nushagak, Wood, Snake, and Nuyakuk rivers are not likely to be affected. The productivity of the Mulchatna drainage outside the SFK is also unlikely to be affected, but greater uncertainty exists about the magnitude and duration of these effects. Overall effects on ex-vessel and first wholesale values and concurrent economic activity would be on a scale relative to fish impacts in the SFK and the Koktuli rivers.

The commercial fishery has expressed concern that a large-scale spill event would affect the value of the fishery by changing the value of harvested salmon in the open market. Historical experience shows the extent to which large-scale spills tend to affect the value of seafood products. After the *Exxon Valdez* oil spill, the Eshamy District of the Prince William Sound Management Area was closed for the duration of the 1989 season, while PWS Management Area districts experienced at least some fishing. History shows that that event resulted in direct financial losses associated with lost harvest opportunities. However, post-event statistical analyses found no effect on salmon prices in 1989, 1990, or 1991. An Alaska jury also found no decline in salmon prices for 1990 and 1991, but did make an award for an effect on prices in 1989 (Owen 1995). In 2015, Japanese researchers found statistically significant, but “negligible” effects on seafood prices in the wake of the Fukushima nuclear disaster (Wakamatsu and Miyata 2015). These studies indicate that seafood price effects associated with industrial accidents tend to be very small or undetectable, and of limited duration. At the same time, in the wake of such disasters, a specific name can be associated with lower consumer desirability if the name is firmly connected with the disaster itself. For example, consumer choice research conducted after the Fukushima nuclear disaster found that labeling seafood as being from Fukushima Prefecture resulted in lower willingness-to-pay, compared to unlabeled seafood or labels from other prefectures (Wakamatsu and Miyata 2017). The study notes that preference research associated with an oceanside nuclear disaster where radioactivity entered the food chain may not be applicable to a hypothetical mine disaster, where pollutants would be less likely to accumulate in seafood.

Directed recreational fishing on the SFK itself is limited. Over the last 20 years, an average of 3.6 anglers per year returned Statewide Harvest Surveys to ADF&G recording activity on the Koktuli (including the NFK), with point estimates of effort ranging from approximately 50 to 850 recreational days per year (median estimate 352 angler days). Far more days are spent angling on the Mulchatna River, which has a 10-year estimated effort of 1,700 angler days per year, including roughly 340 guided angler days, and the Nushagak River. SWHS data indicate that between 2004 and 2016, the Nushagak River averaged just over 12,000 angler days between the Mulchatna confluence and Black Point. In a pyritic tailings spill, the released tailings would pass through the Mulchatna River into the Nushagak River. The increased TSS and turbidity associated with the spill would affect anglers' success rates, because salmonid species feed partially by sight. The impact on the recreational fishery would be limited in the Nushagak River by the duration of increased turbidity or TSS affecting the ability of target species to see or smell prey. The TSS and turbidity could be elevated for weeks to months to years, depending on the success of stream restoration and the resultant decrease in ongoing erosion. Fishing packages in the region cost between $600 and $1,000 per night. A spill before or during the peak summer months could result in trip cancellations and associated economic impacts for guide companies, and the business and communities that support them.

Cultural Resources

A release of pyritic tailings would be similar to the bulk tailings release. Impacts would occur to cultural resources along the shore of the SFK if tailings were carried to a known or potential historic property site, or response efforts with ground-disturbing activities occurred near cultural resources. Resources may not be anticipated to return to previous levels, even after actions that caused the impacts cease. The probability of ground-disturbing cleanup activities occurring at historic property sites is low due to the dispersed geographical distribution of sites downstream of the mine site. Impacts would occur in a discrete geographic area, but could affect rare cultural resources in the region. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Clean-up activities would likely require a mitigation plan to limit impacts to known or potential historic properties, and would occur in accordance with the Programmatic Agreement. It is not possible to identify specific cultural resources that could be affected. Indirect impacts could occur to the setting (visual and noise impacts) of cultural resources if the spill were to occur in the vicinity. Those impacts would be temporary, and would cease when response efforts are complete.

Subsistence

Impacts to subsistence resources would be similar to the bulk tailings release, although the magnitude and geographic extent would be larger. The impacts to subsistence resources, particularly fish, could persist well beyond cleanup efforts due to chronic erosion and increased sediment loads caused by the initial flooding. The most persistent and widespread impact of a tailings spill would likely be concern among subsistence users about contamination of subsistence fish resources in the greater watershed. Subsistence users would likely avoid fishing and some other subsistence activities for a great distance downstream from the release, affecting harvest patterns, as well as harvested quantities of highly valued resources. Contamination concerns resulting from the release may last for several years. Quick response and cleanup of tailings, and a robust system of testing wild foods and communicating the results to local people in a timely manner, could help mitigate contamination concerns.

Health and Safety

The release flood would flow at a maximum of 1,000 cfs initially, which could create a safety hazard if mine personnel were present in the immediate vicinity downstream of the pyritic TSF. However, mine workers would not normally be present in this area.

There are no nearby downstream human habitations. The closest village downstream is New Stuyahok—113 miles downstream by way of the SFK. Modeling suggests that at that distance from the potential release, there would be no observable rise in water level. River water at the village site would be elevated in several metals above applicable WQC for several weeks. Residents of the village would likely see an increase in TSS and turbidity in the river for several weeks after the release.

Downstream communities rely on groundwater wells for drinking water. No measurable impacts to groundwater would be expected from this scenario, although groundwater contamination could be perceived. Perceived contamination of the environment and subsistence foods (e.g., salmon) may affect community concerns about access to, and quantity and quality of subsistence foods, which can affect the socio-economic status, emotional well-being, food security, and dietary patterns of local communities; this concern may extend throughout the extended spills analysis area. Restricted access to the environment (e.g., due to real or perceived contamination) may result in decreased mental health and increased psychosocial and family stress, substance use, suicidal tendencies, and cardiovascular disease (Dillard et al. 2012; Gibson and Klinck 2005).

There are potential adverse impacts to social determinants of health (HEC 1), with psychosocial stress resulting from community anxiety over a tailings release, particularly in areas of valued subsistence and fishing activities. There could be exposures to potentially hazardous materials, including metals (HEC 3). Subsistence and food security may be impacted, with potential perceptions of subsistence food contamination that could extend throughout the area (HEC 4). Reliable and prompt communications about environmental and subsistence food impacts and precautions about both acute and chronic exposures could alleviate psychosocial stress; reduce impacts to subsistence and food security; and allay public health concerns. Establishment of a grievance process and compensation fund for affected individuals and communities could also help reduce potential impacts to socioeconomic and food security concerns. Impacts would vary in duration and be limited to the area of the spill.

4.27.8.10 Release from North Embankment of Pyritic TSF/Flow into Main WMP

A release from pyritic TSF north embankment would likely flow into the main WMP, and be contained in the freeboard. A very high-volume rapid release could potentially spill into the main WMP, and cause a cascading effect, and a flood of combined pyritic tailings plus contact water. This type of release would be dominated by contact water, with very diluted pyritic slurry. Such a scenario is very unlikely (AECOM 2018k).

4.27.9 Untreated Contact Water Release

Contact water is defined as surface water or groundwater that has contacted mining infrastructure. This includes “mine drainage” defined in 40 CFR Part 440.132(h) as any water drained, pumped, or siphoned from a mine, as well as stormwater runoff and seepage from mining infrastructure. Examples of contact water include seepage from waste rock piles, seepage from stockpiles (except ore), and water from horizontal drains that accumulates in the pit. Contact water would also be used and recycled for various mine activities, including the milling process, concentrate production, and mixing of tailings slurries.

The chemistry of contact water would vary, depending on what the water was used for and where it was stored. Contact water in general would have elevated concentrations of metals and other constituents, such as TDS and hardness (as $CaCO_3$). Contact water would therefore not meet discharge water quality standards, and would require treatment to meet applicable WQC prior to release to the environment. At the mine site, contact water would be treated in one of two water treatment plants by various methods (see Section 4.18 and Appendix K4.18, Water and Sediment Quality).

