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
- habitat changes, including:
  - habitat loss (including vegetation removal and fill of wetlands)
  - avoidance of nearby habitat
  - fragmentation
  - spills (discussed in Section 4.27, Spill Risk)
  - fugitive dust impacts (discussed in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, and Section 4.26, Vegetation)
  - invasive species introduction or spread (discussed in Section 4.26, Vegetation)
  - changes in water quality and air quality (detailed in 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, extent, duration, 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 generally 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. The extent of impacts varies depending on the specific area of impact in relation to the species' range that may be affected. The likelihood of impacts is the potential that the impact would occur to the species or habitat if the alternative or variant is constructed and operated.

Impacts to vegetation and 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. 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 from various spill scenarios are not discussed in this impacts analysis, but are detailed in Section 4.27, Spill Risk.

The Environmental Impact Statement (EIS) analysis area (hereafter 'analysis area') for wildlife includes the project footprint for each alternative and the extended geographic area where disturbance to wildlife would be considered possible for the life of the project. The 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. Generally, the lightering locations would be encompassed by the transportation and natural gas pipeline corridor buffer; however, the alternate lightering location west of Augustine Island was not located in this corridor, and therefore had a separate buffer. Buffers are the radial distances placed around the outermost extent of the project component footprint, and encompass the area of both permanent and temporary impacts. Although many wildlife species have a much larger range than the analysis area; this section focuses on species that would be present within the analysis area during project construction, operations, and closure (i.e., for the life of the project).

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	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	3-mile radius	3-mile radius	1-mile radius

In addition to the analysis area, surveys conducted for the project often covered a much larger geographic area than the analysis area. These various 'survey areas' were generally larger than the analysis area in an attempt to assess the local wildlife populations and their distribution at the time of surveys. However, impacts from the project are only considered for species that occur within the analysis area. The various survey areas for different species are detailed in their respective sections below; and for the most part, encompassed the geographic extent of the analysis area.

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 the figures in Section 3.23, Wildlife Values. For Alternative 1, there are three proposed variants (Summer-Only Ferry Operations Variant, Kokhanok East Ferry Terminal Variant, and Pile-Supported Dock Variant); for Alternative 2, there are two proposed variants (Summer-Only Ferry Operations Variant and Pile-Supported Dock Variant); and for Alternative 3, there is only one variant proposed (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.

Pebble Limited Partnership (PLP)'s proposed mitigation incorporated into the project includes development of a Wildlife Management Plan (WMP). The plan would be developed for the project prior to commencement of construction, and the project would use best management practices (BMPs) for wildlife protection. The WMP would describe the equipment, methodology, training, and assessment techniques that would be used to minimize the potential for wildlife interaction with project activities and to minimize impacts to wildlife in the project area (see Chapter 5, Mitigation and Monitoring). The project would use BMPs for prevention, control, and management of invasive species, including implementation of an invasive species management strategy to avoid the importation of invasive species into the area due to project activities during construction, operations, and closure. Additionally, tug and barge speeds around the port and lightering locations would be reduced to less than 10 knots to reduce the potential for collision and disturbance of marine mammals and other species, such as seabirds and waterbirds.

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 proposed 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 proposed 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.

4.23.1 No Action Alternative

The Pebble Project would not be undertaken. No construction, operations, or closure activities would occur, and no additional future direct or indirect impacts to wildlife values would be expected. Although no resource development would occur under the No Action Alternative, PLP would retain the ability to apply for continued mineral exploration activities under the State's authorization process, as well as any activity that would not require federal authorization. Current State-authorized activities associated with mineral exploration and reclamation, and scientific studies would be expected to continue at similar levels. PLP would have the same options for exploration activities that currently exist. In addition, there are many valid mining claims in the area, and these lands would remain open to mineral entry and exploration. Impacts on wildlife values from these ongoing exploration activities would be expected to occur at current levels.

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

4.23.2 Alternative 1 – Applicant's Proposed Alternative

4.23.2.1 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, extent, duration, 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 within 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 noise).

A wide range of avian studies have 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, but in general optimal range is between 1 and 5 kilohertz (kHz), and 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. The ability of a bird's call to be heard can be masked by noise at a variety of levels above the ambient dBA (Dooling and Popper 2007). 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 (Shannon et al. 2016; Dooling and Popper 2007). 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 4.23-2. The calculations that derived these distance estimates, and the list of assumptions to produce the estimates are described in AECOM 2018c, *Pebble Project-Noise Concepts and Methodology*, and further detailed in Section 4.19, Noise.

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 as they are anticipated to be similar to the construction phase, but may vary depending on the type of equipment used.

Table 4.23-2: 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

[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.

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.

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; Korschgen et al. 1985; Keller 1991; 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 39 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-RFI 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 18.5 minutes during operations. 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 proposed Amakdedori port may cause disturbance, because the area currently has no port development.

Behavioral disturbances to birds in Cook Inlet could occur during pipeline 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 3.23, Wildlife Values, in terms of the extent of impacts, there are no seabird colonies within 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 located over 6 miles away. There would be a potential for impacts to foraging seabirds that are searching for food during summer months. 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 within the analysis area, the similar marbled murrelet (*Brachyramphus marmoratus*) has been documented within 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, extent, and duration 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 78 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.

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 occur 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 proposed 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, extent, and duration of potential effects on avian species that breed, stage, migrate, and winter on Iliamna Lake and at Amakdedori port would be a 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.

Power Line Collisions

Additional sources of avian injury and mortality may come from collisions with power lines or elevated structures within project components. In terms of extent, although no power lines would be located along the transportation corridor, there may be distribution lines connecting the mine site power plant with other mine-related facilities. The addition of elevated power lines, 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.

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 project life 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 from 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).

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 indirectly increase the predation on local small mammal and avian populations.

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 WMP 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. 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 WMP 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 within the project would be released back into the environment only after it meets water quality criteria as detailed in Section 4.18, Water and Sediment Quality. 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 WMP.

The predicted water quality standards in the pit lake were projected by Lorax (2018), extending from 20 years to 125 years post-closure. These values vary across the years and for the various metals that were analyzed. Although the WMP would include methods to exclude large mammalian wildlife from the pit lake, 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 waterbodies contain, and 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 metals would remain elevated above water quality standards, such as aluminum, arsenic, cadmium, copper, iron, mercury, manganese, molybdenum, antimony, lead, selenium, and zinc (Lorax 2018). The concentrations of these metals would vary throughout the decades post-closure, however, even at 125 years post-closure; these metals would be elevated above water quality standards.

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 therefore, the most likely route of exposure would be from drinking water from the pit lake. Because waterbirds would have multiple other water sources to drink from (such as nearby Frying Pan Lake to the south, and Long and Nikabuna lakes to the north) that provide higher-quality habitat, they are likely to favor those locations.

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, power lines, 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 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, fugitive dust, 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 located 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 US 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 FR 31132). Therefore, impacts to bald and golden eagles may necessitate the application for an Eagle Take Permit (81 FR 91494).

In summary, the magnitude of the impact would be removal of 9,317 acres of habitat occupied by a variety of avian species. There would be loss of territories, potential abandonment of previous nesting locations, and interspecific species completion from habitat loss. However, the project would not be anticipated to result in population-level impacts for any bird species. 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, etc. Impacts would be expected to be noted because they would affect multiple bird species across many habitat types.

4.23.2.2 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).

Waste Management and Disposal

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 WMP 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. 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 18.5 minutes.

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. Therefore, although the project transportation corridor would be primarily east of the main use area of the Mulchatna caribou herd, the anticipated level of truck traffic would be one truck passing in either direction every 18.5 minutes during a time that coincides with post-calving use of the mine site.

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 third 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, power lines, 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 power lines. 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, which was limited to a few miles around drill or trench sites, but as far 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 radio-collared data presented in Section 3.23, Wildlife Values, the core of the Mulchatna caribou herd currently does not typically range in the area of the transportation and natural gas pipeline corridors. 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 further 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 that caribou would avoid the area around the mine site and transportation corridor due to behavioral disturbance. The duration would be long term, and last for the life of the project. 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). Impacts would be expected to occur but would not be anticipated to result in local population-level effects.

Bear

Brown and black bears may experience a range of potential impacts from the project. This includes loss of habitat due to land conversion, increased mortality from vehicular collisions and defense of life and property, 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, this impacts section focuses primarily on impacts to brown bears.

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 between 1996 and 1997, a study was conducted 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).

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 18.5 minutes (including at night) during operations, and therefore, bears may avoid crossing the mine access road, especially during daytime hours.

In terms of extent, bear movement patterns around the mine site, along the transportation corridor, at the ferry terminals, and at Amakdedori port would be impacted by the project. The magnitude of the effect would be that 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 the transportation corridor or shift their movement patterns during periods of increased vehicular use. 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 WMP would detail specific parameters to prevent disturbance to bears.

In summary, the magnitude of impacts would include potential for avoidance of the mine site, the transportation corridor, and to a lesser extent, the ferry terminals and port. 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. The duration would last for the life of the project, and longer depending on how the roads are managed post-closure. The extent would include the project components and an avoidance buffer, which would likely vary depending on noise and activity levels. Because the area has a high density of bears (per Section 3.23, Wildlife Values) some individuals would experience disturbance, but impacts would not be expected to result in population-level impacts.

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 (USFWS 2000; Person 2001), 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 further, 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 (USFWS 2000; Person 2001).

Small Terrestrial Vertebrates

Some small mammals present at the mine site at the beginning of construction are anticipated to vacate the area due to presence of humans and equipment. Other species may be attracted to the mine site, due to newly created shelter. Some individual small mammals and wood frogs (*Lithobates sylvaticus*) may be more susceptible to predation during the process of mine site development as they vacate the area. Any habitat avoidance during construction and operations would be additive to the direct habitat loss at the mine site.

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.

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 WMP 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 not be anticipated to occur at the mine site and Amakdedori port due to the low speeds vehicles would likely be traveling, and therefore they are not discussed herein. 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 (including mileage from spur roads to Iliamna and Kokhanok). As previously detailed, during operations, daily truck traffic would equate to one truck every 18.5 minutes. A regulated speed limit on the gravel transportation corridor roads would be maintained for dust suppression and safety. 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 is unknown. The WMP 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.

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 regular presence of equipment, vehicles, and humans, would likely cause caribou to avoid the area altogether, which would reduce the potential for injury or mortality. Additionally, the WMP 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 site and mine access road, because few caribou were detected around the ferry terminals, port access road, and the port.

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).

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. 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 construction vehicles typically travel at slower speeds that would reduce the risk of collisions, 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. 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. However, the transportation and natural gas pipeline corridors contain higher-quality moose habitat. The vegetation is taller and dense, and vehicles would likely be traveling at higher speeds. Therefore, there would be a greater potential for moose injury or mortality while crossing the 78 miles of road in the transportation corridor. This risk would be greatest around dawn and dusk, when moose are typically more active; during winter; and during periods of low visibility.

In summary, the magnitude of impacts would be that few individual moose could experience injury and mortality, especially because moose density is low within the analysis area. The duration would last for the life of the project and possibly longer, if any roads would be left in place after closure. The extent would include all project components, but primarily be located around the mine and port access roads. 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 causing reduction in brown bear populations 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-olds or no cubs (Boulanger and Stenhouse 2014).

The port access road would be located 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 Alaska Department of Fish and Game (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 located 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 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. In terms of magnitude of the impact, the number of bears that may potentially suffer injury or mortality along the transportation corridor across the life of the project would likely fluctuate in relation to the location of resources, movement corridors, time of day, and season.

There would 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. Implementation of a WMP would be anticipated to minimize the potential for conflict between wildlife and humans. 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.

In summary, the magnitude of impacts would be expected to be that individual bears may be killed along the access roads and during defence 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 a food-conditioned bear 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; and regulated speed limits on the access roads, and guidance provided in the WMP 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 within the analysis area. The duration would last for the life of the project, and extent would include the entire project footprint. This impact would not be expected to cause any population-level impacts for wolves.

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 mammal and wood frogs that have limited abilities to move away or avoid heavy machinery. In terms of extent, some species 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. Given speed restrictions and the noise of heavy equipment moving along the road, the risk of injury or mortality due to collisions with some wildlife on the road may be reduced. Some species, such as Arctic ground squirrels (*Spermophilus parryii*), 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.

In summary, the magnitude and extent of impacts may include mortality of individual small mammals along the 78 miles of new roads. 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. Due to speed limits, vehicles would move slower within the mine site and hence the potential for vehicle collisions would be reduced. There would be the potential for injury or mortality, especially since smaller terrestrial wildlife may forage along roadsides and experience mortality.

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 9,317 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 would be anticipated to 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.

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

As described previously in Section 3.23, Wildlife Values, the mine site is in the range of the Mulchatna caribou herd. Although the mine site does not appear to be currently used by the herd for calving, the habitat in the mine site may be used by the herd 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 (Lanen 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. 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. Therefore, construction and operations of the mine site would represent a direct loss of 8,129 acres of post-calving summer habitat. In addition to removal of habitat, per Boulanger et al. 2012, caribou avoided area 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.

Loss of habitat from development of the ferry terminals, Amakdedori port, and the transportation and natural gas pipeline corridors represents habitat that is not currently used extensively by caribou.

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. There may be additional acreage of avoidance around the mine access road, ferry terminals, and port. However this habitat loss is not currently in the center of the Mulchatna caribou herd annual range. The duration would last for the life of the project, and potentially longer, depending on the level of human activity post-closure. Because the pit lake would not be filled in and restored, it would represent a permanent loss of habitat. The extent of impacts would include the analysis area around 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 9,317 acres of habitat loss 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 of 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 9,317 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 preferred denning habitat (such as near Amakdedori port), and other locations of seasonal food sources. 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, in particular 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 328 feet of roads, resulting in additional habitat loss (McLellan and Shackleton 1988). Based on the location of highest bear density, a 328-foot-radius buffer around the port access road, south ferry terminal, and Amakdedori port would result in an additional 3,680 acres of habitat loss through avoidance. In terms of impact magnitude and duration, a large portion of the project would be restored following closure of the mine; therefore, the actual amount of permanent habitat loss would be less.

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 habitat loss may reach 13,000 acres (9,317 acres of direct impacts plus 3,680 acres of habitat that would be avoided along the port access road). There may be additional habitat avoidance around the mine site, mine access road, and north ferry terminal. The indirect habitat loss through avoidance may include loss of foraging and denning locations, and may result in increased interspecific competition. The duration would last for the life of the project and longer, because the pit lake would represent a permanent loss of habitat. 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.

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 the Amakdedori port. The magnitude of habitat loss would be 9,317 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 Chapter 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 hoary marmot (*Marmota caligata*), Arctic ground squirrel, snowshoe hare (*Lepus americanu*s), 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 and likely repopulated by these species, but the pit lake would remain a permanent loss of habitat. In summary, the magnitude of habitat loss would be 9,317 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 and would be expected to occur if the project is permitted and constructed.