Contact water would be stored in several facilities, including the main WMP, the open pit WMP, and six seepage collection ponds adjacent to (downstream of) the TSFs. Supernatant ponds in the TSFs and fluid in the open pit are also considered contact water, and would be pumped out of those facilities as needed, to be recycled and/or treated and released. The lowest-quality contact water is expected to be in the bulk TSF main seepage collection pond (Appendix K4.18.3,

Table K4.18-3). This facility would remain in post-closure indefinitely, or until no longer required for water management and treatment.

A “failure” of a contact water storage facility refers to the unintended release of contact water. Such a release could occur as a result of overfilling of storage facilities, a failure in the embankments or liners, or an emergency release.

In the event of an unplanned release, untreated contact water with elevated constituent concentrations would be introduced to the environment. Depending on the release volume, the rate of release, the source of contact water, etc., downstream water could cause adverse effects on aquatic organisms in the receiving waters.

4.27.9.1 Main Water Management Pond

The main WMP is the largest contact water storage facility, and the subject of the scenario analyzed below. The main WMP would be in the NFK watershed, and would be a fully lined facility that would supply water for the milling process and storage of surplus water for the mine site. The main WMP would include a 750- to 825-acre reservoir contained by an embankment with a maximum height of 190 feet. It would be among the largest lined water storage reservoirs in the world. It has been designed as a very high-capacity water storage facility to store excess water pumped from the bulk TSF. This is a key part of the mine site layout designed to reduce water storage in the bulk TSF to promote unsaturated conditions in the tailings, and maintain a minimal supernatant pond (see Appendix K4.27, Spill Risk, for further discussion of the Applicant’s proposed mine site layout.)

The main WMP is designed to safely manage surplus contact water from the mine site under the full range of climate conditions, including prolonged wet and dry periods. The average volume of anticipated contact water stored in the main WMP would be approximately 1,470 million ft^3, with *maximum* storage of approximately 2,440 million ft^3. Storage capacity would also include storage of the required IDF (equal to the probable maximum flood) and additional freeboard (Knight Piésold 2018q).

The embankment would be a zoned rockfill and earthfill dam with a maximum height of 190 feet and geomembrane liner over the entire upstream slope. Overburden material under the embankment would be excavated, and the embankment would be constructed on bedrock (per design changes made during the 2018 FMEA workshop; AECOM 2018k; AECOM 2018l). The facility would cover a total of 955 acres, with a maximum crest length of approximately 2.8 miles, and a maximum dam height of 190 feet (Table K4.15-1). See Chapter 2, Alternatives, for details on the main WMP facility; see Section 4.15, Geohazards and Seismic Conditions, for details on the seismic stability and other geotechnical features of the embankments.

Development of the main WMP would be a major undertaking in line with the largest geomembrane-lined water storage reservoirs in the world. The technology for designing, constructing, and operating such lined facilities is well developed (Scuero et al. 2017a, b, c; Vaschetti 2019; Carpi 2020). Comparable examples of large geomembrane-lined basins are the Columbus Upground Reservoir (CUGR) in Ohio (EPI 2020), which is an 843-acre pump-storage water reservoir; the Panama Canal Expansion Water Savings Basin of 147 acres, and Tampa Bay Reservoir of 97 acres. Comparable geomembrane-lined embankment examples are the water retention and tailings storage facility at Las Bambas Mine in Peru that is now 443 feet high, and is planned to be 754 feet high; the 298-foot-high rockfill Runcu Dam in Romania; and the 182-foot-high concrete-type Filitranos Dam in Greece.

4.27.9.2 Fate and Behavior of Released Untreated Contact Water

This section describes the general fate and behavior of released untreated contact water across a wide range of potential accidental releases. Specific impacts from the analyzed release scenario are presented below.

In the event of an unintended release of untreated contact water, impacts could range from temporary, local water quality impacts to a large flood and extensive contamination that could threaten downstream environments.

The fate and behavior of released contact water would depend on several factors, as described above for tailings releases, including location of release, chemistry of contact water, volume of release, speed/duration of release, downstream topography, summer versus winter, and mode of failure.

Flooding

A large-volume release from a contact water storage facility could lead to a large downstream flood. Flooding could lead to safety concerns for mine site personnel, and potentially for downstream residents and/or recreational land users. Flooding could also cause erosion, sedimentation, increased TSS, and damage to downstream habitat.

Contamination from Metals and Other Constituents

Contact water would have elevated concentrations of metals and other constituents that could impact downstream water quality. Aqueous chemistry of contact water across the mine site would vary by storage facility. Modeling predicts that contact water in the main WMP would have concentrations of the following metals at levels exceeding the most stringent WQC: aluminum, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, nickel, selenium (a metalloid), silver, and zinc (Knight Piésold 2018a; Table K4.18-3). In addition, levels of TDS, alkalinity, hardness, and sulfate would also fail to meet applicable WQC.

The magnitude of the impact of an untreated contact water release would depend on many factors, as described above. For small releases, downstream dilution would minimize potential impacts due to constituent contamination. In the event of a large volume or a persistent ongoing release, however, the elevated metals could cause a more intense impact.

The predicted pH of contact water would vary from 7 to 8; therefore, acidification of downstream water would not be an anticipated impact of a release.

4.27.9.3 Historical Examples of Contact Water Releases

Historical contact water releases have caused damage, including human casualties, destruction of homes and property, economic loss, and environmental impacts, especially impairment of aquatic habitat in downstream drainages. Examples of some historic failures (from WISE 2018) include:

- In June of 2017, 100,000 cubic meters of acidic wastewater was accidentally discharged from a phosphate mine in Mishor Rotem, Israel. The toxic wastewater surged through the dry Ashalim riverbed and damaged habitat for more than 20 kilometers downstream.
- In November of 2012, in Sotkamo, Kainuu province, Finland, hundreds of thousands of cubic meters of contaminated wastewater leaked from a pond, resulting in nickel, zinc, and uranium concentrations in nearby Snow River that exceeded water quality criteria.

- In December of 1998, 50,000 cubic meters of acidic and toxic water were released from a phosphate mine in Huelva, Spain, from a dam failure during a storm.

4.27.9.4 Probability of Release/Spill Frequency and Volume

Water reservoir dams (often constructed of concrete) are generally built to last for decades to centuries. Water management ponds and other water storage facilities at mine sites (usually constructed of earthen materials) are generally not built to last beyond the operational life of a mine.

Most mine water management ponds are generally much smaller than the main WMP. As noted in the “Main Water Management Pond” subsection, there are few precedents for such a large lined WMP, and therefore, there are limited statistics on their failure rates. This introduces uncertainty to the performance of the proposed main WMP. Large earthen water reservoirs that are in use around the world could be considered as an analogue. Their failure rates fall within the range of failure rates for many types of dams, on the order of 1×10^{-4} to $1 \text{ X } 10^{-5}$ annual probability of failure, or a 0.01 to 0.001 percent chance of failure in any given year (Stanford 2020; NID 2020).

4.27.9.5 Risk Assessment for the Proposed Embankment

In October of 2018, AECOM hosted an EIS-FMEA workshop in Anchorage, Alaska. The objective of the workshop was to develop reasonable failure scenarios for the bulk TSF, the pyritic TSF, and the main WMP to be analyzed as part of the EIS. It is recognized that this EIS-Phase FMEA was not intended to be a complete risk analysis, but rather one risk assessment tool used for EIS purposes.

To be in accordance with the NEPA guidelines, the failure scenarios selected for analysis in the EIS need to have a reasonable level of probability and a comparatively high level of consequence (AECOM 2018k).

At the time of the workshop, the design for the main WMP involved construction of the embankments on overburden materials. The expert panel addressed potential problems with the stability of such embankments constructed on overburden, rather than on bedrock. The initial risk rating of some failure modes was rated as a “low” probability. PLP proposed a design change in which the overburden materials would be excavated and removed, and the embankment would be constructed directly on bedrock. This reduced the risk rating for the relevant failure modes down to a “very low” probability. (Note that due to the unique design and construction of individual embankments, probabilities of failure of the proposed embankments were determined by the FMEA process, not by statistical analysis of historical spills, as was completed for trucking accidents, etc.)

Due to the early-phase conceptual design and recent modification to the conceptual design, limited data are available on the quality of the underlying bedrock.