4.23.2.3 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 mammal populations through behavioral disturbance and habitat changes, as detailed in the following sections. Injury and mortality of marine mammals would not be anticipated to be factors as a result of any of the components of the project, 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 addition, other mitigation measures to prevent vessel strikes are discussed in Chapter 5, Mitigation and Monitoring.

Impacts from the construction and operations of the proposed 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; pile driving and other 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, and the construction of the Amakdedori port. 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.

Noise sources are previously described in Section 3.23, Wildlife Values, for non-federally listed marine mammals. Potential environmental consequences to threatened and endangered marine mammal species are discussed separately in Section 4.25, Threatened and Endangered Species. Where available, species-specific information is discussed regarding potential impacts from published literature; otherwise, potential impacts to all marine mammals are discussed.

Behavioral Disturbance

Underwater and Airborne Noise

The effects of underwater and airborne sound from industrial activities on marine mammals might 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). Impacts to federally listed marine mammals would be the same for non-federally listed species, and therefore, the detailed analysis on noise impacts to federally listed species in Appendix K4.25 and the Biological Assessments in Appendix G and Appendix H are relevant, and provide information on acoustic thresholds from project activities.

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 to a lesser extent, operations at Amakdedori port.

Vessel and aircraft noise generally does not exceed thresholds that may result in injury, but pile-driving noise may exceed injury thresholds. A discussion on project noise is presented in Appendix K4.25. The locations of the north and south ferry terminals would be far enough away from harbor seal haul-out sites to prevent exceedance of airborne thresholds from construction and operations.

The magnitude of impacts from underwater and airborne noise on marine mammals would be expected to affect marine mammals if they are present during construction and operations. Underwater noise from ice-breaking operations in Iliamna Lake could displace harbor seals from overwintering sites. During periods when Iliamna Lake is covered in ice, seals may 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). In winter months when ice breaking would occur, seals have historically been located on the eastern portion of the lake, east of an imaginary line between Kokhanok and Newhalen, where small areas of water can remain open (Burns et al. 2016). The extent of impacts includes those underwater areas where noise is able to be detected, and varies by species. 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 affect some marine mammals. However, implementation of industry-standard mitigation measures required through Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA) consultation would reduce impacts. The duration of time that marine mammals may be exposed to underwater sound would be short term, and lasting only during pipeline installation, dredging, and construction activities, and from vessel traffic during mine operations. 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 can disturb marine mammals, particularly individuals resting on the sea surface (reviewed in BOEM 2012). 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). Helicopter traffic may result in temporary behavioral responses.

Reactions of marine mammals to vessels often include changes in general activity (from resting or feeding to active avoidance), changes in surfacing-respiration-dive cycles, and changes in speed and direction of movement (NMFS 2013a). Because there is existing oil and gas infrastructure in Cook Inlet, as well as numerous shipping routes and large amounts of vessel traffic, it is unlikely that the addition of physical presence as part of this project would change marine mammals' behavioral patterns.

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 were disturbed and the level of disturbance (e.g., detection, alarm, and harassment) varied by region, type of vessel, and vessel speed. 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). 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). However, 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).

The magnitude of impacts from physical presence of vessels or construction equipment on marine mammals would primarily be behavioral avoidance. Cook Inlet has historical and current high use from fishing- and tourism-related vessel traffic, and the incremental addition of vessels associated with the project would be unlikely to result in increased impacts to marine mammals. Likewise, there is a high level of use of Iliamna Lake by recreational and subsistence watercraft. In terms of extent, the construction of the natural gas pipeline and operations of the proposed ferry across Iliamna Lake may initially cause some disturbance of harbor seals occurring in the immediate area; however, harbor seals are known for vessel tolerance (Richardson et al. 1995a). Therefore, although long term, occurring throughout the life of the project, impacts would not be expected to have a detrimental effect on harbor seals. Also, in terms of geographical extent, as discussed under "Underwater and Airborne Noise," above, harbor seals inhabiting Iliamna Lake are most commonly observed on the eastern side of the lake, east of an imaginary line between Kokhanok and Newhalen, and therefore east of the natural gas pipeline and transportation corridor. The extent that physical presence would occur would be expected to only affect the area in the immediate vicinity of the project activity. The duration that marine mammals may be exposed to vessel presence would be short term, occurring during pipeline installation and construction activities, but would result in a long-term increase in physical presence from the operations of the ferry across Iliamna Lake, lasting though operation of the mine until closure. However, vessels associated with activities would have a transitory presence in any specific location with a limited effect on marine mammals, because marine mammals typically avoid known high-vessel areas. The magnitude of impacts would be limited to brief behavioral responses such as reducing surface time, diving, and swimming away.

The magnitude of impacts from the physical presence of aircraft at Amakdedori port on marine mammals may occur infrequently during construction of the port access road. 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. The extent would primarily include the area around Amakdedori port, and any other locations where aircraft, including helicopters, may occur. Based on the short duration of potential exposure to aircraft-related noise and visual disturbance, effects on marine mammals would be limited to brief behavioral responses (such as diving, swimming away, reducing surfacing time).

The magnitude of impacts from vessels during construction, operations, and closure would be related to the number of vessels transiting Amakdedori port and the increase in vessel traffic in Kamishak Bay. The number of vessels is provided in Chapter 2, Alternatives. The duration of impacts from vessels would last for the life of the project. The extent would be localized in Kamishak Bay. Generally, potential impacts on marine mammal behavior would be localized in the analysis area, and would not result in population-level effects. If any responses of marine mammals associated with aircraft were to occur, they would likely be of short duration.

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. Between 1999 and 2003, the California Stranding Network reported only one ship strike of a gray whale (*Eschrichtius robustus*) in Alaska (Allen and Angliss 2012). No collisions of gray whales with vessels have been reported in Cook Inlet. The majority of the gray whale population migrates outside of the analysis area, and those individuals that do occur in lower Cook Inlet would be expected to avoid vessels. 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 within the analysis area. 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). 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

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 analysis area, 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). 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.

In terms of magnitude and extent, development of onshore support facilities might displace a small number of harbor seals near the Amakdedori port and the south ferry terminal site (in Iliamna Lake and Kamishak Bay). These impacts, which would be limited to the immediate vicinity of the facilities and short term in nature, would not be expected to affect local populations of harbor seals, because the animals are highly mobile and feed near river mouths. Harbor seals have not been documented feeding at the mouth of Amakdedori Creek.

The magnitude of direct impacts would be 10.7 acres of loss of benthic marine habitat from construction of Amakdedori port. There would be additional acreage lost due to the construction of the ferry terminals; however, this acreage is not next to a haul-out location, and therefore loss of habitat at these locations would not be expected to impact harbor seals in Iliamna Lake. The extent that habitat alteration would occur would only be expected to affect the immediate area around the south ferry terminal and Amakdedori port during construction. Potential effects from seafloor disturbance would be expected to limit the foraging quality of the disturbed area during construction. The duration that marine mammals may be exposed to habitat alteration from construction would be temporary, because habitat alteration activities would be of short duration, and possibly for a few years afterward in some locations. The duration that marine mammals may be exposed to habitat loss from development of Amakdedori port and the south ferry terminal would be permanent. Impacts would be likely due to loss of foraging habitat.

4.23.2.4 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 78 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 9 minutes during the summer. 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, and 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 9,343 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 upon 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 9,395 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 (9,265 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.

4.23.3 Alternative 2 – North Road and Ferry with Downstream Dams

Impacts to wildlife from construction, operation, and closure of the mine site under Alternative 2 are similar to those discussed previously under Alternative 1, and are not reiterated here. Under this alternative, the mine site footprint would be approximately 155 acres larger than Alternative 1, and result in more habitat loss for wildlife species. The primary difference with Alternative 2 is the geographical shift of the transportation and natural gas pipeline corridors to the north at the east end of Iliamna Lake, and the Diamond Point port located 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 located. Additionally, there would be no airstrip at the port, because the Pile and Pedro Bay airstrips that would be used during construction are further 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.

4.23.3.1 Birds

Impacts to birds that occur along the transportation and natural gas pipeline corridor would be similar to Alternative 1, but different in geographic extent, located 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 located 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.

Behavioral Disturbance

As discussed in Section 3.23, Wildlife Values, there are several golden eagle nests located 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 US Fish and Wildlife Service (USFWS), and possibly an Eagle Take Permit (81 Federal Register [FR] 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 currently no road 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 currently is not 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. Vessel traffic may cause species to swim away, fly, dive, or otherwise avoid approaching vessels. Although Kittlitz's murrelets have not conclusively been detected within 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 northern 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 10,341 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.

4.23.3.2 Terrestrial Wildlife

The magnitude, extent, duration, and likelihood of impacts to terrestrial wildlife from the mine site under Alternative 2 would be similar to those for Alternative 1, and are not repeated here. 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 1. 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, and impact 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 39 round-trip truck trips per 24-hour day (one vehicle every 18.5 minutes) would be anticipated to temporarily disturb wildlife while vehicles are passing. 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. As detailed in Section 3.23, Wildlife Values, wildlife cameras were placed along seven anadromous streams along the northern 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 timelapse 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.

Injury and Mortality

Because the transportation and natural gas pipeline corridors roughly parallel the northern 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 WMP 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 1. 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 18.5 minutes. In terms of magnitude, the potential would be greatest at dawn and dusk, nighttime, 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 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. If Alternative 2 is chosen, permitted, and constructed, impacts would be expected to occur, especially with wildlife being killed along highways, 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 (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 and extent of impacts would be the loss of 10,341 acres, which includes all mine components. The duration would last for the life of the project, and the extent would include all of the mine 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.

4.23.3.3 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 1, but shifted north into Iliamna Bay. The ferry route would go through the eastern portion of Iliamna Lake, where most of the harbor seal haul-outs occur. Marine mammals in Cook Inlet would generally occur in similar densities throughout the analysis area, and impacts would be similar to those presented above for Alternative 1. One of the main differences for marine mammals with Alternative 2 would be that vessel access to Diamond Point port would require regular dredging. In terms of magnitude and duration, this would result in short-term modification of marine habitat resulting from an increase in turbidity and decreased water quality during dredging activities. Increased turbidity may potentially have impacts on marine mammal prey.

In terms of magnitude of impacts, another difference with Alternative 2 is the transportation corridor crossing Iliamna Lake would be longer under Alternative 2, and located at the eastern side of Iliamna Lake, potentially increasing adverse interactions with harbor seals that inhabit the lake. The Eagle and Pile Bay ferry terminals would be closer to harbor seal haul-out locations (see Section 3.23, Wildlife Values, Figure 3.23-17). The ferry would transit past several harbor seal haul-out locations. In summary, the magnitude of impacts to marine mammals 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. The duration would last for the life of the project. The extent would be limited to Diamond Point port and the eastern side of Iliamna Lake, where seal haul-outs are located. If Alternative 2 is selected, there is a likelihood of impacts to marine wildlife, particularly harbor seals.

4.23.3.4 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 78 per 24-hour day on each side of the ferry terminals during the summer (PLP 2018-RFI 065). Therefore, the number of truck trips on the access roads would be one truck passing in either direction every 9 minutes during the summer. 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 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 and increased noise levels), 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, and therefore have no effect on overwintering seals in Iliamna Lake.

The magnitude of impacts would be 10,408 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.

Pile-Supported Dock Variant

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, and 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 10,330 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, the reduction in impacts compared to an earthen causeway port would be expected to occur.

4.23.4 Alternative 3 – North Road Only

The magnitude, extent, duration, and potential for direct and indirect impacts from the mine site to wildlife species from Alternative 3 would be similar to Alternatives 1 and 2. The main differences would be no ferry in Iliamna Lake, and the length of the road associated with the transportation corridor would be 82 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 over Alternative 2. Up to 39 round trips per day would equate to a truck passing in either direction approximately every 18.5 minutes during a 24-hour period. Impacts to birds and terrestrial wildlife from injury and mortality from this level of truck traffic would be similar to Alternative 1. The main difference would be the north access road traverses forested vegetation communities 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 generated by truck traffic, so that the distance where behavioral impacts to birds may occur would be less.

Additionally, forested habitat along the road provides a visual buffer and adjacent cover for wildlife to use.

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 the same as Alternative 2, because there would be no changes to the Diamond Point port.

In summary, the magnitude of impacts from Alternative 3 would be a loss of 10,047 acres of habitat for a variety of wildlife species. The duration of impacts would extend for the life of the project. 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.

4.23.4.1 Variant Impacts Analysis

Concentrate Pipeline Variant

Anticipated wildlife impacts include habitat loss from the concentrate pipeline pump house (1 acre located 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 10,048 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. This would equate to a truck passing in either direction every 40 minutes. The Concentrate Pipeline Variant would lower impacts through reduced potential for injury and mortality, as well as decreasing the overall level of noise and behavioral avoidance around the access road. The duration of impacts would extend for the life of the project. 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.

4.23.5 Summary of Key Issues

The project would be anticipated to have a wide variety of potential impacts to terrestrial wildlife, birds, and marine mammals. Table 4.23-3 summarizes the key issues for wildlife resources from Alternatives 1, 2, 3, and their variants.

Table 4.23-3: Summary of Key Issues for Wildlife Resources

Impact From Project Component	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, especially during construction and operations. There would be no behavioral changes from the variants at the mine site. N/A for marine mammal species	Same as Alternative 1.	Same as Alternative 1.

Table 4.23-3: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
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 for bears to be killed in defense of life and property. There would be no additional injury or mortality from the variants at the mine site. N/A for marine mammal species	Same as Alternative 1.	Same as Alternative 1.
Habitat changes	Loss of 8,086 acres of habitat. *Summer-Only Ferry Operations Variant* would result in loss of 8,124 acres. *Kokhanok East Ferry Terminal Variant* and *Pile-Supported Dock Variant* do not result in additional changes at the mine site. Additional terrestrial wildlife avoidance of habitat surrounding all project components due to noise, lighting, etc.	Loss of 8,241 acres of habitat. *Summer-Only Ferry Operations Variant* would result in loss of 8,279 acres. *Pile-Supported Dock Variant* does not result in additional changes at the mine site. Additional terrestrial wildlife avoidance of habitat surrounding all project components due to noise, lighting, etc.	Loss of 8,086 acres of habitat. *Concentrate Pipeline Variant* would result in loss of 8,087 acres. Additional terrestrial wildlife avoidance of habitat surrounding all project components due to noise, lighting, etc.
Transportation Corridor			
Behavioral changes	Traffic volumes, at 39 round-trip truck trips per 24-hour day (one vehicle every 18.5 minutes) would be anticipated to temporarily disturb wildlife while vehicles are passing. *Summer-Only Ferry Operations Variant* would result in traffic volumes at 78 round-trip truck trips per 24-hour day (one vehicle every 9 minutes). *Kokhanok East Ferry Terminal Variant* and *Pile-Supported Dock Variant* would not result in additional behavioral changes. Terrestrial wildlife would avoid the project components due to increased noise, vehicle, and human presence. Underwater noise from vessels may exceed injury thresholds as defined by regulatory	Same as Alternative 1. 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 78 round-trip truck trips per 24-hour day (one vehicle every 9 minutes). *Pile-Supported Dock Variant* would not result in additional behavioral changes.	Same as Alternative 1. *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.