4.27.9.6 Existing Response Capacity

There is no existing response capacity for a spill of untreated contact water in the mine area. The Applicant would have a spill response plan in place by the onset of the construction phase. An EAP is required by the State of Alaska Dam Safety Program, as described above for the tailings sections. Recovery of spilled contact water once it enters the NFK would not be possible. The general spill response protocol is provided under the “Spill Response” subsection.

4.27.9.7 Mitigation

- Dam/embankment safety is regulated by the ADNR Dam Safety Program under AS 46.17, Supervision of Safety of Dams and Reservoirs; and Title 11, Chapter 93, Article 3 (11 AAC 93), Dam Safety. Note that ADSP has provided updated draft guidelines (ADNR 2017a) referred to throughout the EIS. These draft guidelines have not yet been adopted under Alaska Statutes.
- ADNR approval is required to “construct, enlarge, repair, alter, remove, maintain, operate or abandon” a dam.
- The embankment would be constructed to the Class I hazard classification (highest potential hazard), requiring that PLP and their engineering consultants provide a high level of technical risk assessment prior to request for and issuance of Certificates of Approval to Construct a Dam.
- Available storage capacity (freeboard) would always be maintained in the TSFs to account for the IDF (PLP 2018d).
- The embankment would be constructed on bedrock, which is considered to increase its stability. All surficial soils and other unconsolidated materials would be removed beneath the embankment areas prior to construction. (The facility reservoir would rest on overburden.)
- Per ADSP draft guidelines (ADNR 2017a), two levels of design earthquake must be established for Class I dams: an OBE that has a reasonable probability of occurring during the project life (return period of 150 to more than 250 years); and an MDE that represents the most severe ground shaking expected at the site (return period from 2,500 years up to that of the MCE). These design earthquakes cannot be represented by a single magnitude value. Rather, impacts would vary with not only magnitude, but also with the type of earthquake, epicenter location, depth, duration of shaking, etc. A range of earthquake magnitudes and characteristics is used to represent each level of design earthquake (Section 3.15 and Section 4.15, Geohazards and Seismic Conditions).
- The main WMP would be constructed with an FoS of 1.9 to 2.0. See Section 4.15, Geohazards and Seismic Conditions, for more details on FoS.

See Section 4.15 and Appendix K4.15, Geohazards and Seismic Conditions, for further discussion of seismic stability design for the main WMP.

4.27.9.8 Untreated Contact Water Release Scenario

Modeling the Scenario

Information on the selected scenario from the FMEA was then used as input for modeling the release scenario described below to analyze potential impacts on physical, biological, and social resources. Because the flow rate of the release scenario is so low (2 cfs), there would be no potential for flooding; therefore, inundation modeling (as described for the tailings releases) was not required to model the contact water release.

Modeling of the contact water release scenario focused on estimating water quality in the receiving waterbodies. A mass balance analytical approach was used to determine mixing rates and dilution factors to model downstream water quality. Dilution ratios were calculated along the NFK, Koktuli River, Mulchatna River, and Nushagak River to estimate the amount of dilution that would be provided by natural flows. This allowed for calculation of the downstream distance required to dilute contaminated water to below water quality exceedance.

USGS and PLP streamflow-gaging stations in the Koktuli and Nushagak river drainage basins were used to characterize hydrological conditions, and provide MAD and natural 2-year flood levels. See Knight Piésold 2018q for full details on the modeling methodology, inputs, and assumptions used for the analysis.

Scenario: Failure of the Main WMP

The contact water release scenario presented here is a slow release failure of the main WMP, in which 2 cfs of untreated contact water leaks from the facility over a period of 1 month, for a total release of 5.3 million ft^3 (120 acre-feet) into the NFK (Figure 4.27-8). This volume represents only 0.4 percent of the average contact water stored in this facility.

This hypothetical failure is due to liner damage from ice hitting the geomembrane liner during spring break-up. The resulting seepage through the liner is powerful enough to begin internally eroding the embankment. Intervention is successful at preventing a full breach of the dam, but seepage overwhelms the seepage collection system, resulting in downstream discharge (AECOM 2018l). This failure scenario was selected by the FMEA workshop as the most reasonable probability of occurrence of the failure modes evaluated that would have relatively high consequences.

Released contact water would flow into Tributary NFK 1.120, which feeds into the NFK. The NFK joins with the SFK to form the Koktuli River, which is a tributary of the Mulchatna River; which in turn is a tributary of the Nushagak River that flows into Nushagak Bay, part of the greater Bristol Bay, about 230 miles downstream of the mine site.

The constant outflow of 2 cfs in this scenario is relatively small compared to the natural flows in the NFK and other downstream drainages. This scenario would not increase the discharge into downstream drainages above the natural 2-year flood level during average stream levels, and no downstream overbank flooding would occur. There would be no flood wave and no downstream flooding safety concerns in this scenario.

Released contact water would immediately begin to mix with natural stream water. Modeling results show that full mixing would occur within no more than 3.6 miles downstream (Knight Piésold 2018q).

Untreated contact water released into the downstream drainages would contain elevated levels of aluminum, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, nickel, selenium (a metalloid), silver, and zinc in exceedance of the most stringent WQC (Knight Piésold 2018a; Table K4.18-3). The metals that would be at the highest concentrations, and therefore require the most dilution to meet water quality standards, would be molybdenum, cadmium, lead, zinc, and manganese. Molybdenum would require the most dilution, at a ratio of 213 parts natural stream water to 1-part untreated contact water. Depending on flow conditions, the required stream distance to dilute molybdenum to within applicable WQC would be approximately 15 to 45 miles downstream of the mine site (estimated from Figure 5.2 in Knight Piésold 2018q). Most other metals would be diluted to within WQC farther upstream. Copper would require a dilution ratio of 19 parts stream water to 1 part untreated contact water, so that it would be diluted to within WQC by about 10 miles downstream of the mine site (values estimated from Knight Piésold 2018q).

Depending on the flow conditions at the time of the unintended release, water quality would fail to meet applicable WQC for up to 45 miles downstream. This would continue for the entire month of the release.

Spill Response

See the “Spill Preparedness, Prevention, and Response Measures” subsection for the actions that the Applicant has committed to. Any soils impacted by the elevated metals from the contact water could be removed, and the impacted habitats could be restored.

The Applicant has committed to taking the following remedial actions under this failure scenario:

- Investigating the increased flows in the downstream monitoring/collection system to identify the general area of the embankment where the increased seepage is occurring
- Lowering the water level in the Main WMP
- Inspecting the liner and repairing any liner damage, as necessary
- Repairing the Main WMP embankment/seepage collection system, if required
- Monitoring downstream water for water quality

Alternatives Analysis

The potential for a release of contact water as described in the scenario would be the same across all alternatives.

4.27.9.9 Potential Impacts of Untreated Contact Water Release from the Main WMP

Soils

Metals Contamination

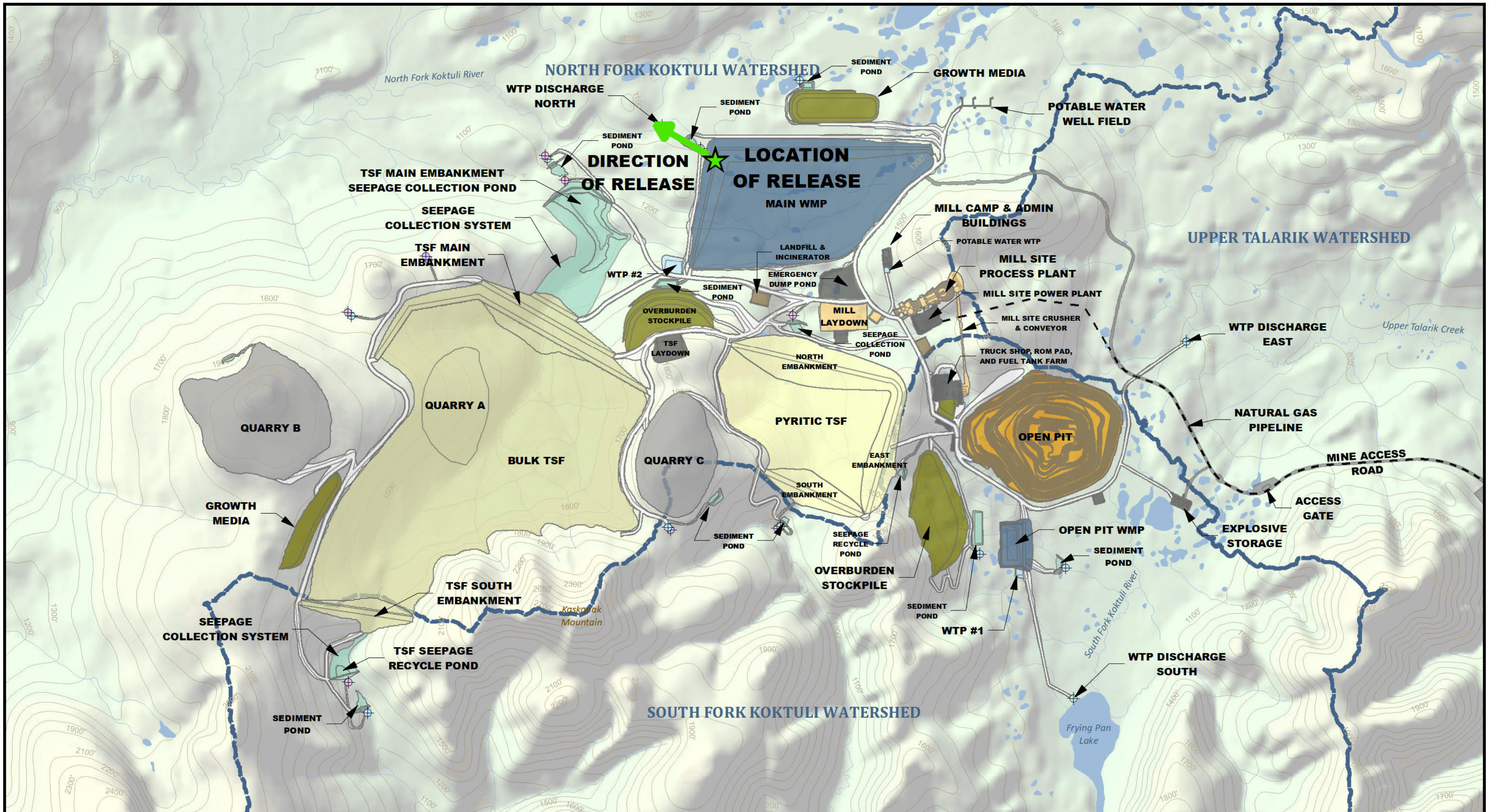
Soil could become contaminated with elevated levels of metals from the release of untreated contact water. Where contact water spills onto soils beneath the point of release at the main WMP for 1 month, some of the fluid would likely percolate into the soil column, and metals present in the contact water would adsorb onto surficial soil. Where metals in soils exceed ADEC soil cleanup level guidelines, soils could be excavated to the extent practicable and the impacted habitats could be restored. If contaminated soil is not fully recovered, some contaminated soil would remain at the site of the release. Ongoing monitoring could detect remaining elevated levels of metals, and additional excavation could be carried out as needed.

Erosion

Some temporary, low-intensity soil erosion could occur at the point of release beneath the failed embankment. No significant soil erosion would occur downstream due to the very low volume and slow release of the contact water. Soil erosion damage beneath the embankment could be stabilized following the release.

Surface Water Hydrology

There would be no measurable impact to surface water hydrology due to the low volume of the release. The released flow would be well within the range of the natural 2-year flood.



Sources: KP 2018q; PLP 2019-RFI153

US Army Corps of Engineers®

0.5 0 0.5 1

Miles

Location of Release

Direction of Release

Alternative 1a

GW Quality Monitoring and Pump Back

Water Quality Monitoring Point

Natural Gas Pipeline

Bulk Tailing Storage Facility

Mine Site Infrastructure

Mineral Processing Facilities

Onsite Access Roads

Open Pit

Pyritic Tailings Storage Facility

Quarries

Sediment/Seepage Collection Systems

Stockpiles

Waste Management Facilities

Water Management Ponds

Water Treatment Plants

Other Features

River/Stream

Lake/Pond

Watershed

100' Contour (Existing)

UNTREATED CONTACT WATER RELEASE LOCATION

PEBBLE PROJECT EIS

FIGURE 4.27-8

Water and Sediment Quality

Surface Water Quality

Metals—Under this scenario, untreated contact water with elevated metals concentration would be released to Tributary NFK 1.120 and transported downstream (Knight Piésold 2018q). Metals that would be present at levels above WQC in the untreated contact water include aluminum, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, nickel, selenium (a metalloid), silver, and zinc (Knight Piésold 2018q) (see Table K3.18-1 and Table K4.18-3).

Released contact water would be rapidly diluted by stream water. The amount of dilution is dependent on the level of streamflow in the drainage at the time. The scenario would occur during spring break-up, so downstream modeling of metals concentrations was completed for streamflows during the months of April, May, and June.

As summarized below and in Figure 4.27-9, modeling results indicate that concentrations of several metals would exceed applicable WQC in the downstream drainages following the spill. In Figure 4.27-9, the points along the drainages labeled "Dilution Ratio Achieved" indicate the point at which metals would be diluted to within WQC for the particular mean monthly streamflow. The metals that would be present in the highest concentration would be cadmium, lead, manganese, molybdenum, and zinc. Copper levels in the released fluid would also be elevated above the most stringent WQC (Knight Piésold 2018q). Depending on flow conditions, several metals would exceed their WQC as follows (downstream distances estimated from Figure 4.27-9):

- Molybdenum would exceed its WQC for about 15 to 45 miles downstream.
- Cadmium would exceed its WQC for a shorter downstream distance than molybdenum; cadmium would require 60 percent of the dilution required by molybdenum.
- Lead, zinc, and manganese would require less than one-quarter of the dilution compared to molybdenum; therefore, concentration of these metals would exceed their WQC for a shorter downstream extent compared to molybdenum.
- Copper would require about 10 percent of the dilution required by molybdenum, and would be diluted to below its WQC within several miles of the release site.

These metals would remain at elevated levels above WQC for a month or more during and after the release. See Appendix K4.24, Fish Values, for discussion of metals toxicity.

The formation of secondary metal salts is not likely from this scenario, due to the strong amount of dilution of released metals by downstream waters. The formation of secondary metal salts would require years. Impacts to water quality from dissolution of secondary metal salts would be the same as those noted above for other released metals.

Acid—Impacts from acidic conditions would not occur in this scenario. Contact water from the main WMP would have a relatively neutral pH of 7 to 8 (Knight Piésold 2018a), and would therefore not contribute to acidic conditions.

Sediment Quality

A small amount of metals carried in downstream flows could be incorporated into streambed sediments over the month-long release. Due to the high level of surface water dilution, however, this would likely not be a measurable impact.

Groundwater Quality

At the release site adjacent to the main WMP, some of the untreated contact water would likely mix with shallow groundwater. To reduce the potential for discharge of contaminated groundwater into the NFK watershed, monitoring/pumpback wells would be installed in the area around the main WMP (see Section 4.17, Groundwater Hydrology). Should monitoring of these wells show groundwater contamination from the release, the wells would be used to intercept and recycle shallow groundwater back to the main WMP, to then be treated and released.There is also potential for shallow groundwater downstream of the release site to be contaminated with elevated levels of metals from the month-long release of untreated contact water. There are numerous shallow aquifers throughout the downstream area, and many losing segments of downstream drainages where surface water enters groundwater. Metals present in the released contact water could potentially permeate through soils and sediments into shallow groundwater during the month-long release.

Due to the strong dilution of surface water and groundwater that would occur, it is likely that metals would be diluted to below ADEC groundwater cleanup levels. However, in the event of a spill, monitoring wells could be installed to assess the extent of contamination, and the site could be remediated, as addressed above for Groundwater Quality under the pyritic tailings release scenario. Containment of affected groundwater would be monitored using monitoring/pumpback wells to assess groundwater quality (Knight Piésold 2018a), and the groundwater in the area could be monitored for metals content.