Table 4.23-3: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	agencies. Physical presence of vessels over 18 miles of travel and aircraft may displace harbor seals that inhabit Iliamna Lake.		
Injury and mortality	Potential for terrestrial wildlife collisions with vehicles across 78 miles of road. Potential for harbor seals that inhabit Iliamna Lake to collide with vessels during construction and operation 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 72 miles, and therefore reduce the potential for collisions. However, it would increase the length of the ferry crossing to 27 miles, and would be located closer to harbor seal locations in Iliamna Lake. *Pile-Supported Dock Variant* would not change the potential for injury and mortality.	Potential for terrestrial wildlife collisions with vehicles across 53 miles of road. Potential for harbor seals that inhabit Iliamna Lake to collide with vessels during construction and operation 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 larger 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. No impact to harbor seals from an ice-breaking ferry during the winter.	Potential terrestrial wildlife collisions with vehicles across 82 miles of road. *Concentrate Pipeline Variant* would reduce the number of truck-trips, and therefore reduce the potential for injury and mortality for all terrestrial species.
Habitat changes	Loss of 892 acres (plus 241 acres from material sites) 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 715 acres (plus 422 acres from material sites) 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	Loss of 1,036 acres (plus 717 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 4.23-3: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Summer-Only Ferry Operations Variant and *Pile-Supported Dock Variant* do not change the amount of habitat impacted. *Kokhanok East Ferry Terminal Variant* would result in 833 acres (plus 349 acres from material sites) of habitat loss.	the ferry terminals. *Summer-Only Ferry Operations Variant* would increase habitat loss to 737 acres. *Pile-Supported Dock Variant* does not change the amount of habitat impacted.	
Port			
Behavioral changes	Terrestrial wildlife avoidance of area. Underwater noise from construction, operations, and closure may exceed injury thresholds for marine mammals as defined by USFWS and National Marine Fisheries Service (NMFS). Physical presence of vessels and aircraft (mainly during construction) may displace marine species. *Summer-Only Ferry Operations, Kokhanok East Ferry Terminal,* and *Pile-Supported Dock Variants* do not result in behavioral changes.	Same as Alternative 1. *Summer-Only Ferry Operations* and *Pile-Supported Dock Variants* do not result in behavioral changes.	Same as Alternative 1. *Concentrate Pipeline Variant* would not result in behavioral changes.
Injury and mortality	Potential for terrestrial wildlife to be killed in defense of life and property at Amakdedori port. Potential for bird species to collide with port infrastructure (including lighted navigation buoys), vessels, and bulk carriers at lightering locations. Potential for vessels to collide with marine mammals. *Summer-Only Ferry Operations, Kokhanok East Ferry Terminal,* and *Pile-Supported Dock Variants* do not result in changes to injury and mortality.	Same as Alternative 1, except there would be no lighted navigation buoys at Diamond Point port, and therefore no collision hazard. *Summer-Only Ferry Operations* and *Pile-Supported Dock Variants* do not result in changes to injury and mortality.	Same as Alternative 1, except there would be no lighted navigation buoys at Diamond Point port, and therefore no collision hazard. *Concentrate Pipeline Variant* would not result in changes to injury and mortality.
Habitat changes	Loss of 20 acres of terrestrial wildlife habitat and 10.7 acres of benthic marine habitat. *Summer-Only Ferry Operations Variant* would result in an additional 27 acres of habitat loss to the terrestrial	Loss of 41 acres of terrestrial wildlife habitat and 72 acres of benthic marine foraging habitat. *Summer-Only Ferry Operations Variant* would not cause any habitat	Same as Alternative 2. *Concentrate Pipeline Variant* would not result in habitat changes at the port.

Table 4.23-3: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	environment. *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.	changes. *Pile-Supported Dock Variant* would result in less than 0.1 acre of benthic marine habitat loss plus 58 acres of dredged area in the benthic marine environment.	
Natural Gas Pipeline			
Behavioral changes	Avoidance of 187 miles during construction for wildlife species. During construction, underwater noise levels may exceed the injury thresholds as defined by USFWS and NMFS. Physical presence of vessels and aircraft may displace marine species. *Summer-Only Ferry Operations* and *Pile-Supported Dock Variants* do not result in additional behavioral changes. *Kokhanok East Ferry Terminal Variant* would be 185 miles long.	Avoidance of 164 miles during construction for wildlife species. During construction, underwater noise levels may exceed the injury thresholds as defined by USFWS and NMFS. Physical presence of vessels and aircraft may displace marine species. *Summer-Only Ferry Operations* and *Pile-Supported Dock Variants* do not result in additional behavioral changes.	Avoidance of 165 miles during construction for wildlife species. During construction, underwater noise levels may exceed the injury thresholds as defined by USFWS and NMFS. Physical presence of vessels and aircraft may displace marine species. *Concentrate Pipeline Variant* does not result in additional behavioral changes.
Injury and mortality	Potential for bird species to collide with vessels during construction. Potential for wildlife, including marine mammals, to collide with construction equipment during installation. *Summer-Only Ferry Operations*, *Kokhanok East Ferry Terminal*, and *Pile-Supported Dock Variants* do not result in additional injury and mortality.	Same as Alternative 1. *Summer-Only Ferry Operations* and *Pile-Supported Dock Variants* do not result in additional injury and mortality.	Same as Alternative 1. *Concentrate Pipeline Variant* does not result in additional injury and mortality.
Habitat changes	40 acres of disturbed habitat from pipe-laying activities. *Summer-Only Ferry Operations* and *Pile-Supported Dock Variants* do not result in additional behavioral changes. *Kokhanok East Ferry Terminal Variant* would have a slightly different pipeline alignment, but acreage of impacts would be similar.	856 acres of disturbed habitat from pipe-laying activities. *Summer-Only Ferry Operations* and *Pile-Supported Dock Variants* do not result in additional habitat changes.	97 acres of disturbed habitat from pipe-laying activities. *Concentrate Pipeline Variant* does not result in additional habitat changes.

Table 4.23-3: Summary of Key Issues for Wildlife Resources

Impact From Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Total of all Direct Impacts			
Total Direct Impact Footprint	Alternative 1 9,317 acres *Summer-Only Ferry Operations Variant* 9,343 acres *Kokhanok East Ferry Terminal Variant* 9,395 acres *Pile-Supported Dock Variant* 9,265 acres	Alternative 2 10,341 acres *Summer-Only Ferry Operations Variant* 10,408 acres *Pile-Supported Dock Variant* 10,330 acres	Alternative 3 10,047 acres *Concentrate Pipeline Variant* 10,048 acres

Notes:

Acres and miles derived from Table 2-2 in Chapter 2, Alternatives.

4.23.6 Cumulative Effects

The cumulative effects analysis area for wildlife includes the project footprint for each alternative and the extended geographic area where direct and indirect effects to wildlife can be expected from project construction, operations, and closure. Past, present, and reasonably foreseeable future actions (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 as shown on Figure 4.1-1.

4.23.6.1 Past, Present, and Reasonably Foreseeable Actions

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, gas and mineral exploration, residential activities, sport and subsistence hunting and sport subsistence, and commercial fishing. Most of 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.

Reasonably Foreseeable Future Actions

Several of the RFFAs detailed in Section 4.1, Introduction to Environmental Consequences, are considered to have no potential for cumulatively impacting wildlife in the analysis area, such as those outside the analysis area (e.g., Donlin).

RFFAs in the cumulative effects analysis area have the potential to contribute cumulatively to such project-related impacts as habitat loss or fragmentation, disturbance from construction and operations activities, and collisions with vehicles.

The Pebble Mine Expanded Development Scenario is the only mineral deposit RFFA considered for development. All other mineral deposit RFFAs are considered for exploration only. The cumulative effects from the Pebble Mine Expanded Development Scenario are discussed below for each alternative. The cumulative effects would differ by alternative because the Pebble Mine Expanded Development Scenario would include two new pipelines along a route that would already be developed under two of the alternatives, but not the third.

Terrestrial Wildlife and Birds

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 buildout – develop 55 percent of the resource over an additional 78-year period (Pebble Mine Expanded Development Scenario)
- Pebble South/PEB*
- Big Chunk South*
- Big Chunk North*
- Fog Lake*
- Groundhog*
- Shotgun*
- Johnson Tract*
- Diamond Point Rock Quarry
- Alaska Liquefied Natural Gas (LNG)
- Drift River Oil Pipeline
- Cook Inlet Lease Sales
- Onshore Hydrocarbon Exploration*
- Lake and Peninsula Transportation, Infrastructure and Energy Projects
- Kaskanak Road Project

**Indicates exploration activities only.*

The most important 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. Loss of habitat or 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 may cause habitat fragmentation or avoidance of preferred habitat areas. 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 areas and have increased mortality from new roads and mortality from defense of life and property.

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 buildout – develop 55 percent of the resource over an additional 78-year period (Pebble Mine Expanded Development Scenario)
- Johnson Tract*
- Diamond Point Rock Quarry
- Alaska Stand Along Pipeline Project / Alaska LNG (one or the other, project would be developed based on funding)
- Drift River Oil Pipeline Transportation Project

- Cook Inlet Oil and Gas Lease Sales
- Lake and Peninsula Borough and other regional Renewable Energy Initiatives
- Commercial, Sport, and Subsistence Fishing
- Subsistence Activities
- Scientific Surveys and Research

**Indicates exploration activities only.*

Potential impacts on marine mammals from RFFAs include noise and behavioral disturbance, displacement from habitat alteration, resource consumption, 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). The expected potential incremental cumulative effects from project impacts are not expected to result in population-level impacts for non-federally listed species of marine mammals in Cook Inlet.

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. Such effects would likely be short term, and would not be expected to result in population-level effects.

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 footprint of the Diamond Point Rock Quarry overlaps with the Diamond Point port footprint proposed under Alternatives 2 and 3. Cumulative impacts would be limited to a potential increase in localized marine mammal impacts from commonly shared project footprints with the quarry site.

4.23.6.2 No Action Alternative

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

4.23.6.3 Alternative 1 – Applicant's Proposed Alternative

Pebble Mine Expanded Development Scenario – The Pebble Mine Expanded Development Scenario is described in Section 4.1, Introduction to Environmental Consequences, and illustrated on Figure 4.1-1. Expanded development and associated contributions to cumulative impacts would be the same for all alternatives at the mine site and the Iniskin Bay port; however, there would be differences among the alternatives in the transportation, pipelines, and natural gas compressor station footprints. This is because the transportation/pipeline corridor under Alternative 1 would be located along the north access road that would be used as the route for the additional diesel and concentrate pipelines associated with the Pebble Mine Expanded Development Scenario. As shown in Table 4.23-4, under Alternative 1 the concentrate and diesel fuel pipelines to Iniskin Bay would have a larger footprint and would include an adjacent service road (because the north access road and pipeline corridor would not have been constructed).

Table 4.23-4: Pebble Mine Expanded Development Scenario – Wildlife Impacts by Alternative and Component

Project Component	Alternative 1	Alternative 2	Alternative 3
	Estimated Pebble Expanded Development footprint	Estimated Pebble Expanded Development footprint	Estimated Pebble Expanded Development footprint
Mine Site	29,632 acres	29,632 acres	29,632 acres
Port	Additional compressor station at Amakdedori port – 3 acres	Additional compressor station at Diamond Point port – 3 acres	Additional compressor station at Diamond Point port – 3 acres
Concentrate and diesel fuel pipeline to Iniskin Bay	1,022 acres	194 acres	194 acres
Iniskin Bay Port	30 acres	30 acres	30 acres
Total	30,717 acres	29,971 acres	29,971 acres

At the mine site, an additional 21,546 acres of habitat would be lost. The habitat and wildlife species affected would be similar to those described above under "Alternative 1 – Applicant's Proposed Alternative." The expanded development would increase the magnitude, extent, duration, and likelihood of impacts. The longer duration would also increase the likelihood of injury or mortality and cause longer habitat avoidance of nearby areas.

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 for a total right-of-way of 100 feet, to be constructed in a previously undisturbed area. The construction and operation of this additional linear feature would increase the project footprint compared to either of the other two alternatives. This would increase the likelihood of habitat fragmentation effects, because road density can adversely 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 construction and operation of a deep-water port in Iniskin Bay would affect wildlife habitat by direct loss of 30 acres of nearshore habitat and disturbance of marine-associated species such as American mink (*Neovison vison*), river otter, 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.

Mineral Exploration Projects – Some RFFAs associated with mineral exploration activities (e.g., Pebble South, Big Chunk North, Big Chunk South, Fog Lake, and Groundhog) could have some limited wildlife impacts, primarily water quality, in watersheds common to the project (e.g., drill pads, camps); however, they would be seasonally sporadic, temporary, and localized, based on remoteness. Although exploration activities are considered to have minimal cumulative impacts to wildlife, there could be potential for greater impacts from disturbance and habitat loss from future development.

Other Marine RFFAs – Cook Inlet RFFAs, including Alaska Stand Alone Project, Alaska Liquid Natural Gas (LNG), 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. Construction and operations of these projects would increase the likelihood of a spill which would be managed by implementation of industry-standard BMPs. Temporary effects from sedimentation during construction are likely, but expected to be minimal.

Community Development and Transportation Infrastructure Projects – Most community development projects would take place within the confines or adjacent to existing communities, and would have minimal effects on birds and wildlife. 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. 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. Any new roads would also contribute to increased hunting pressure on local wildlife populations.

4.23.6.4 Alternative 2 – North Road and Ferry with Downstream Dams

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

As shown in Table 4.23-4, under Alternative 2, the additional compressor station would be located at the Diamond Point port instead of the Amakdedori port, and the concentrate and diesel fuel pipelines to Iniskin Bay would be added to the natural gas pipeline trench along the existing sections of the north access road. Because the natural gas pipeline and portions of the road would already exist under Alternative 2, the amount of habitat loss necessary for mine expansion would be much lower under Alternative 2 (102 acres) compared to Alternative 1 (1,022 acres). Because a portion of the north access road would already exist, the new impacts to previously undisturbed area would be limited to that portion of the pipeline/access road between the two Iliamna Lake ferry terminals. In addition, there would be one linear feature operating between mine years 20 and 78, rather than two; therefore, the magnitude of habitat fragmentation impacts under Alternative 2 would be lower than Alternative 1.

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 the close proximity of the two ports.

The magnitude of cumulative impacts from this alternative would be lower than Alternative 1, but higher than Alternative 3. The duration of impacts would increase to 78 years, extending the intermittent impacts and increasing the likelihood of impacts from spills. The geographic extent of impacts would be localized. The additional compressor station at the Diamond Point port is not expected to affect wildlife.

Mineral Exploration, Marine Projects, and Community Development and Transportation Infrastructure Projects – The contributions to cumulative impacts of these projects would be the same as discussed under Alternative 1.