The State of Alaska may require ongoing monitoring and reclamation work as it deems necessary. See Section 4.18, Water and Sediment Quality, for additional potential monitoring and mitigation of contaminated groundwater.

Noise

No impacts.

Air Quality

No impacts.

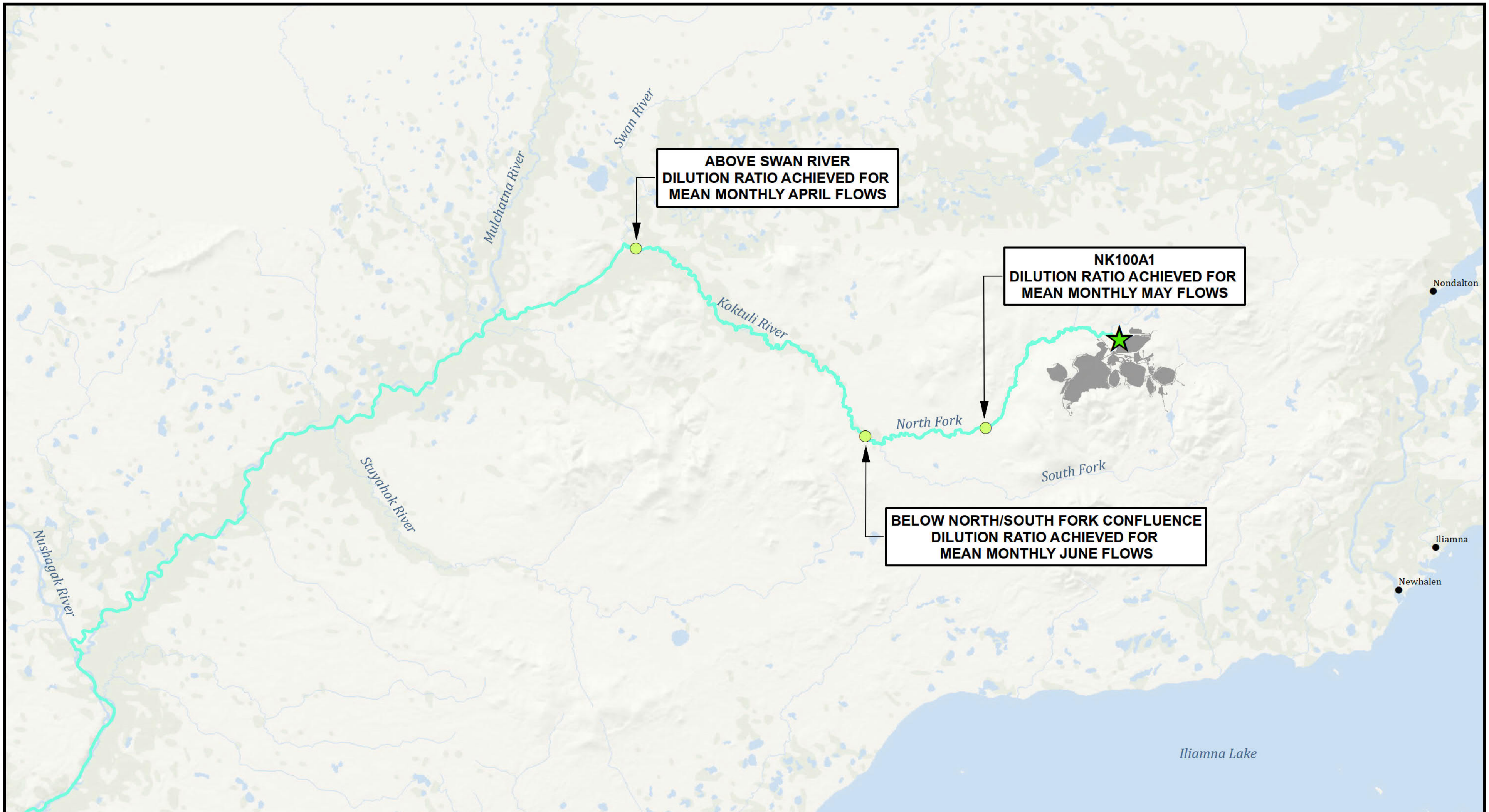
Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

There is a high likelihood that vegetation or wetlands near the seepage area at the main WMP would be affected by soils contaminated with elevated levels of metals from the released contact water. Metal-related toxicity could have acute or chronic effects on vegetation or wetlands. The results may be mortality or reduction of growth.

Any soil erosion at the point of release beneath the embankment would also affect vegetation, and any wetlands or special aquatic sites present. No significant soil erosion is expected due to the very low volume and slow release of the contact water.

Vegetation would be impacted because it would occur during early spring, when plants are actively growing and more likely to absorb contaminants. See Appendix K4.24, Fish Values, for discussion of metals toxicity.

The geographic extent of impacts would be limited to the area directly downgradient from the seepage area. The duration of impacts could range from a few growing seasons (for vegetation recovery in eroded areas) to long-term (if metal-related toxicity occurs), pending habitat restoration efforts.



Sources: KP 2018q; PLP 2019-RFI153

US Army Corps of Engineers

5 0 5 10

Miles

Location of Release

Dilution Ratio Achieved

Modeled Rivers

Mine Site

MODELED EXTENT OF ELEVATED METALS DOWNSTREAM OF UNTREATED CONTACT WATER RELEASE

PEBBLE PROJECT EIS

FIGURE 4.27-9

Terrestrial Wildlife

Several potential impacts can be inferred based on a literature review of toxicology for several metals on various wildlife species. An analysis of the various metals and their acute and chronic levels for fish are detailed in Chapter 8 of the EPA Bristol Bay Watershed Assessment (EPA 2014). Because fish are an important part of the food chain for terrestrial mammals such as brown bears, wolves, and others, impacts to fish may result in impacts to these species. Impacts may include altered foraging locations (if fish levels are reduced), potential for increased competition, and decreased fitness through increased energy expenditure to find resources.

There are multiple pathways that metals in the environment can have impacts on wildlife species. Species can directly consume water that is high in metals; they can consume vegetation that has absorbed metals; they can consume contaminated soil; and they can consume various trophic levels of organisms that have in turn consumed metals. One way to predict the ecological risk of metals to species is to understand the ability of different metals to bioaccumulate and biomagnify in the environment and within organisms (Mann et al. 2011). The metals with the highest concentrations in the released water, which would require the most dilution to reach water quality standards, are discussed in the following paragraphs (see Appendix K4.24, Fish Values, for additional discussion of metals toxicity).

Molybdenum, the metal with the highest concentration in the released contact water (that would remain above WQC for 45 miles downstream of the release location for a month), can cause a disease in ruminants called molybdenosis. Water-soluble molybdenum is readily absorbed by plants (especially aquatic plants/macrophytes and riparian plants) and incorporated into vegetation (Fitzgerald et al. 2009). Water-soluble molybdenum is also taken up by fish and mammals and excreted by the kidneys. However, when ruminants such as moose and caribou feed on molybdenum-rich vegetation, the molybdenum reacts with sulfur in the rumen and causes copper to become biologically unavailable (Swank and Gardner 2004). This causes molybdenosis, in which copper deficiency has been implicated in the death of moose in Sweden (Fitzgerald et al. 2009). The proper balance between molybdenum and copper in ruminant forage is necessary to prevent the disease. Several studies have been conducted around mines in British Columbia, Canada to assess the potential for molybdenosis in ruminants in the surrounding habitat. One study associated with Brenda Mines looked at the potential risk for moose contracting molybdenosis by consuming forage high in molybdenum (Fitzgerald et al. 2009). Field studies in 1999 and the following decade documented no moose suffering from molybdenosis despite elevated levels of molybdenum in the vegetation. Therefore, although a ratio of too much molybdenum to copper may cause molybdenosis, the exact ratio for moose is unknown, and the ability of moose to browse on a variety of forage species across a wide area makes them less likely to suffer the impacts of the disease.