4.23.6.5 Alternative 3 – North Road Only

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

As shown in Table 4.23-4, under Alternative 3, the additional compressor station would be located at the Diamond Point port instead of the Amakdedori port, and the concentrate and diesel fuel pipelines to Iniskin Bay would be added to the natural gas pipeline trench along the existing north access road. Because the natural gas pipeline and most of the road would already exist under Alternative 3, the amount of additional disturbance resulting from the expanded mine scenario would be less than the same scenario under Alternative 1 or Alternative 2.

Marine mammals in the vicinity of the Diamond Point port and Iniskin Bay could be affected by the increased vessel traffic at these locations. The additional compressor station at the Diamond Point port is not expected to affect wildlife habitat.

The magnitude of cumulative impacts from this alternative would be lower than either Alternative 1 or Alternative 2. The duration of impacts would increase to 78 years, extending recurring impacts, and increasing the likelihood of some impacts. The geographic extent of impacts would be localized.

Mineral Exploration, Marine Projects, and Community Development and Transportation Infrastructure Projects – The contributions to cumulative impacts of these projects would be the same as discussed under Alternative 1.

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4.24 FISH VALUES

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

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

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

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

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

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

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

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

4.24.1 No Action Alternative

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

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

4.24.2 Alternative 1 – Applicant's Proposed Alternative

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

4.24.2.1 Habitat Loss

<u>Mine Site</u>

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

North Fork Koktuli

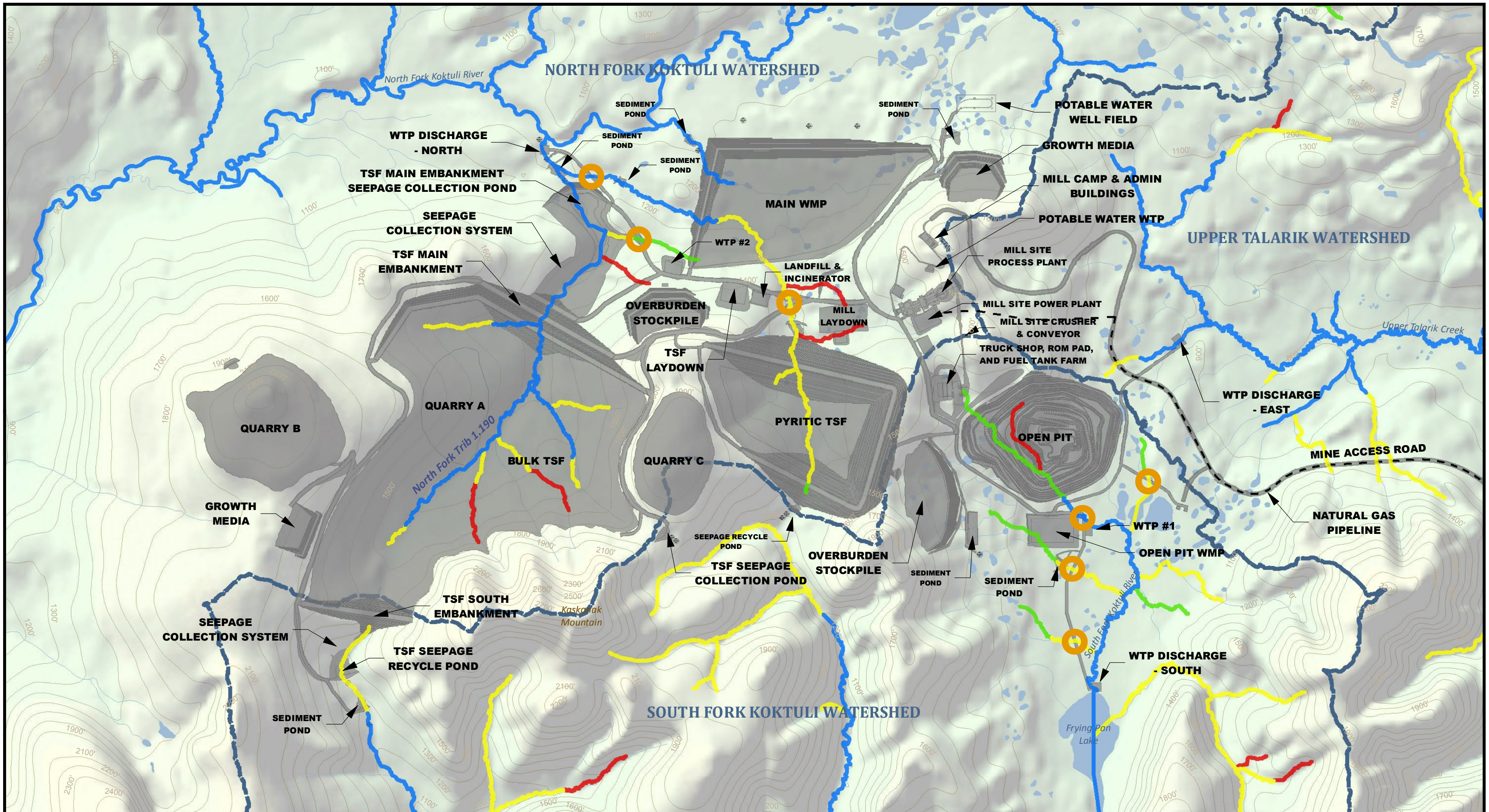
As described in Chapter 3, Affected Environment, approximately 82 percent of the mine site footprint would be in the NFK River drainage (Figure 4.24-1). In terms of magnitude, extent, and duration of impacts, approximately 7.5 miles of anadromous habitat would be permanently removed in Tributary 1.190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

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

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

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

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



Sources: PLP 2018; HDR 2012

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

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

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

US Army Corps of Engineers®

0.5 0 0.5 1
Miles

FISH AND AQUATICS MINE SITE IMPACTS

PEBBLE PROJECT EIS

FIGURE 4.24-1

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

Documented anadromous waters only represent waters where salmon have been observed, and are not considered representative of all anadromous waters in the Bristol Bay drainage. The total estimated mileage of anadromous waters in Bristol Bay drainage is likely much higher. The mine site area is one of the few areas in the Bristol Bay drainage where numerous small channels and tributaries have been surveyed.

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

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

South Fork Koktuli River

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

Upper Talarik Creek

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

Summary

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

Transportation Corridor

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

Road/Pipeline

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

Ferry Terminals/Iliamna Lake Pipeline

Docking facilities for the ice-breaking ferry at the north and south ferry terminals are expected to include rock and gravel ramps extending approximately 40 feet into Iliamna Lake. The magnitude and extent of impacts are such that the two terminals would remove 0.8 acre and 923 feet (0.2 mile) of approximately 300 miles of existing littoral zone. Rip-rap placed around the landing ramp would be similar in size and character to the boulder habitats currently present in both locations, and would not represent a novel habitat feature. Rip-rap would be colonized in the short term, and subsequently used by fish and their prey organisms. Habitat abutting fill locations may be disturbed or degraded during construction, but the duration of the impact would be short term, because habitat is expected to recover after construction activities are completed.

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

Amakdedori Port

The magnitude and extent of impacts would be that construction would remove and/or fill 11.3 acres of nearshore habitat, including 2.5 acres of beach complex and 8.8 acres of subtidal mixed-gravel habitat. The duration of impact would be such that discharge of fill material to construct the Amakdedori port would permanently remove benthic habitat; however, fish surveys indicate the beach complex and subtidal mixed-gravel habitat are less productive than other areas sampled in Kamishak Bay (GeoEngineers 2018a, 2018b). In terms of magnitude and extent, the beach complex and subtidal mixed gravel would represent a reduction of 0.05 percent and 0.06 percent, respectively, of locally mapped habitat (GeoEngineers 2018a, 2018b). These impacts would be certain to occur if the project is permitted and the Amkadedori port is built. Rip-rap placed on the causeway slopes would be similar in size and character to the boulder habitats currently present in both locations, and would not represent a novel habitat feature. Rip-rap would be colonized in the short term, and subsequently used by prey organisms.

Natural Gas Pipeline

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

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

The magnitude and extent of potential impacts from the placement of anchors for the pipe laying barge would include disruption to the seafloor habitat structure. Impact sources include anchor scarring each time an anchor is set, and the scraping or sweeping of the seafloor from the movement of the anchor cables across the seafloor (cable sweep). The typical sea anchor footprint is generally small, but the depression could be 7 to 8 feet in soft bottom. The weight of the anchor and potential depth of the scar could potentially result in disruption to the habitat structure within the footprint of the scar. These scars would be short term, because they would fill in with marine sediments.

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

4.24.2.2 Fish Displacement, Injury, and Mortality

<u>Mine Site</u>

North Fork Koktuli and South Fork Koktuli

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

Blasting would be necessary to construct the mine site, and would be ongoing during operations as the mine pit is developed. Blasting would occur near fish-bearing waters in the headwaters of the SFK and tributaries to the NFK. Blasting can cause in-water overpressures and particle velocities lethal to fish (Kolden and Aimones-Martin 2013).

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

Upper Talarik Creek

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

<u>Transportation Corridor</u>

Bridge, Culvert, and Natural Gas Pipeline Installation

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

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

Water pump intake screens used for dewatering and water withdrawal would be designed, constructed, and certified according to ADF&G standards to prevent fish impingement to reduce impacts. In terms of magnitude and extent, potential direct impacts from HDD activities include loss of fluid through subsurface fractures (frac-out) and unconsolidated gravel or coarse sand. Drilling mud (fluid) used in HDD is non-toxic and poses a low risk to aquatic life. However, fluid loss may result in a temporary increase in turbidity or siltation that can negatively impact aquatic life by covering spawning and feeding areas, and clogging fish gills. Monitoring would be conducted throughout the HDD process to determine whether a subsurface fluid loss occurs. Details regarding prevention, detection, and response to a potential frac-out or drilling fluid release would be addressed in the HDD and Stormwater Pollution Prevention plans. These impacts would be expected to occur if the project is constructed and the natural gas pipeline is installed.

Iliamna Lake Pipeline

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

Sockeye salmon are known to use shoreline habitat for spawning, and therefore could be potentially affected; however, documented spawning areas are more than 0.5 mile from the ferry terminals and primary entry points of the pipeline into the lake (EPA 2014). Investigations by PLP have documented that nearshore lake habitat at the ferry terminal is lightly used by juvenile salmonids, and is not used for adult spawning (Paradox NR 2018a). Nearshore trenching at Iliamna Lake has the potential to temporarily disturb and displace sockeye salmon fry and adults during construction, but fish use is expected to return to previously existing conditions after the activity ceases.

Ferry Terminals

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

Ferry Operations

Propeller Entrainment or Injury

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

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

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

The potential exists for chronic, direct adverse interaction of ferry propeller blades and various life stages of migratory and non-migratory fish species throughout the 20-year operations phase of the project. The ferry has the potential to entrain fish into the turbulent zone created by propeller blades, although benthic species or midwater species larger than 10 millimeters are less susceptible to entrainment, and are expected to detect and avoid propeller-related impacts. Although unlikely, propeller strikes or shear forces could result in fish injury or mortality. Impacts are expected to be localized at the individual level, and would be expected to occur if the project is permitted and constructed.

Wake Impacts

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

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

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

The ferry terminal locations are relatively exposed, short beaches unprotected from wave energy. Numerous small storm berms are present on the beach faces, indicative of changing seasonal water levels. In contrast to studies conducted on rivers, stranding of fry from ferry wakes is not expected to be a source of mortality in Iliamna Lake due to the perpendicular route of ferry travel in relation to the shoreline. The magnitude of the wake produced by the Iliamna Lake ferry is expected to be 4 inches at the ferry's 6-knot approach speed; however, the wake would dissipate within 30 feet of the hull. Consequently, any impacts on juvenile and adult fish due to boat wake would be limited in scale—both spatially and temporally.

Amakdedori Port

Short-term effects on both migratory and non-migratory marine fish species may occur during construction of the port. Fish are susceptible to injury and mortality from sound waves generated by pile-driving during construction of the dock (Caltrans 2015). The installation of sheet pile would require a permit from ADF&G; permit conditions (if issued) would limit exposure to noise to be consistent with established criteria. If the ADF&G determines that pile driving would occur in a location and during a timeframe to cause impacts to a managed species, a noise monitoring and mitigation plan would be required to mitigate the potential impacts. The duration of impact would be temporary: fish may be disturbed or displaced, but mortalities would not be expected, and fish behavior would be expected to return to prior conditions after the activity ceases. The impacts would be expected to occur if the project is permitted and the Amakdedori port is constructed. No shellfish have been documented at the port location, but other benthic organisms beneath the facility footprint as described in Section 3.24, Fish Values would experience direct mortality.

Propeller Entrainment or Injury

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

Wake Impacts

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

Natural Gas Pipeline

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

Potential impacts from the placement of anchors for the pipe lay barge include benthic fauna mortality. Impact sources include anchor scarring each time an anchor is set, and the scraping or sweeping of the seafloor from the movement of the anchor cables across the seafloor (cable sweep). Assuming an average anchor scar of 360 square feet with up to a 12-anchor array, and resetting the anchors twice per mile, for the 104.5-mile length of the submarine pipeline, the magnitude and extent of anchor scarring would be to temporarily impact approximately 21 acres of benthic habitat. The weight of the anchor and potential depth of the scar could potentially result in mortality of benthic fauna, including weathervane scallops. The benthic fauna would be expected to recover; therefore, the duration of the impacts would be short term.

4.24.2.3 Stream Flow

Mine Site

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

During project construction and operations, a network of seepage and sedimentation ponds would collect runoff and seepage from stockpiles, the mine pit, and other mine components (e.g., roads, embankments, and construction sites). Runoff and seepage water would be routed into the mill for ore processing and reuse, or routed to one of two water treatment plants for use in dust control or power plant cooling. Water would also be treated and released into stream channels at three locations: 1) NFK Tributary 1.190 immediately upstream of the NFK confluence; 2) the SFK at its confluence with Frying Pan Lake; and 3) a tributary to the UTC approximately 2 miles below its headwaters (Figure 4.24-1). The water would be treated before discharge in compliance with water quality standards to protect aquatic life, as specified in an Alaska Pollutant Discharge Elimination System (APDES) permit, if issued. Treated water would be discharged via buried infiltration chambers designed to provide energy dissipation, erosion control, and freeze protection.

The magnitude and extent of impacts from the reduction in stream flows would be to directly change the quantity and quality of instream habitat for upstream migration of adult salmonids, spawning and egg incubation, and rearing habitat for juvenile fish. Reductions in flows could also directly alter available habitat for benthic macroinvertebrate (BMI) production, which is important for fish growth and survival. The magnitude and extent of impacts as described below would vary among the three principal tributaries, according to the degree of surface water and groundwater capture, the location of impacts in the basin, the proximity and size of downstream tributaries, and the magnitude of flow augmentation at the water release facilities.