Other metals in higher concentrations that would require more dilution to reach water quality standards include cadmium, copper, lead, manganese, and zinc. The relative toxicity of cadmium to mammals is considered moderate to high, because they have no effective mechanism for elimination of ingested cadmium, and it can accumulate in the liver and kidney. In addition, cadmium is considered highly toxic to aquatic organisms at low concentrations (Gough et al. 1979). Lead is a well-documented metal that causes various levels of poisoning. Lead can be ingested, inhaled, and directly consumed (as fragments in prey sources). Both acute and chronic lead poisoning has been detected in a variety of species from cattle and horses near smelters, to wildlife in zoos (Gough et al. 1979). Zinc and manganese are relatively non-toxic to mammals; therefore, elevated levels based on the spill scenario are not considered to be a risk to wildlife. The final metal at elevated levels that would require several miles of dilution is copper. Copper at high concentrations in bioavailable form is acutely toxic to fish; it does not readily bioaccumulate and does not biomagnify (Cardwell et al. 2013). Copper toxicity in mammals is insignificant because they possess barriers to copper absorption (Gough et al. 1979). Therefore, fish that are killed by exposure to copper are unlikely to pose a hazard to species that may feed on them.

Other metals in the released water may cause impacts to terrestrial wildlife species, but on a small, more localized scale due to lower concentrations in the released water. One such metal is mercury, which biomagnifies when present as methyl mercury, which is formed under anoxic conditions; is readily bioaccumulated by algal species; and subsequently biomagnified through trophic transfer (Mann et al. 2011). Species such as river otters and bears can bioaccumulate mercury from fish (Mann et al. 2011).

In summary, terrestrial wildlife species would be impacted from increased levels of metals in the NFK, given the wide range of potential metals, varying concentrations, their abilities to be absorbed and cause toxicity, and impacts to fish. Generally, carnivorous species show higher biomagnification compared to herbivorous species (Mann et al. 2011). The duration of impacts is expected to occur for at least a month during the spill, and for several months afterwards, depending on the actual toxicity levels for fish. The duration may increase to years depending on impacts to fish. The extent would stretch from the location of the spill downstream in the NFK until the confluence of the Swan River, at which point all metals would be diluted. The distance for which various metals would be diluted would vary, depending on stream flows during the release. The actual extent of impacts from metals on various wildlife species is expected to be much shorter, occur closer to the location of the spill, and be directly related to altered prey. Therefore, the extent to which salmon and other prey species experience impacts would parallel the extent of impacts to wildlife species.

Birds

Impacts are anticipated to primarily affect piscivorous (fish-eating) birds and birds that consume aquatic invertebrates and aquatic vegetation. The magnitude of impacts would be highest during spring, summer, and fall when migrating and breeding birds and their young are present. Although direct impacts of toxic metals biomagnification in birds is dependent on the specific concentrations of metals in prey items, some metals are known to cause serious deleterious impacts on avian species. Lead poisoning in birds is a well-documented occurrence and may occur through ingestion of lead particles (Mann et al. 2011), as well as ingestion of lead in soil substrates and aquatic vegetation. In some cases, lead poisoning in waterfowl has led to several population declines. A study of tundra swan (*Cygnus columbianus*) mortality events from 1987 to 1989 in the Coeur d'Alene River system in northern Idaho revealed that swans were ingesting lead and cadmium from contaminated sediment and aquatic vegetation (Blus et al. 1991). In the Coeur d'Alene River system, die-offs of waterfowl have occurred since at least the early 1900s from mining and smelting activities, in which large quantities of mining wastes were dumped into the South Fork of the Coeur d'Alene River for several decades. The lead levels examined by Blus et al. (1991) indicated that tundra swans accumulated high levels of lead from ingestion of sediment. Even though birds only spent a few weeks in the areas during spring migration, the amount of lead consumed through sediment and vegetation was lethal. Although the die-off events of birds analyzed by Blus et al. (1991) are not comparable to predicted impacts from the project, the study highlights how birds can suffer mortality by ingesting metals from contaminated sediment and vegetation.

Lead continues to be a threat for several raptor species, such as bald and golden eagles (*Aquila chrysaetos*). Lead poisoning may result in toxic results such as damage to the nervous system, paralysis, and death. At lower sub-lethal concentrations, lead can cause damage to tissues and organs, damage to the immune and reproductive systems, elevated blood pressure, and neurological impairments (Rattner et al. 2008). Species that occur in the vicinity of the SFK that may be impacted include waterbirds, waders, raptors, and some shorebird species that consume freshwater invertebrates and fish.

Other metals may be harmful to avian species, similar to those mentioned above for terrestrial wildlife, although the precise pathways for consumption and absorption may be different. An additional metal where elevated concentrations can result in toxic effects is selenium. Elevated selenium has caused adult mortality, reproductive failure, embryonic mortality, and developmental abnormalities in several aquatic bird species (Martinez 1994). Selenium is bioaccumulated in aquatic habitats, and biomagnification can occur when predators consume selenium-rich prey (such as fish and invertebrates; Martinez 1994). Selenium poisoning may persist for several generations and can be passed from parents to offspring through their eggs (Mann et al. 2011). Selenium concentrations generally accumulate in waterbodies such as ponds and lakes that are not readily flushed. Therefore, although the potential duration of impacts may extend beyond the initial period of exposure to elevated levels of selenium, the flushing of the system by rain and snow melt would reduce impacts of elevated selenium through dilution.

One final metal that is bioaccumulated and biomagnified is mercury. High body burdens of mercury are known in birds as a result of consuming aquatic invertebrates and fish. Elevated levels of mercury may result in several neurological disorders in predatory birds (Mann et al. 2011) (such as bald eagles) (see Appendix K4.24, Fish Values, for additional discussion of metals toxicity).

In summary, birds may be impacted by increased metals concentrations in the NFK. A wide variety of species may be both directly and indirectly impacted through exposure to metals. The toxicity of certain metals to avian species and their prey is related to the amount of dilution that occurs in the NFK. It is possible that some sub-lethal impact to avian species may result from consumption of high concentrations of metals in the water, and prey sources in the area immediately downstream of the spill. The duration may last for several weeks during the spill, but sub-lethal chronic impacts may last longer, depending on the amount of dilution and specific location where contaminated water extends. The extent of impacts would extend several miles downstream until metals concentrations are diluted to within water quality standards. Overall, avian species may experience localized impacts to breeding, feeding, wintering, and migrating habitat.

Fish

Potential impacts to fish from the release of untreated contact water would be similar to those described above for elevated metals impacts from the pyritic release scenario.

The spatial extent of the WQC exceedances are more limited than in the previous scenario, but the duration of exceedances are longer (months compared to weeks). The conservative nature of the WQC, species sensitivity differences, and results of the toxicity tests using mine site process water samples are discussed in greater extent under the previous scenario. Of particular importance is the assumption (under this scenario) that the metals released via the contact water spill are 100 percent bioavailable. As discussed previously, several factors are likely to limit metals bioavailability when they are released to surface water, including binding by natural ligands (such as dissolved organic matter) and binding phases on particulates. EPA's recommended aquatic life WQC for copper is based on the Biotic Ligand Model to account for various factors that modify its aquatic toxicity (EPA 2007b). Metals bioavailability in the current evaluations presents uncertainties, but site-specific toxicity tests (as discussed previously) are indicative of limited impacts on fish species. An undiluted aqueous sample from the mine site that was used in the previously described toxicity studies (Nautilus Environmental 2012; described above for the pyritic tailings release) is also understood to be representative of the untreated contact water, although there is uncertainty regarding the representativeness of the sample. The toxicity tests did not demonstrate acute and chronic toxicity to fish species, including rainbow trout and fathead minnow. No impact was observed on survival of water flea neonates, but their reproduction was adversely affected when exposed to 12.5 percent or higher aqueous sample (by volume); or 8 times dilution or less. These results indicate chronic exposures for 7 days or more to tailings fluid at lower dilutions in the streams could have sub-lethal effects on sensitive aquatic species, but likely less so on fish species.

Based on the above considerations, acute toxicity due to metals would not occur. However, prolonged exposure (beyond months) to metals concentrations in slight exceedance of WQC may result in sub-lethal effects. See Appendix K4.24, Fish Values, for further discussion of metals toxicity. Impacts of these potential sub-lethal effects would be limited temporarily (within months) and spatially (to less than several miles). Therefore, the overall magnitude of the toxic effects of metals would be limited under this scenario.