Fish Habitat Changes Associated with Stream Flow

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

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

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

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

Spawning Habitat

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

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

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

North Fork Koktuli

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

South Fork Koktuli

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

Upper Talarik Creek

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

Juvenile Habitat

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

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

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

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

North Fork Koktuli

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

South Fork Koktuli

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

Upper Talarik Creek

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

Transportation Corridor

Road Construction

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

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

Natural Gas Pipeline

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

The magnitude and extent of potential impacts to groundwater and surface water during pipeline construction would involve interception of shallow groundwater and surface water during trenching activities, which would be captured and locally flow along the trench backfill. The duration of impacts could extend beyond the life of the project, because the pipeline would be abandoned in place, and likelihood of the impact is certain if the project is permitted and the pipeline is constructed. Ditch plugs are typically installed to intercept shallow groundwater flows. Typical BMPs for surface water management could include maintaining natural surface water patterns; crowning of ditch backfill to allow for settlement to original ground level; contouring of surrounding terrain; construction of settlement infiltration basins; and prompt revegetation of riparian and wetlands and a robust monitoring and maintenance program (see Chapter 5, Mitigation). Ditch dewatering and hydrotest water would be discharged to approved sites as per

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

4.24.2.4 Stream Productivity

Mine Site

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

Baseline concentrations of dissolved organic carbon in the surface waters in the project area ranged from 1 milligram per liter (mg/L) to 2 mg/L; concentrations of nitrate+nitrite ranged from 0.1 to 0.3 mg/L; and mean concentrations of total phosphorous ranged from 0.02 to 0.04 mg/L, indicative of oligotrophic nutrient status in the aquatic ecosystem. This is consistent with the characteristics of headwater stream orders 1, 2, and 3; with existing riparian vegetation providing low inputs of organic matter. The lack of a mature deciduous overstory likely contributes to the oligotrophic conditions, and is unique to headwater streams in the project area; specifically, the NFK and SFK. The extent or scope of the impact of loss of riparian productivity would likely be limited to waters in the vicinity of the mine site footprint, and may not extend downstream from the affected stream channel.

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

The importance of marine-derived nutrients in Bristol Bay watershed lakes from returning salmon is well documented, as noted in Section 3.24, Fish Values. As shown in the baseline data above, marine-derived nutrients do not appear to influence the nutrient availability in the Koktuli or uppermost reaches of the Upper Talarik watersheds in the project area. This may be due to the comparatively small numbers of spawning fish, high flushing flows in the fall after spawning has occurred, and the lack of large woody debris for carcass retention. The extent or scope of any impacts would likely be limited to waters in the vicinity of the mine site footprint, and may not extend downstream from the affected stream channel. These impacts on stream productivity would be expected to occur if the project is permitted and built.

Transportation Corridor

Road and Pipeline

The road and pipeline would cross 16 anadromous and 36 resident fish streams. In some locations, such as culvert crossings, the road/pipeline footprint would impact riparian and floodplain connectivity in the 100-year floodplain. This could reduce terrestrial inputs and downstream productivity, and the duration would be for the life of the project. Loss of riparian vegetation can result in increased erosion and stream sedimentation and reduction in stormwater retention capacity, and can increase flows and alter instream functions, including productivity. In terms of magnitude and extent, the road/pipeline footprint and associated crossing structures would impact approximately 13.5 acres of riparian vegetation, and interrupt floodplain connectivity in certain locations. However, additional riparian habitat is available that would not be impacted throughout the watersheds. The duration of the impact to riparian vegetation would be for the life of the project, and would be expected occur if the project is permitted and built. BMPs such as road fill drain culverts may be considered during design and permitting to maintain floodplain connectivity, and to maintain riparian habitat function.

Iliamna Lake Pipeline

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

Ferry Terminal and Operation

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

Amakdedori Port

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

Rip-rap would be colonized in the short term, and subsequently used by prey organisms. Impacts to beach complex and subtidal mixed gravel would represent a reduction of 0.05 percent and 0.06 percent, respectively, of the total nearshore habitat mapped and available for colonization (GeoEngineers 2018a). Because of the existing available nearshore benthic habitat, there would be no anticipated impacts to the overall benthic productivity to Kamishak Bay.

Cook Inlet Natural Gas Pipeline

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

4.24.2.5 Stream Sedimentation and Turbidity

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

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

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

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

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

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

The extent of measurable changes in the quality and character of aquatic habitat from sedimentation would be limited to the mine site and road corridor footprint and immediate downstream areas in the NFK, SFK, and UTC drainages. The duration of sedimentation impacts would be temporary short term, only occurring during construction. Permit-required monitoring of fine sediments deposited in spawning gravel would identify any degradation in spawning habitat quality and sources of potential impact. These impacts would be expected to occur if the project is permitted and constructed.

Mine Site

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

Transportation Corridor

In terms of magnitude, extent, duration, and likelihood, road construction, maintenance, and use can result in short- and long-term impacts to streams and drainages from increased surface erosion and deposition of fine sediments; alteration of water temperature; delays or barriers to fish migration at culverts; changes in streamflow and hydrologic processes; and introduction of invasive plant species (Limpinsel et al. 2017). Surface erosion can also result from clearing and grading activities and from poorly surfaced or maintained roads with steep grades, high traffic volume, and insufficient stormwater management facilities. Accumulations of fine sediments in streams have been associated with decreased fry emergence, reductions in winter carrying capacity and benthic production, and changes in species composition in benthic invertebrate communities (NMFS 2011a).

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

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

In terms of magnitude, operations are expected to require 35 truck round trips per day, which would result in dust impacts in proximity to roads, including at stream crossings. See Section 4.20, Air Quality, for additional discussion on extent and magnitude of fugitive dust generation. Implementation of dust suppression and enforcement of slow speed limits at all stream crossings would minimize dust-related impacts to aquatic ecosystems. The duration of impacts would be through the life of the project, and the likelihood is certain if the project is permitted and built.

Road and Pipeline

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

Ferry Terminals

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

Amakdedori Port

Temporary increases in turbidity would occur during construction of the Amakdedori port. Turbidity and deposition of suspended sediments in the nearshore environment at the port site could impact marine benthos. Temporary effects on both migratory and non-migratory marine fish species may also occur, particularly for benthic fish species expected to inhabit the immediate area. The magnitude of impacts of sediment deposition on aquatic vegetation could be a reduction of potential spawning habitat for species such as Pacific herring.

The existing marine substrate at the port site consists of subtidal gravels (GeoEngineers 2018a). Although project-related activity would contribute to suspended sediment levels in marine water around the port site, sediment in the area is coarse-grained, and the incremental increase in suspended sediment and redeposition due to project-related disturbance of this coarse-grained material would be limited in magnitude and extent (see Section 3.18, Water and Sediment Quality). The duration impacts from port construction are expected to be short term, lasting only during construction, but would be certain to occur if the project is permitted and constructed.

4.24.2.6 Fish Migration

Mine Site

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

Transportation Corridor

Access Roads and Pipeline

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

Ferry Terminal

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

Amakdedori Port

In terms of magnitude and extent, the Amakdedori port causeway and jetty would extend 1,900 feet into Cook Inlet and would alter local currents and water circulation. The causeway and jetty would be an obstacle that fish migrating along the beach would encounter. Obstacles are common along the Alaska coast, primarily in the form of reefs, rocky points, and peninsulas, many of which have similar structure as the rock-armored causeway. Prevention or delay of fish migration is not anticipated from the port structure.

Natural Gas Pipeline

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

4.24.2.7 Water Temperature and Quality

Construction and operations of the mine site may lead to changes in several water quality parameters in area streams that have the potential to impact fish. The ADEC (2018b) standards for water temperature criteria associated with growth and propagation of fish, shellfish, and other aquatic life and wildlife in freshwater state that at no time should maximum water temperatures exceed 20 degrees Celsius (^{o}C), with the following life-stage specific maxima: 15^{o}C for migration and rearing, and 13^{o}C for spawning and egg incubation. Ambient water temperatures monitored from 2004 to 2009 frequently exceeded the ADEC 15°C criteria in many stream reaches (ADEC 2018b). In each year of study, the daily maximum water temperature in the NFK immediately upstream of the mine site exceeded the 20^{o}C criteria on about 28 percent of all instantaneous readings during the summer months. The lower temperature thresholds for migration and rearing (15^{o}C) were exceeded on 78 percent of summer readings; and the spawning and egg incubation criteria (13^{o}C) were exceeded on 89 percent of summer readings.

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

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

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

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

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

North Fork Koktuli River

In terms of magnitude and extent, average changes in water temperature are expected to increase by approximately 1.2 ^{o}C during summer, and 2.8^{o}C during winter within 0.5 mile downstream of the water discharge location. As described in Chapter 3, Affected Environment, Chinook and other salmon species have been observed spawning in this reach of the NFK. Modeled discharges indicate that water temperatures would not exceed ADEC's temperature threshold for spawning fish of 13^{o}C for the summer months during mine operations and closure. Baseline winter water temperatures in this reach are just above 0^{o}C. NFK River habitats could warm to near the optimum alevin development temperatures for coho salmon, or could be slightly higher. A 2.8^{o}C increase in surface water temperature would be well below the ADEC threshold, and would not be expected to adversely impact incubating eggs, juveniles, or other overwintering resident fish. The duration of these changes would be long term, lasting though the life of the project; and they would be expected to occur if the project is permitted and built.

South Fork Koktuli River

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

Upper Talarik Creek

The magnitude and extent of average changes in water temperature would be an increase of approximately 0.12°C during summer and 0.54°C in winter 3 miles downstream of the water discharge location. As described in Chapter 3, Affected Environment, Chinook, sockeye, and coho salmon use this reach of the UTC for spawning and rearing. Modeled discharges indicate that water temperatures would not exceed ADEC's temperature threshold for spawning fish of 13°C for the summer months during mine operations and closure (PLP 2018-RFI 047). Baseline winter water temperatures in this reach are just above 0°C. A 0.54°C increase in surface water temperature would be well below the ADEC threshold, and would not be expected to adversely impact incubating eggs, juveniles, or other overwintering resident fish. The duration of these impacts to water temperatures would be long term, lasting though the life of the project; and would be expected to occur if the project is permitted and built.

Water Chemistry

Baseline natural water quality conditions have been documented throughout the project area, and can be referenced in Section 3.18, Water and Sediment Quality. Stream samples collected proximal to the Pebble deposit contained elevated concentrations of copper, molybdenum, nickel, zinc, and sulfate, sometimes exceeding the most stringent water quality standards.

Non-point discharges of process water to surface water are not planned. Permitted point discharges of process water to surface water would occur at three locations: 1) NFK Tributary 1.19 immediately upstream of the NFK confluence; 2) the SFK at its confluence with Frying Pan Lake; and 3) a tributary to the UTC approximately 2 miles below its headwaters (Figure 4.24-1; see Section 3.18 and Section 4.18, Water and Sediment Quality). Such permitted discharges would be in compliance with APDES permit; that is, discharge process water would have been treated to achieve the water quality criteria that are protective of aquatic life. Therefore, release of metals to surface water via point discharges of process water are not expected to cause metals toxicity (lethal and sub-lethal) on fish and aquatic invertebrates. Refer to Section 4.27, Spill Risk, for an analysis of impacts associated with upset conditions. As described in Section 4.18, fugitive dust would contribute metals to surface water, but would not exceed the water quality standards.

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

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

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

4.24.2.8 Essential Fish Habitat

EFH Assessment is included as Appendix I.

4.24.2.9 Alternative 1 Variants

Summer-Only Ferry Operations Variant

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

Fish Displacement, Injury, and Mortality

The ferry vessel would be larger than in Alternative 1, or there could be two vessels. Increased vessel size and horsepower could result in increased impacts from wake and propeller strike to juvenile fish, as described in Alternative 1.

Kokhanok East Ferry Terminal Variant

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

Habitat Loss

The variant portion of the road (Kokhanok east spur road) and pipeline corridor would cross 7 non-anadromous channels requiring culverts, and 1 bridge crossing an anadromous stream supporting sockeye salmon spawning and the presence of Arctic char. In terms of magnitude and extent, the port access road with the Kokhanok east spur road, and pipeline route is 6 miles shorter than Alternative 1, and would have 18 fewer stream crossings. Six of the Alternative 1 crossings provide resident fish habitat, and 5 provide anadromous fish habitat, including the Gibraltar River bridge crossing. The magnitude and extent of impacts would be a reduction in impacts to anadromous and resident fish stream habitat due to the reduction in stream crossings under this variant, as compared to Alternative 1 without the variant. The duration and likelihood of impacts would be the same as Alternative 1 without the variant.

Fish Displacement, Injury, and Mortality

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

Stream Flow, Productivity, Sedimentation, and Turbidity

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

Fish Migration

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

Pile-Supported Dock Variant

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

Habitat Loss

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

Fish Displacement, Injury, and Mortality

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

Stream Productivity

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

Stream Sedimentation and Turbidity

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

4.24.3 Alternative 2 – North Road and Ferry with Downstream Dams

4.24.3.1 Mine Site

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

4.24.3.2 Transportation Corridor

<u>Habitat Loss</u>

Access Roads/Pipeline

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

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

Ferry Terminals and Operation

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

Diamond Point Port

In terms of magnitude and extent, construction of dock facilities at Diamond Point would have a greater spatial and temporal direct impact on marine fisheries and benthic invertebrates than Alternative 1; because the footprint of these structures would cover roughly 58 more acres of benthic habitat due to channel dredging than the Amakdedori port (PLP 2018-RFI 072). Maintenance dredging is anticipated to be ongoing during operations on a 5-year recurrence interval. This would result in a reoccurring impact to 58 acres of benthic habitat for the life of the project, compared to Alternative 1.

<u>Fish Displacement, Injury and Mortality</u>

Access Road/Pipeline

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

Ferry Terminals and Operation

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

Iliamna Lake

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

Diamond Point Port

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

Stream Flow, Productivity, Sedimentation, and Turbidity

Access Road/Pipeline

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

Ferry Terminals and Operations

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

Diamond Point Port

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

Fish Migration

Access Roads/Pipeline

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

Diamond Point Port

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

Water Temperature and Chemistry

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

4.24.3.3 Natural Gas Pipeline

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

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

4.24.3.4 Alternative 2 Variants

Summer-Only Ferry Operations Variant

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

Pile-Supported Dock Variant

In terms of magnitude and extent, construction of a pile-supported dock at Diamond Point would result in less direct impact to benthic habitat and organisms than a fill causeway, because piles would be driven through vibratory and hammer methods, and require no fill (PLP 2018-RFI 072). Noise impacts from pile installation during construction could cause injury or mortality to fish and benthic organisms. Short-duration and limited suspended sediment impacts would be expected to occur during construction of the pile structure.

4.24.4 Alternative 3 – North Road Only

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

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

4.24.4.1 Transportation Corridor

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

4.24.4.2 Natural Gas Pipeline

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

4.24.4.3 Concentrate Pipeline Variant

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

Inclusion of a concentrate pipeline under this alternative would result in a slightly greater impact in magnitude to fish and fish habitat than Alternative 3 without the concentrate pipeline. The concentrate pipeline would be buried at the same time as road construction, and the mine access road corridor widened by less than 10 percent for inclusion of the pipeline, which could result in a marginal increase in water quality impacts during construction and fill placement over riparian wetlands. Because only the molybdenum concentrate (2.5 percent of the total concentrate production) would be trucked from the mine site to the port, a large reduction in road traffic would be anticipated, thereby reducing some potential impacts from dust, erosion, and runoff. The duration and likelihood of impacts would be the same as Alternative 3 without the variant.

4.24.5 Summary of Key Issues

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

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

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

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

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

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

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

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

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

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

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

4.24.6 Cumulative Effects

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

Past and Present Actions

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

The primary human activity affecting fish in the analysis area is fishing. The marine harvest of salmon has been estimated at 70 percent of the salmon returning to spawn (EPA 2014). However, none of the salmon stocks in Alaska has been determined to be "overfished" (NOAA 2018g). During the past decade, the numbers of pink, chum, and sockeye salmon have increased, due to a combination of generally favorable climatic conditions in the ocean and increased hatchery production (Schoen et al. 2017), whereas Chinook and coho salmon populations have decreased (Irvine and Fukuwaka 2011). The ADF&G (2018v) attributes the decline in Chinook numbers to poor smolt survival in the ocean. Decadal-scale cycles in Chinook and coho salmon productivity in North America, including the recent downturn, have been associated with an indicator of marine climatic conditions—the North Pacific Gyre Oscillation (Kilduff et al. 2015; Ohlberger et al. 2016).

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

RFFAs that could contribute cumulatively to aquatic resource impacts, and are therefore considered in this analysis, are those activities that would occur in the Nushagak River or Kvichak River drainages, or in other waterbodies intersected by the transportation corridor in the Cook Inlet drainage.

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

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

*Indicates exploration activities only.

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

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

No Action Alternative

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

Alternative 1 – Applicant's Proposed Alternative

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

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

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

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

The construction and operation of a deep-water port in Iniskin Bay would affect fish and aquatic habitat by direct loss of nearshore habitat and discharge of fill that would affect benthic habitat, and disturbance, injury, or mortality. Iniskin Bay is designated as EFH for all five species of Pacific salmon and several other pelagic and groundfish species. Pacific herring spawn in Iniskin Bay, particularly on the eastern side (ADNR 2001).

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

Other Mineral Exploration Projects – Some RFFAs associated with mineral exploration activities (e.g., Pebble South, Big Chunk North, Big Chunk South, Fog Lake, and Groundhog) could have some limited aquatic resource impacts, primarily water quality, in watersheds common to the project (e.g., drill pads, camps); however, they would be seasonally sporadic, temporary, and localized, based on remoteness. Although exploration activities are considered to have minimal cumulative impacts to soil resources, there could be potential for greater surface water and substrate impacts from future development through transportation infrastructure co-use with the project.

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

Oil and Gas Projects – Cook Inlet RFFAs, including Alaska Stand Alone Project, Alaska LNG, and Cook Inlet lease sales, would increase shipping traffic, and result in temporary disturbance to aquatic resources. Loss of fish habitat associated with new ports and drill rigs would be minimal in the context of Cook Inlet. Construction and operations of these projects would increase the likelihood of a spill; however, this is considered unlikely due to the BMPs and regulatory requirements. Temporary effects from sedimentation during construction are likely, but expected to be minimal.

Community and Transportation Infrastructure Development – Community development, transportation, and utility projects would have the potential to affect fish and aquatic resource habitat, injury/mortality, water quality/sedimentation, and fish migration. Potential impacts from community development projects would be highly localized, small in scale, and unlikely to have much impact on fish and aquatic resources. Transportation and utility projects, such as improvement to the Williamsport-Pile Bay Road and new road connections to Cook Inlet, would have potential direct and indirect impacts to those described for the project transportation corridors earlier in this section. Impacts would be primarily limited to construction activities and the immediate vicinity of a specific project, and would be subject to the same BMPs and permit requirements described earlier in this section.

Alternative 2 – North Road and Ferry with Downstream Dams

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

Under Alternative 2, the additional compressor station would be located at the Diamond Point port instead of the Amakdedori port, and the concentrate and diesel fuel pipelines to Iniskin Bay would be added to the natural gas pipeline trench along the existing sections of the North Access Road. Because the natural gas pipeline and portions of the road would already exist under Alternative 2, there would be fewer additional stream crossings necessary for mine expansion under Alternative 2 compared to Alternative 1. The additional compressor station at the Diamond Point port is not expected to affect fish or aquatic habitat. The magnitude of impacts from this alternative would be the lower than Alternative 1, but higher than Alternative 3.

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

Alternative 3 – North Road Only

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

Under Alternative 3, the additional compressor station would be located at the Diamond Point port instead of the Amakdedori port, and the concentrate (Concentrate Pipeline Variant) and diesel fuel pipelines to Iniskin Bay would be added to the natural gas pipeline trench along the existing North Access Road. Because the natural gas pipeline and most of the road would already exist under Alternative 3, the amount of additional disturbance resulting from the expanded mine scenario would be less than the same scenario under Alternative 1 or Alternative 2.

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

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

The magnitude of impacts from this alternative would be the lower than either Alternative 1 or 2. The duration of cumulative impacts would be extended by another 78 years, extending ongoing impacts, and increasing the likelihood of impacts from spills. The geographic extent of impacts would be localized.

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

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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 project, the agency is required to consider the effects that a federal action may have on all listed species in the EIS analysis area. To analyze the potential effects that a federal action may have on a listed species, a biological assessment has been prepared. 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 for Alternative 1.

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 Sections 3.23 and 4.23, Wildlife Values.

This section details the potential impacts of the project alternatives and their variants on TES in the project's EIS analysis area. The EIS analysis area (hereafter referred to as 'analysis area') for TES includes all marine components of the project in Cook Inlet, plus a surrounding buffer. The analysis area including a buffer around the port, each lighted navigation buoy (for Alternative 1 only), the natural gas pipeline construction corridor, the anchor mooring system at lightering locations, and a vessel corridor between the port and lightering locations is specified in Table 4.25-1.

The radial distance of the analysis area for Cook Inlet beluga whale (*Delphinapterus leucas*), humpback whale (*Megaptera novaeangliae*), fin whale (*Balaenoptera physalus*), and Steller sea lion (*Eumetopias jubatus*) of 11.3 miles around the port was a conservative distance based on the radial distance to the 120-decibel (dB) sound pressure level (SPL) isopleth for continuous noise levels from vibratory pile-driving activities. This is the level at which Level B harassment may occur for whales and Steller sea lion. The 984-foot buffer around the port was determined based on the extent of in-water impact pile driving to the 160 dB SPL isopleth, which is the harassment take threshold for northern sea otters (*Enhydra lutris kenyoni*), (and is being used for Steller's eider [*Polysticta stelleri*]; USFWS 2015).

The analysis area for the lighted navigation buoys is based on the area of Cook Inlet that may be disturbed during buoy anchorage placement. The analysis area for the natural gas pipeline construction is the total corridor width that may experience temporary impacts during summer pipeline construction. The analysis area for the lightering locations is the spread of the physical footprint for the anchor mooring system centered on the lightering location. If rock drilling to place screw anchors is necessary for anchoring the buoys at the lightering location, then the analysis area would expand to the extent of underwater noise levels that fall below the harassment take threshold for northern sea otters. The analysis area of the vessel corridor between the port and lightering locations is double the average width of the lightering barges (60 feet) (PLP 2018-RFI 039). The geographic extent of the analysis area differs between alternatives, but the buffers are the same regardless of alternative and variant.

No terrestrial components of the project (e.g., the mine site, ferry terminals, terrestrial portion of the transportation and natural gas pipeline corridors, and compressor station on the Kenai Peninsula) are included in the analysis area, because TES do not have historical ranges that include terrestrial areas; only marine components of the project are included in the analysis area.

Table 4.25-1: EIS Analysis Area for TES[1]

Project Component	Radial Distance for Cook Inlet Beluga Whale, Humpback Whale, Fin Whale, and Steller Sea Lion	Radial Distance for Northern Sea Otter and Steller's Eider
In-water portion of port[2]	11.3 miles	984 feet
Lighted navigation buoys (Alternative 1 only)	33 feet	
Natural gas pipeline construction corridor	4,101 feet (total corridor width is 8,202 feet)	
Lightering location (spread of the anchor mooring system)	1,150 feet (equivalent to a 2,300-foot by 1,700-foot rectangle centered on the mooring location)	
Vessel corridor between port and lightering locations	60 feet (total corridor width is 120 feet)	

[1] The radial distances for TES were determined based on direct and indirect impacts, and the justification for the distances is defined in Appendices G and H.
[2] The radial distance around the port would be the same distance regardless of the port construction type and alternative. Although the footprint for the Pile-Supported Dock Variant would be slightly smaller than the earthen-filled causeway, the radial distance around the analysis area would remain the same. The same applies to the dredging footprint associated with Alternative 2.

Potential direct and indirect impacts on TES include:

- Behavioral disturbance (such as disturbance from aircraft and vessel traffic at port locations)
- Injury and mortality (from collisions with structures, vessels, or other components)
- Habitat changes (such as loss of foraging habitat).

Impacts are assessed by four factors, including magnitude, extent, duration, and likelihood of impacts to TES and/or TES habitat. The magnitude of impact from the project depends on the specific species' sensitivity to the disturbance and the type of disturbance; the duration and extent of impacts depends on the location and season in which the disturbance occurs (e.g., during whale migrations); and the likelihood (or potential) of the impact occurring.

Scoping comments expressed concern that the proposed port site 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 comments are addressed in impact discussions.

Potential impacts from various spill scenarios are not discussed in this section, but are detailed in Section 4.27, Spill Risk. There are no impacts anticipated from water discharged into Cook Inlet from the project, because any water released would meet or exceed water quality standards. Additional information on water quality is provided in Section 4.18, Water and Sediment Quality.

The different alternative variants that occur outside of Cook Inlet (Kokhanok East Ferry Terminal Variant, Summer-Only Ferry Operations Variant, and Concentrate Pipeline Variant) would not impact TES. Specifically, under the Summer-Only Ferry Operations Variants for Alternatives 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 variant that would impact TES in Cook Inlet is the Pile-Supported Dock Variant. As this section is organized by species rather than by component, separate variant subheadings are not included (this structure differs from other Chapter 4 sections). Discussion of the Pile-Supported Dock Variant is integrated into the discussion where appropriate below.

Impacts to TES species would be minimized or mitigated by implementation of mitigation measures that would be developed through the permitting process, in consultation with the USFWS and NMFS. Proposed mitigation measures are detailed in the specific biological assessments in Appendices G and H. Pebble Limited Partnership (PLP)'s proposed mitigation incorporated into the project includes development of a Wildlife Management Plan (WMP). The plan would be developed for the project prior to commencement of construction, and the project would use Best Management Practices (BMPs) for wildlife management. The WMP would describe the equipment, methodology, training, and assessment techniques that would be used to minimize the potential for wildlife interaction with project activities and to minimize impacts to wildlife in the project area (see Chapter 5, Mitigation).

The project would use best management practices for prevention, control, and management of invasive species, including implementation of an invasive species management strategy to avoid the importation of invasive species into the project area due to project activities during construction, operations, and closure. Additionally, tug and barge speeds in northern sea otter critical habitat would be controlled to minimize the potential impacts to northern sea otters. This would involve regulating vessel speeds to less than 10 knots in northern sea otter critical habitat to reduce the potential for collision and disturbance for all TES.

4.25.1 No Action Alternative

The Pebble Project would not be undertaken. No construction, operations, or closure activities would occur and no impacts to TES would be expected. Under the No Action Alternative, PLP would retain the ability to apply for continued mineral exploration activities under the State's authorization process, as well as any activity that would not require Federal authorization. Current State-authorized activities associated with mineral exploration and reclamation and scientific studies would be expected to continue at similar levels. PLP would be required to reclaim any remaining sites at the conclusion of their exploration program. If reclamation approval is not granted immediately after the cessation of reclamation activities, the State may require continued authorization for ongoing monitoring and reclamation work as deemed necessary by the State of Alaska.

4.25.2 Alternative 1 – Applicant's Proposed Alternative

Potential TES impacts specific to the Amakdedori port and natural gas pipeline corridor across Cook Inlet are described herein. Project sources of noise and physical presence that may disturb the natural behavior of TES include construction, operations, and decommissioning of the marine portions of project components. This may occur through the presence of various project-specific vessels in Kamishak Bay; pile driving and other construction noise associated with the construction of the Amakdedori port; and aircraft used primarily during construction.

As detailed in Chapter 2, 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. This would increase vessel traffic in Kamishak Bay. 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.

4.25.2.1 Cook Inlet Beluga Whale

<u>Behavioral Disturbance</u>

Underwater and Airborne Noise

Beluga whales (*Delphinapterus leucas*) are categorized as mid-frequency hearing cetaceans with functional hearing in the 50-Hertz (Hz) to 200-kilohertz (kHz) range (Ciminello et al. 2012). 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. Beluga whale responses to underwater noise include changes in behavioral states (Richardson et al. 1995a), changes in vocalizations (Gervaise et al. 2012), and avoidance (Erbe and Farmer 2000). Lesage et al. (1999) observed vocal responses, which included a reduction in call rate, an increase in emissions of certain call types, repetition of specific calls, and a shift in frequency bands.

Beluga whales are generally observed north of the analysis area during summer months; therefore, noise during the summer construction of Amakdedori port would only be expected to impact the few animals that may be in the construction area at that time. A detailed discussion on noise sources from project components is in Appendix K4.25. Construction of the earthen causeway and jetty would result in increased underwater noise, but the magnitude of noise levels would be below the NMFS disturbance thresholds, and the extent of potential impacts to TES would be localized to the immediate vicinity of the causeway.

The magnitude of the impact from underwater noise on beluga whales would be reduced with the implementation of mitigation measures identified through consultation with NMFS, including those detailed in the NMFS Biological Assessment (BA) in Appendix H.

The extent of potential impacts on beluga whale behavior is anticipated to be limited to the analysis area. Under the Pile-Supported Dock Variant, the underwater noise associated with pile driving would 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, but not injury. The extent of potential impacts would be within 1.6 to 2.9 miles from the port site, depending on type of hammer used. The method of calculation is detailed in Appendix K4.25. Anchor handling during installation of the natural gas pipeline may also result in temporary disturbance to beluga whales. Underwater noise levels from anchor handling vessels are well below injury thresholds, and are typically at or below disturbance thresholds. The NMFS disturbance thresholds for beluga whales would generally be less than 1.4 miles from vessels, which would be the extent of the impact for this component.

The duration of the impact would be short-term, occurring only during construction of the pipeline. The duration that beluga whales may be exposed to underwater sound from vessels 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). Decibel levels associated with transportation vessels during operations are expected to be below NMFS Level A harassment and Level B harassment noise criteria.

In terms of likelihood, impacts would be expected to occur if the project is permitted and constructed.