Threatened and Endangered Species

No impacts to TES are anticipated from the scenario, because none of the released water would contact Cook Inlet, and would be within water quality standards prior to reaching areas in Bristol Bay with TES.

Marine Mammals

No direct impacts to marine mammals are anticipated, because metal concentrations would be diluted to within water quality standards prior to reaching Nushagak Bay and beyond. Although acute toxicity to fish is not predicted, sub-lethal effects may extend the duration of impacts. Loss of prey (primarily salmonid species) may indirectly impact marine mammals. The magnitude would be low, because marine mammals would have other species to feed on. The impacts of sub-lethal effects of fish may extend the duration, depending on the amount of time necessary for salmon to recover; however, it would be difficult to determine if there is a correlation between a reduction in salmon and marine mammal impacts in Nushagak Bay. As detailed previously under the bulk and pyritic tailings release scenarios, beluga whales in Nushagak Bay have an abundance of salmon, and do not appear to be constrained by a lack of salmon. The minor temporary loss of a small portion of salmon from the contact water release scenario is not expected to impact the prey base for beluga whales. Furthermore, although beluga whales swim upstream in the early spring and summer to feed on rainbow smelt and outmigrating salmon smolt (Citta et al. 2016), they do not range far enough upstream to reach areas that would have elevated levels of metals.

Needs and Welfare of the People—Socioeconomics

No employment opportunities would be created by a contact water release, because cleanup crews would be small and likely consist of PLP personnel.

Over the longer term, the impacts on employment, income, and sales would be negative if commercial and recreational fishing and/or tourism were to suffer due to the real or perceived impacts of the release. Real or perceived water contamination could also negatively impact local business and consumers.

Environmental Justice

Impacts from a tailings release would not impact socioeconomics, but subsistence and health and safety could be impacted. Taken as a whole, adverse impacts from the spill event would disproportionately impact minority and low-income communities. There would be interrelated subsistence, health, and socioeconomic impacts to the minority and low-income communities in the area.

Recreation

In the event of a contact water release, the spill and response effort would have little effect on recreational resources. There would be no displacement of recreational activities or impacts to recreational setting from cleanup equipment.

Commercial and Recreational Fishing

As noted previously, the release of contact water would result in sub-lethal effects, which would be limited to several weeks and to within about 45 river miles downstream of the mine site. Temporally and spatially limited sub-lethal effects would not be expected to affect the commercial fishery, as long as those effects do not result in a change in the number of returning adult salmon in future years. Recreational anglers fishing these waters could experience a temporary reduction in harvest rates or catch per unit effort rates if the sub-lethal effects reduced target species' ability or desire to feed/strike at anglers' lures.

Cultural Resources

Direct impacts to cultural resources from a potential water contact spill would be similar to the tailings scenarios discussed above. It would directly impact cultural resources along the NFK if ground-disturbing response efforts occurred within the bounds of a cultural resource area or known or potential historic property site. These impacts could include contamination of organic cultural materials and site sediments. Such an event would likely result in direct impacts through loss of integrity for eligibility to the National Register from cleanup activities. These impacts would likely severely damage the site, and resources would not be anticipated to return to previous levels even after actions that caused the impacts were to cease. Indirect impacts could occur to the setting (visual, noise, and olfactory impacts) of cultural resources if the spill were to occur in the vicinity. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Those impacts would be temporary, and would cease when response efforts are complete.

Subsistence

Some subsistence resources downstream of the release could experience toxic effects. The duration of impacts to subsistence resources is expected to occur for months or possibly years, depending on the actual toxicity levels for wildlife and fish. The extent would stretch from the location of the spill downstream in the NFK until the confluence of the Swan River, at which point all metals would be diluted enough to meet water quality standards. The contact water release would likely cause concerns over contamination for subsistence users that harvest in areas downstream from the release, and could cause users to avoid the area and alter their harvest patterns. The delayed detection and invisible nature of the release could create uncertainty and anxiety, and could undermine public confidence in the safety of the resource even after the impacts of the release have faded. A system of testing wild foods and communicating the results to local people in a timely manner could help mitigate these concerns.

Health and Safety

No overbank flooding would occur due to this scenario. There are no nearby downstream human habitations. The closest village downstream is New Stuyahok, 105 miles downstream by way of the NFK. Therefore, there would be no safety risk due to flooding from this scenario.

Modeling results show that surface water quality would be impacted for a maximum of 45 miles downstream of the mine site. Downstream communities rely on groundwater wells for drinking water. No measurable impacts to groundwater would be expected from this scenario, although groundwater contamination could be perceived. Perceived contamination of the environment and subsistence foods may affect community concerns about access to, and quantity and quality of subsistence foods (e.g., salmon), which can affect the socioeconomic status, emotional well-being, food security, and dietary patterns of local communities; this concern may extend throughout the extended spills analysis area. Restricted access to the environment (e.g., due to real or perceived contamination) may result in decreased mental health and increased psychosocial and family stress, substance use, suicidal tendencies, and cardiovascular disease (Dillard et al. 2012; Gibson and Klinck 2005).

There are potential adverse impacts to social determinants of health (HEC 1), with psychosocial stress resulting from community anxiety over a release of untreated contact water, particularly in areas of valued subsistence and fishing activities. Subsistence and food security may be impacted, with potential perceptions of subsistence food contamination that could extend throughout the area (HEC 4). Reliable and prompt communications about environmental and subsistence food impacts, or lack thereof, would alleviate psychosocial stress, reduce impacts to subsistence and food security, and allay other public health concerns. Impacts would vary in duration and be limited to the area of the spill. Table 4.27-1 summarizes variations in spill risk by alternative for each spill scenario.

4.27.10 Cumulative Effects

The geographic extent of potential impacts of the spill scenarios extends beyond the EIS analysis area for other potential impacts analyzed in the EIS. The "Spills Impact Analysis Areas—Affected Environment" at the beginning of this section describes the extended analysis areas addressed throughout.

The same methodology assumptions used to evaluate impacts associated with potential spill risk also applies to the cumulative effects analysis of spill risk. This includes assumptions about tailings dam failure and the fate and behavior of tailings should there be an accidental release. Similarly, diesel fuel is being offloaded, stored, and transferred under the alternatives evaluated in this EIS. In both cases, the reasonably foreseeable future action associated with Pebble Project expansion would extend the operating life of the mine and the volume of material with a potential for spill risk over a period of time.

4.27.10.1Past and Present Actions

Given the limited nature of community, infrastructure, and project development in the area of analysis, past and present spills would primarily be related to the storage and transportation of petroleum products; would be relatively small in volume; and have effects that are limited to the area of the spill. These would include onshore and offshore pipeline leaks, marine spills in Cook Inlet, small spills in Iliamna Lake, fuel tank spills in existing communities, and vehicle rollover spills on community roads. Any past or present spills that have had an impact on the physical, biological, and social environment have been addressed in Chapter 3, Affected Environment, for specific resources that have been affected.

4.27.10.2 Reasonably Foreseeable Future Actions

Because spills (unintended releases) associated with project construction and operation are not a planned or routine event, they are not typically analyzed for cumulative effects as an element of a specific Reasonably Foreseeable Future Action (RFFA); where they are analyzed, quantitative information on the mode of failure, probability, and volume of potential spills has not been available or is based on assumptions that are not relevant or have not been substantiated. This section provides a qualitative analysis of potential spills associated with RFFAs.

RFFAs that could contribute cumulatively to effects on spill risk in the cumulative effects analysis area include those activities that would occur in the Nushagak River or Kvichak River watersheds, or in other waterbodies intersected by the transportation and pipeline corridors in both Bristol Bay and Cook Inlet watersheds and marine waters of Cook Inlet. RFFAs that could contribute cumulatively to effects on spill risk, and are considered in this analysis include: Pebble Project expansion scenario; mining exploration activities for Pebble South/PEB, Big Chunk South, Big Chunk North, Fog Lake, and Groundhog mineral prospects; offshore oil and gas development; and road improvements and the continued development of the Diamond Point Rock Quarry.

The No Action Alternative would not contribute to cumulative effects related to spill risk.

The RFFA contributions to cumulative effects on spill risk are summarized by alternative in Table 4.27-3.