Physical Presence (Vessel and Aircraft)

An increase in vessel traffic is expected to occur from construction and operations of Amakdedori port, the lightering locations, 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; and there are no large commercial fisheries in the immediate vicinity. The estimated timeframe for construction of the port, lightering locations, and natural gas pipeline corridor is provided in Chapter 2, Alternatives. There would be an increase in vessel traffic during construction and operations, as detailed in Section 4.12, Transportation and Navigation.

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). The magnitude of effects to Cook Inlet beluga whales that may occur as a result of disturbance from vessel traffic associated with project activities would be changes in behavior, movement patterns, or habitat use. The extent of the impacts would be limited to the analysis area, and the duration would be long term lasting from construction through the life of the project. 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 upper Cook Inlet despite oil and gas 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 be a major use area for beluga whales. Based on data 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, it is unlikely that the additional vessel activity from the project would result in a discernible disturbance to beluga whales that transit past Amakdedori port. In particular, because vessels would be traveling slowly (less than 10 knots [knots is a unit of measure for speed of aircraft or boats; 1 knot equals 1.15 miles per hour]), 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 depending on the time of year. Additionally, vessels associated with activities would have a transitory presence in any specific location, as do beluga whales, so they would likely have a limited effect on beluga whales. Based on the short duration of potential exposure to vessel-related noise and visual disturbance at any given location when vessels and whales are present, it is expected that effects on Cook Inlet beluga whales would be limited to brief behavioral responses, such as reducing surface time and diving. 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.

The duration of time that Cook Inlet beluga whales may be exposed to physical presence of aircraft and therefore the duration of the impact, would be short term and temporary occurring only during the construction period of the port access road. Construction would occur primarily during the summer, when beluga whales are generally outside of the analysis area in upper Cook Inlet. The likelihood of impact of exposure to the physical presence of project aircraft would be expected if the project is permitted and constructed.

Based on the short duration of potential exposure to vessel- or aircraft-related noise and visual disturbance, it is expected that any effects on Cook Inlet beluga whales would be limited to brief behavioral responses such as reducing surface time and diving. Vessel and aircraft presence concurrent with the presence of beluga whales would be short-lived, and only temporary effects on Cook Inlet beluga whales are expected.

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 other large vessels. 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 standard marine mammal disturbance guidelines would be followed to avoid vessel strikes (which would be outlined a Wildlife Management Plan, developed by PLP if the project were to be permitted; see Chapter 5, Mitigation, for additional information on mitigation measures). While encounters between beluga whales and project vessels could occur. 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 and lightering locations the port at slow speeds (less than 10 knots) that improve ability to avoid marine mammals. There is no indication that strikes would become a major source of injury or mortality in the analysis area (NMFS 2017a).

In addition, there are no records of lethal vessel strikes involving Cook Inlet beluga whales. Therefore, impacts to the Cook Inlet beluga whale as a result of injury or mortality from vessel collisions are not anticipated.

Habitat Changes

Cook Inlet beluga whale habitat use 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 located considerably north of the analysis area. Cook Inlet beluga whales are found further south in Cook Inlet during the fall and winter months, resulting in a higher probability of overlap with project activities during that time. Disturbance to habitat is discussed in the critical habitat section below, because the majority of potential impacts to Cook Inlet beluga whale habitat could occur in their federally designated critical habitat.

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. The analysis area has less-concentrated spring and summer beluga whale use; however, it also includes fall and winter feeding and transit areas.

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] Section 226.220(c)(5)]). The magnitude and extent of project impacts on the physical or biological features of beluga whale critical habitat would be 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 the 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.

Additionally, beluga whale primary prey fish species are anticipated to pass around the port, and their distribution in Kamishak Bay is not likely to be altered by the presence of the port. A discussion on anadromous fish streams in the analysis area is provided in Section 3.24, Fish Values, and includes Amakdedori Creek. The port is not expected to impede anadromous fish from using Amakdedori Creek, because fish already have multiple rocky reefs, shoals, and other areas to negotiate before entering the creek. Finally, because Cook Inlet beluga whales rarely feed on benthic fauna, it is not expected that these animals would be impacted by disturbances to the benthic environment (NMFS 2017a).

The magnitude of 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 physical partitioning from project activities. The magnitude and extent of permanent direct impacts would be the placement of fill in approximately 10.7 acres of designated Cook Inlet beluga whale critical habitat for construction of the port; 11.5 acres of critical habitat would be temporarily impacted during installation of the natural gas pipeline. Under the Pile-Supported Dock Variant, the magnitude and extent of impacts would be the placement of fill in 0.07 acres of Cook Inlet beluga critical habitat to construct the dock. These acreages were calculated based on the area of critical habitat (derived from USFWS geographic information system layers) that overlaps with project components, and occurs below mean high higher water levels (MHHW). There is also a 30-foot temporary construction buffer around the port; however, there would be no ground disturbance associated with the in-water portion of this buffer, and therefore no additional impacts to Cook Inlet beluga whale critical habitat.

Table 4.25-2: Summary of Key Issues for TES

Impact Causing Project Component		Alternative 1 and Variants	Alternative 2 and Variants		Alternative 3 and Variant	
Port						
Behavioral changes		Physical presence of vessels and aircraft (primarily during construction) may temporarily displace marine TES. Wintering Steller's eiders may swim, dive, or fly away from approaching vessels and aircraft.				
Injury and mortality		Underwater noise could exceed injury thresholds as defined by NMFS and USFWS during construction. Low potential for TES to collide with port infrastructure (including lights on the causeway and lighted navigation buoys) and vessels.				
Habitat Changes	Project Component	Earthen Causeway and Jetty (Pile-Supported Dock Variant)	Diamond Point port (Pile-Supported Dock Variant)(the same acreages apply for both Alternatives 2 and 3 and their variants)		Transportation Corridor (the same acreages apply for both Alternatives 2 and 3 and their variants)	
	Species	Permanent Impacts[1]	Permanent Impacts	Temporary Impacts[2]	Permanent Impacts	Temporary Impacts[2]
	Beluga Whale Critical Habitat	10.7 acres (0.07 acre)	72.3 acres (61.5 acres)	14.5 acres (21.4 acres)	1.5 acres	1.0 acre
	Northern Sea Otter Critical Habitat[3]	10.7 acres (0.07 acre)	69.9 acres (59.1 acres)	13.6 acres (20.5 acres)	22.7 acres	12.2 acres
	Steller's Eider Foraging and Wintering Habitat	10.7 acres (0.07 acre)	69.9 acres (59.1 acres)	13.6 acres (20.5 acres)	22.7 acres	12.2 acres
Lightering Locations						
Behavioral changes		Avoidance of lightering locations and the immediate vicinity while vessels are moored and loading concentrate for all TES.				
Injury and mortality		Low potential for collision for all TES.				
Habitat changes		None, the lightering locations are outside of critical habitat for all TES.				
Natural Gas Pipeline						
Behavioral changes		Physical presence of vessels and aircraft (primarily during construction) may temporarily displace marine TES.				
Injury and mortality		Underwater noise may exceed injury thresholds during pipeline installation as defined by NMFS and USFWS. Low potential for TES to collide with vessels during construction.				

Table 4.25-2: Summary of Key Issues for TES

Impact Causing Project Component	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Habitat changes	Temporary disturbance to 11.5 acres of Cook Inlet beluga whale and 38.8 acres of Northern sea otter critical habitat during summer construction. No temporary impact to Steller's eider habitat, because the species is not present during summer construction.	Temporary disturbance to 42.9 acres of Cook Inlet beluga whale and 64.6 acres of Northern sea otter critical habitat during summer construction. No temporary impact to Steller's eider habitat, because the species is not present during summer construction.	Temporary disturbance to 42.9 acres of Cook Inlet beluga whale and 64.6 acres of Northern sea otter critical habitat during summer construction. No temporary impact to Steller's eider habitat, because the species is not present during summer construction.

[1] There are no acreages of temporary impacts associated with construction of Amakdedori port, because any construction equipment outside of the permanent footprint would not impact the benthic marine environment.
[2] The temporary construction footprint is a conservative estimate based on a 30-foot buffer in case potential construction equipment needs to operate outside of the permanent footprint (such as around Diamond Point) in the marine environment.
[3] These acreages also represent the amount of Steller sea lion foraging habitat that may be impacted. No acreage of habitat loss is provided for fin or humpback whales, because they do not occupy or forage on the benthic marine habitat.

The extent of impacts altering critical habitat would be localized, only affecting the area immediately surrounding the port. Potential effects from seafloor disturbance would likely limit the foraging quality of the disturbed area during construction due to increased turbidity, which would eventually settle out, and only the direct footprint of the port would remain permanently impacted. The duration of time that Cook Inlet beluga whales may be exposed to habitat alteration would be permanent for the life of the project. The duration of these impacts would be permanent. In terms of likelihood, these impacts on critical habitat would be certain to occur if the project is permitted and built.

4.25.2.2 Humpback Whale

<u>Behavioral Disturbance</u>

Underwater and Airborne Noise

Humpback whales (*Megaptera novaeangliae*) have the potential to be affected by vessel noise associated with the construction and operations of Amakdedori port, and avoidance of the area by the whales would be the most likely response. The magnitude of the impact would be an interruption of normal behavior if approached by a vessel; Humpback whales would swim away. After this response, surfacing, respiration, and diving cycles could be affected; although vessels moving slowly and in a direction 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 would be short term and temporary. Lower Cook Inlet has a high volume of vessel traffic, especially during the summer months when humpback whales are present. Incremental additional noise from the anticipated few vessels associated with the project per day would not add to the existing levels of noise. A detailed discussion on noise sources from project components is presented in Appendix K4.25.

The low-frequency, percussive noise produced by pile driving would be detectable to humpback whales at a distance of several miles. Noise as a result of construction of the port site under the Pile-Supported Dock Variant of Alternative 1 at the Amakdedori port site would have the greatest potential of inducing behavioral changes to humpback whales. Pile-driving noise may exceed injury thresholds as defined by NMFS. Underwater sound levels from pile driving vary with size and type of piles, as well as the size and type of hammer, and would be further analyzed in ESA consultation and MMPA consultation (if required). Potential impacts to humpback whales from pile-driving activities at Amakdedori port are unknown, because species presence is not well-documented. As detailed in the biological assessment (Appendix H), PLP would develop a Marine Mammal Monitoring and Mitigation Plan in association with an Incidental Harassment Authorization to implement a robust monitoring strategy during pile driving to mitigate exposures to noise and impacts to whales from noise exposure. Noise may be generated during dredging and trenching for pipeline installation, and humpback whales would likely have behavioral responses such as avoidance to these noises. The extent and duration of these impacts would be the vicinity of pipeline installation and short-term, occurring only during construction. The impacts would be certain if the pipeline was permitted and installed.

The magnitude, 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 where the water is deeper. The airstrip would be used infrequently once the port access road from Amakdedori port to Kokhanok and the south ferry terminal is completed, because flights would land at Kokhanok instead of Amakdedori. The sounds produced by aircraft above the surface of the water do 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).

The extent of which noise from project activities would be audible to the cetaceans depends on sound source levels, frequency, ambient noise levels, the propagation characteristics of the environment, and sensitivity of the receptor (Richardson et al. 1995a); however, the extent of impacts to humpback whales would be expected to be limited to the immediate vicinity of project activities. The duration of the impact during which humpback whales may be exposed to underwater sound from vessels would be short-term and temporary during pipeline installation, but would occur for the life of the project during operations. Exposure to vessel sounds would occur when seasonal distribution and habitat selection overlap in time and space with project vessel activities. Under the Pile-Supported Dock Variant of Alternative 1, the magnitude and duration of impacts to humpback whales would be a short term exposure to noise from pile driving during the 2 years of summer construction at this location (total construction phase for the project is 4 years). Impacts from vessel noise would last for the life of the project during operations, especially when vessels transit to the secondary lightering location. The magnitude of impacts would be reduced through implementation of industry-standard mitigation measures (such as marine mammal monitoring) that would be further defined through MMPA consultation (if required). Any potential impacts on humpback whale behavior would occur in the analysis area, and would not result in population-level effects. However, in terms of likelihood, the impacts would be certain to occur if the project is permitted and the port and pipeline are constructed.

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). Additionally, 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 disturbance from the area. Only a few animals would be expected to 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 project construction phase lasts a total of 4 years).

The extent of impacts from the physical presence of aircraft would be only the area near Amakdedori port and the lightering locations. Data from ABR (2018c, 2018e) and from May 2018 northern sea otter surveys (Garlich-Miller et al. 2018) recorded the presence of humpback whales west and southwest of Augustine Island. The alternate lightering location for the project is situated 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 as 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).

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. As detailed in the biological assessment (Appendix H), PLP would develop a Marine Mammal Monitoring and Mitigation Plan in association with an Incidental Harassment Authorization to apply mitigation measures to reduce impacts to whales. The plan would include employing Protected Species Observers to monitor these areas and initiate activity shutdown as needed to prevent Level A harassment of cetaceans and pinnipeds.

The duration of impacts due to potential vessel collisions would be for the life of the project, and these impacts could occur more frequently during summer, when humpback whales are present in Cook Inlet. The potential or likelihood for non-lethal or non-injurious encounters between humpback whales and project vessels would be higher during operation of the mine as vessels would be regularly transiting between the port and lightering locations; more vessels on the water means a greater possibility of encounters between whales and vessels and a greater potential for impacts due to collisions.

The level of vessel traffic between the port and lightering locations would not change under the Summer-Only Ferry Operations Variant.

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 alteration of humpback whale habitat in the form of increased turbidity. This 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 rare, because humpback whales are not common in the vicinity of the port. Potential impacts may be higher along the natural gas pipeline route during summer construction, because humpback whales are more common outside of the nearshore areas around Amakdedori port. The magnitude of effects from construction of the port would be a direct loss of 10.7 acres of benthic habitat (with 0.7 acres of benthic habitat removed under the Pile-Supported Dock Variant), However, humpback whales rarely feed on benthic fauna, and they are not expected to be impacted by changes in the benthic environment (NMFS 2017a). The extent of 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 would be short term, occurring only during construction. The magnitude and duration of potential effects from seafloor disturbance would be a reduction in the foraging quality of the disturbed area for a short time during construction. In terms of likelihood, these impacts would be expected to occur if the project is permitted and constructed.

Critical Habitat

No critical habitat has been designated for humpback whales.

4.25.2.3 Fin Whale

Behavioral Disturbance

Underwater and Airborne Noise

Fin whales (*Balaenoptera physalus*) generally prefer deep marine waters in offshore areas. Vessels in transit to the analysis area during construction and operations of Amakdedori port 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). A detailed discussion on noise sources from project components is in Appendix K4.25.

Impacts to fin whales from underwater and airborne noise are not expected because the species is rare in Cook Inlet, and has not historically been documented in the analysis area. Noise as a result of construction of the port site under the Pile-Supported Dock Variant of Alternative 1 at the Amakdedori port would have a greater potential behavioral impact on fin whales that without the variant. Pile-driving noise may exceed injury thresholds, as defined by NMFS. Underwater sound levels from pile driving vary with the size and type of piles, as well as the size and type of hammer, and would be further analyzed in ESA consultation and MMPA consultation (if required). A detailed discussion on project noise is presented in Appendix K4.25.