Table 4.27-3: Contribution to Cumulative Effects on Spill Risk

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Pebble Project Expansion Scenario	**Mine Site**. The Pebble Project expansion would have an additional larger bulk TSF, an additional larger pyritic TSF, larger/additional fuel storage facilities, and other expanded storage facilities that would contribute to cumulative effects on spill risk through higher volumes of storage for a longer period of time. Longer-term tailings storage could allow for increased acid generation and metals leaching from stored tailings, depending on storage conditions, resulting in deteriorating water quality of supernatant ponds. The main WMP would be used beyond its original 20-year operational life, and may be at an increased risk of failure as it ages. Portions of the north WRF and north WRF collection pond would be in the UTC watershed. Waste rock storage facilities are stabilized structures, and drainage is collected, treated, and released; spill risk would be similar to that discussed previously under TSF seepage collection ponds, with the exception that there is the potential for an unintentional release in the UTC watershed under Pebble Project expansion. The Pebble Project expansion and associated development would be similar for all alternatives. The Pebble Project expansion scenario could involve the use of cyanide at the mine site, introducing new spill risk. Any cyanide used would be destroyed on site. **Other Facilities**: A north access road and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment, and extended to a new deepwater port site at Iniskin Bay. The spill risk of large spills of concentrate and diesel from the ferry into Iliamna Lake would be	**Mine Site**: Identical to Alternative 1a. **Other Facilities**: Similar to Alternative 1a, except that the mine access road would extend south to the north ferry terminal instead of the Eagle Bay ferry terminal. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. **Magnitude**: Similar to the magnitude of Alternative 1a. **Duration/Extent**: Similar to duration and extent of Alternative 1a. **Contribution**: The contribution to cumulative effects would be similar to Alternative 1a.	**Mine Site**: Similar to Alternative 1a. **Other Facilities**: The spill risk of a natural gas release from the gas pipeline into Iliamna Lake would be eliminated, because the pipeline would not traverse the lake. The north access road would be extended east from the Eagle Bay ferry terminal to Iniskin Bay. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. **Magnitude**: Similar to the magnitude of Alternative 1a, except that there would be no spill risk of natural gas release to Iliamna Lake. **Duration/Extent**: Similar to duration and extent of Alternative 1a. **Contribution**: The contribution of spill risk to cumulative impacts for Alternative 2 would be similar to Alternative 1a, except for elimination of	**Mine Site**: Similar to Alternative 1a. **Other Facilities:** The spill risk of large spills from the ferry and releases from the natural gas pipeline into Iliamna Lake would be eliminated, because materials would be transported by road and/or pipeline instead of ferry. Overall expansion would use the existing north access road; Concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay. **Magnitude**: Similar to the magnitude of Alternative 1a, except for reduced spill risk to Iliamna Lake. **Duration/Extent**: Similar to duration and extent of Alternative 1a. **Contribution**: Alternative 3 would eliminate the spill risk of a large spill from the ferry into Iliamna Lake; other spill risk contributions to cumulative impacts would be similar to Alternative 1a.

Table 4.27-3: Contribution to Cumulative Effects on Spill Risk

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	eliminated once those materials are transported by pipeline instead of ferry. Potential diesel and concentrate spills from the pipelines could result from leaks, involving small quantities of spilled material; or from a pipeline rupture, which would be a low-probability event involving a higher spill volume. The consequences of potential diesel spills as a result of truck transportation have been discussed previously in this section, and the environmental impacts from a diesel pipeline spill would be similar in terms of resources and geographic areas that are affected. The probability and consequences of a concentrate pipeline spill have been previously addressed in this section, and would likely be similar in terms of resources and geographic areas that are affected. If the Pebble Project expansion scenario includes a larger-diameter concentrate pipeline, then spilled volumes could be larger. Risk of spills from diesel and concentrate pipelines could increase over the additional decades of operation due to deterioration of the pipelines, such as from corrosion, if pipelines are not maintained/replaced as needed. There would continue to be a spill risk for transport of molybdenum concentrate, reagents, and other materials transported by road, as described above. The Pebble Project expansion scenario would require increased storage of diesel at the port site. In the Pebble Project expansion scenario, there is a potential spill risk of cyanide spills at the mine site or on the transportation corridor.		the risk of a natural gas release into Iliamna Lake.	

Table 4.27-3: Contribution to Cumulative Effects on Spill Risk

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Magnitude. The Pebble Project expansion scenario would impact spill risk by increased volume of storage of tailings, waste rock, and untreated contact water across a wider footprint for an operational life that extends an additional 78 to 98 years longer than the 20-year project. Additional bulk and pyritic TSFs would be constructed with the same design features as the original TSFs. Bulk tailings storage footprint would increase from 2,797 to 7,045 acres; pyritic tailings storage footprint would increase from 1,000 to 2,560 acres. In the event of a release of pyritic tailings, the increased volume of storage could result in a larger volume of release, increasing the chance of contamination in the UTC, as described above. **Duration/Extent**: The duration and extent of cumulative impacts to spill risk would vary from temporary spill risks during construction to long-term risk during operation in the footprint of mine and other project facilities. **Contribution:** The probabilities and potential impacts of spills associated with PLP's alternatives and alternative variants have been addressed previously in this section for the following substances: diesel fuel, natural gas, copper-gold concentrate, chemical reagents, bulk and pyritic tailings, and untreated contact water. For project features and elements previously discussed in this section, it is assumed that design, construction, and operational parameters associated with expansion would be the same (such as for tailings dams, water treatment, and concentrate pipeline). However, they would be handling larger volumes of material and represent expansion of facilities over an operational life that extends an additional 78 to 98 years through			

Table 4.27-3: Contribution to Cumulative Effects on Spill Risk

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	post-mining milling, which could increase the volume and geographic extent of an unintentional release. Some project features that create spill risk, such as transport of copper-gold concentrate by truck and ferry traffic, would cease after 20 years, and be replaced by construction of additional roads and the concentrate and diesel pipelines.			
Other Mineral Exploration Projects	**Magnitude**: Mining exploration activities, including additional borehole drilling, road and pad construction, and development of temporary camp facilities, would contribute a small amount of soil disturbance at discrete locations, depending on landowner permitting and restoration requirements. For example, the 2018 drilling program by PLP consisted of 61 geotechnical boreholes and 19 diamond-drilled core boreholes with diameters ranging from 2 to 8 inches. **Duration/Extent**: Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. Table 4.1-1 in Section 4.1, Introduction to Environmental Consequences, identifies seven mineral prospects in the EIS analysis area where exploratory drilling is anticipated (four of which are in relatively close proximity of the Pebble Project). **Contribution**: There would be limited seasonal contribution from alternatives to the cumulative effects related to spill risk associated with mineral exploration.	Similar to Alternative 1a.	Similar to Alternative 1a.	Similar to Alternative 1a.
Oil and Gas Exploration and Development	**Magnitude:** Onshore and offshore oil and gas exploration activities in the western Cook Inlet area could involve seismic and other forms of	Similar to Alternative 1a.	Similar to Alternative 1a.	Similar to Alternative 1a.

Table 4.27-3: Contribution to Cumulative Effects on Spill Risk

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	geophysical exploration; and in limited cases, exploratory drilling. A large oil spill in Cook Inlet associated with oil and gas exploration could affect the project area (BOEM 2016a). **Duration/Extent:** Seismic exploration and exploratory drilling are typically temporary, seasonal activities. A large oil spill in Cook Inlet associated with oil and gas exploration could affect the shoreline of western Cook Inlet in the vicinity of the proposed port (BOEM 2016a). **Contribution:** If there were concurrent oil spills in Cook Inlet from project activities and oil and gas exploration, the spills would contribute to the cumulative effects related to spill risk.			
Road Improvement and Community Development Projects	**Contribution:** There would be no contribution from alternatives to the cumulative effects related to spill risk associated with road improvement, and community development projects.	Same as Alternative 1a.	Same as Alternative 1a.	Same as Alternative 1a.

Notes:
EIS = Environmental Impact Statement
PLP = Pebble Limited Partnership
TSF = Tailings Storage Facility
UTC = Upper Talarik Creek
WRF = waste rock facility