The magnitude and extent to which project activity 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); however, the extent of impacts would be the immediate vicinity of project activities. The duration of time that fin whales may be exposed to underwater sound from vessels or aircraft noise would be short-term and temporary during pipeline installation and construction activities. However, the exposure would only be expected when seasonal distribution and habitat selection overlap in time and space with project vessel activities. Any potential impacts on fin whale behavior would be limited to the analysis area, and would not result in population-level effects. In terms of likelihood, the impacts would occur if the project is permitted and built.

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) approximately 80 miles south of the analysis area. Fin whales may exhibit varying reactions to the presence of vessels, ranging from attraction to avoidance (NMFS 2017b). Impacts to fin whale behavior as a result of the physical presence of vessels and aircraft from project construction and operations are not expected because the species is rarely observed in the analysis area.

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 have been reported as fin whales, none of which occurred in Cook Inlet (NMFS 2015). 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).

Impacts to the fin whale as a result of injury or mortality from vessel collision are not expected to occur for the duration of the project due to the species' rarity in the analysis area.

Habitat Changes

Fin whales in the North Pacific prefer euphausiids and large copepods, followed by schooling fish such as herring, walleye pollock, and capelin as prey. Information on the effects of sound on prey items of fin whales is limited. Because fin whales are not benthic feeders or feed on benthic fauna only rarely (NMFS 2017b), it is not anticipated that these animals would be impacted by disturbances to the benthic environment.

The magnitude of impacts to fin whales from construction of the Amakdedori port and installation of the natural gas pipeline would be a temporary disturbance of habitat in the form of increased turbidity. The extent to which this impact would occur would be limited to area around Amakdedori port. Direct loss of habitat from construction of the port site under the Pile-Supported Dock Variant of Alternative 1 at the Amakdedori would result in habitat loss of only 0.07 acres. The magnitude and duration of potential effects from seafloor disturbance such changes to water quality and increased turbidity would be a reduction in the foraging quality of the disturbed area for a short time during construction of the port and natural gas pipeline. In terms of likelihood, these impacts would be expected to occur if the project is permitted and the port and natural gas pipeline are constructed.

Critical Habitat

No critical habitat has been designated for the fin whale.

4.25.2.4 Steller Sea Lion

<u>Behavioral Disturbance</u>

Underwater and Airborne Noise

Noise sources (described in Section 3.23, Wildlife) for non-listed marine mammals are the same for listed marine mammals. Steller sea lions (*Eumetopias jubatus*) have the potential to be affected by vessel noise associated with the project components. Because sea lions are cautious by nature, loud, pulsed, frequent, or unfamiliar noises, such as pile driving at Amakdedori port, could disrupt resting sea lions or animals foraging near the sound source (NMFS 2005). The extent of with the greatest potential for impact from noise exposure would generally occur at haul-outs and near rookeries. The magnitude of impacts would include trampling and abandonment of pups if adult animals stampede due to the disturbance (discussed in the exposure to aircraft noise section below). However, because there are no rookeries near project components and most haul-outs are in designated critical habitat far south of the analysis area, these effects are not expected. A detailed discussion on noise impacts from project components is in Appendix K4.25.

If the Pile-Supported Dock Variant of Alternative 1 is chosen, the magnitude and duration of impacts to Steller sea lions would be behavioral changes due to short term exposure to underwater and airborne noise from pile driving activities during the 2 years of summer construction. Pile-driving noise may exceed injury thresholds as defined by NMFS. Underwater sound levels from pile driving vary with the size and type of piles, as well as the size and type of hammer, and would be further analyzed in ESA consultation and MMPA consultation (if required). A detailed discussion on project noise is presented in Appendix K4.25. The extent to which project activity 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), but the extent of the impact is expected to be only the area of construction. The duration of time that Steller sea lions may be exposed to underwater sound from vessels and aircraft would be short-term and temporary during pipeline installation, dredging, and construction activities. However, the exposure would only be infrequent, occurring only when Steller sea lion seasonal distribution and habitat selection overlap in time and space with project vessel and aircraft activities. Any potential impacts on Steller sea lions would occur in the analysis area, and would not result in population-level effects. In terms of likelihood, the impacts would be certain to occur if the project is permitted and the port and pipeline are constructed.

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. They 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. Some Steller sea lions use areas around Amakdedori port, particularly near the mouth of Kamishak Bay; those individuals or groups could be disturbed by project activities. However, Cook Inlet has a high level of vessel activity during summer from recreation, commercial fisheries, barging, and other forms of commercial and scientific vessel traffic. Because of the frequent vessel activity in Cook Inlet, Steller sea lions in the area could be partially habituated to vessel presence.

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 haul-outs or rookeries; therefore, no Steller sea lions haul-outs would be disturbed by the noise or presence of aircraft. If any responses of Steller sea lions associated with aircraft were to occur, they are likely to be short-lived, and therefore are not expected to cause more than a temporary disturbance to Steller sea lions (NMFS 2017a). Additionally, in recognition of this vulnerability, Steller sea lion critical habitat includes air zones 3,000 feet above the terrestrial zones of designated haul-outs and rookeries, none of which occur in the analysis area.

The magnitude and extent of impacts to Steller sea lions from the physical presence of project vessels would be disturbance from foraging in the area around Amakdedori port, and to a lesser extent, the lightering locations. The duration of the impact on Steller sea lions 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. In terms of likelihood, these impacts would be expected to occur if the project is permitted and the port and pipeline are constructed.

Injury and Mortality

Vessel Collision

There is one suspected vessel collision with a Steller sea lion in Cook Inlet, reported near Homer in 2002, approximately 80 miles east of Amakdedori port (NMFS 2017a). 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).

Injury or mortality of Steller sea lions as a result of collisions with project vessels collision would not be expected to occur during construction and operation of the port. There are no nearby haulouts or rookeries, 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 extent of potential non-lethal 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. Encounters could occur over the short term, during summer construction of the port and natural gas pipeline, but injury and mortality from vessel collisions are not expected given the slow speeds of the equipment installing the natural gas pipeline and mitigation measures that PLP would employ as detailed in the biological assessment (Appendix H). Any potential impacts from vessels transiting between the port and lightering locations may potentially occur for the life of the project in terms of likelihood.

Habitat Changes

The magnitude and extent of impacts from project construction would be an alteration of Steller sea lion foraging habitat in the vicinity of the Amakdedori port and 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. This 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 2017a). However, the magnitude and extent of effects from increased turbidity would be the potential deterrence of Steller sea lions from accessing prey species in the water column. The duration of these effects are would be short term and last only for the duration of construction. In terms of likelihood, the impacts would be expected to occur if the project is permitted and the port and pipeline are constructed.

Critical Habitat

No impacts to Steller sea lion critical habitat would occur from project activities because it is located south of the analysis area near the mouth of Cook Inlet.

4.25.2.5 Northern Sea Otter

Behavioral Disturbance

Underwater and Airborne Noise

Noise sources (described in Section 3.23, Wildlife Values) for non-listed marine mammals are the same for listed marine mammals. Sea otters (*Enhydra lutris*) 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 construction activities at the Amakdedori port and natural gas pipeline, with vessel operations at the port and at lightering locations, and from project aircraft using the airstrip near the port site. The magnitude of 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 detailed discussion on noise impacts from project components is in Appendix K4.25, and in the biological assessment (Appendix G).

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). The extent of the impact would be that only animals in immediate proximity to the sound source would be expected to exhibit a response. To date, the USFWS has not documented and is not aware of any evidence that serious injury, death, or stranding of sea otters can occur from exposure to industry noise (USFWS 2016b). Any disturbance to sea otters from underwater noise associated with the project construction would be expected to be temporary and occur only in the immediate vicinity of project activities.

The extent that noise from project activities would be audible to sea otters depends on source levels, frequency, ambient noise levels, the propagation characteristics of the environment, and sensitivity of the receptor (Richardson et al. 1995a); impacts such as behavioral responses to the noise would be expected to only affect sea otters in the analysis area. Construction of the earthen causeway and jetty would result in some underwater noise, but noise levels would be well below the USFWS disturbance thresholds, and would be limited to the immediate vicinity of the causeway. The magnitude of impact of the airborne noise of the heavy equipment sea otters rafting in the immediate vicinity of construction could be a temporary disturbance and departure from the area.

If the Pile-Supported Dock Variant of Alternative 1 is selected, the magnitude and duration of impacts to sea otters would be behavioral changes due to short term exposure to underwater and airborne noise from pile driving activities during the 2 years of summer construction (total construction phase for the project is 4 years). 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 extent of potential impacts to sea otters would be within 1.3 miles of the port construction site. In terms of likelihood, these impacts would only occur if the Pile-Supported Dock Variant of Alternative 1 is selected, permitted and constructed.

Noise from anchor handling during installation of the natural gas pipeline could also result in temporary disturbance to sea otters. Underwater noise levels from anchor-handling vessels would be generally below the USFWS disturbance thresholds for sea otters, approximately 49 feet from the vessels. The duration of potential impacts from these construction activities would be temporary and short-term, lasting only over the 4 year construction phase. 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). In terms of likelihood, these impacts would occur if the project is permitted and the port and pipeline are installed.

During operations, noise from vessels using the port and the lightering locations may result in disturbance to sea otters. Although the western side of Kamishak Bay has a high density of sea otters, they are fairly tolerant of vessel noise and would likely habituate to the regular presence of vessels at these locations. The lightering locations under this alternative are not in critical habitat for northern sea otter. The magnitude and extent of impacts on sea otters from underwater and airborne noise generated during use of the airstrip at Amakdedori port during construction would be behavioral disturbance, because the aircraft are approaching or departing at lower altitudes. The highest noise levels would occur when aircraft are directly over sea otters, thus the duration of impact would be temporary. Fixed-wing and helicopter activity is relatively high in Cook Inlet; therefore, sea otters may be habituated to these noise sources. The extent of potential impact from underwater or airborne noise on sea otters would be limited the analysis area, and would not result in population-level effects when mitigation measures, detailed in the biological assessment (Appendix G), and measures from the consultation process are implemented. In terms of likelihood, the impacts would be certain to occur if the project is permitted and the port and pipeline are constructed.

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. Because sea otters spend much of their time at the surface, they could be disturbed by the presence of vessel traffic.

Specific impacts from vessel presence would be disturbance and displacement of sea otters that are hauled-out or rafting, and females and pups near the Amakdedori port (USDOI, MMS 2003). If impacts to behavior occur at all, these effects would be expected to be short term, limited to the immediate area of the port, and would have no population-level impact.

The duration of time that sea otters may be exposed to physical presence of vessel and aircraft would be temporary, because such disturbance is expected to be intermittent, and of short duration. Based on the short duration of potential exposure to physical presence at any given location, it is expected that effects on sea otters would be limited to brief behavioral responses. These impacts would be expected to occur if the project is permitted and the port and pipeline are constructed.

Injury and Mortality

Vessel Collision

Injury and mortality of sea otters from collisions with vessels would not be expected 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. The extent of non-lethal encounters between project vessels and sea lions would range from the Amakdedori port to lightering locations, with the greatest potential for vessel encounters at the alternative lightering location west of Augustine Island due to higher sea otter densities there, compared to around 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. In terms of likelihood, any potential impacts from vessels transiting between the port and lightering locations could occur for the life of the project. However, during construction, Protected Species Observers and other mitigation measures would be employed to reduce the potential for encounters and impacts, as detailed in the biological assessment (Appendix G).

Habitat Changes

Organisms commonly consumed by sea otters, such as urchins, crabs, and clams, may be impacted by seafloor disturbance from port construction and natural gas pipeline installation. The magnitude of 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 across Cook Inlet from Amakdedori port to the Kenia Peninsula. Habitat loss was ranked as 'low importance' in the recovery plan for the southwestern stock of northern sea otters (USFWS 2013b). The magnitude of project impacts would be low because sea otters may easily disperse to unaffected habitat nearby. The extent to which habitat alteration could occur would be expected to be the area around the port and the footprint of the natural gas pipeline. The duration of time that sea otters may be exposed to habitat alteration would be permanent at Amakdedori port and temporary during construction and installation of the natural gas pipeline. Additionally, information on potential effects on habitat from several spill scenarios is included in Section 4.27, Spill Risk.

Critical Habitat

The magnitude, extent and duration of impacts from construction of the port would be a direct loss and permanent modification of 10.7 acres of northern sea otter critical habitat under the

Pile-Supported Dock Variant, 0.07 acre of critical habitat would be lost. There would be 38.8 acres of temporary impacts to critical habitat through installation of the natural gas pipeline. See Table 4.25-2 for the anticipated critical habitat impacted per marine component and by alternative and variant. The project is in Critical Habitat Unit 5: Kodiak, Kamishak, and Alaska Peninsula. Bottom-contact stages of construction, the permanent placement of a causeway, and construction of the natural gas pipeline have potential to temporarily adversely affect critical habitat. All northern sea otter critical habitat primary constituent elements (discussed in detail in Section 3.25, Threatened and Endangered Species) could be directly affected. Although there is potential for seafloor habitat disturbance from the project, only a portion of northern sea otter critical habitat occurs in the analysis area (Figure 3.25-1). Impacts to northern sea otter critical habitat as described would occur if the project is permitted and the port and pipeline are constructed. Additional analysis on impacts to northern sea otter PCEs are provided in Appendix G, and potential impacts from several spill scenarios are included in Section 4.27, Spill Risk.

4.25.2.6 Steller's Eider

All phases of mine site activities (including the Summer-Only Ferry Operations Variant) 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).

Additionally, 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, including all variants) because there would be no elevated structures that could pose a collision hazard, such as power lines. Towers, power lines, 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 magnitude and extent of impacts to Steller's eiders would be collisions with moored vessels at lightering locations in Kamishak Bay and Amakdedori port, as well as 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 further 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 further north are generally observed later in the season after molt is complete. Steller's eiders wintering in Kamishak Bay could be disturbed by aircraft and vessels. In terms of likelihood, these impacts would be expected to occur if the project is permitted and constructed.

Potential impacts to Steller's eiders from port construction noise are not considered herein because the port would be constructed primarily during the summer months, when Steller's eiders are generally not present. Impacts from construction of the natural gas pipeline are also not expected to occur, because construction is anticipated to occur primarily during summer months, when Steller's eiders are not present in Cook Inlet. Potential impacts to eiders from vessel and aircraft noise are discussed under behavioral disturbance, below. Potential impacts to Steller's eiders from several spill scenarios are discussed in detail under Section 4.27, Spill Risk.

Behavioral Disturbance

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) very slowly 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. Because Steller's eiders prefer nearshore areas where water depths are shallow, vessel speeds are required to be slow. 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. Therefore, the magnitude, extent and duration 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. Additionally, 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 height 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 to 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. Therefore, while the magnitude and duration of impacts from project vessels would be behavioral disturbance during construction of the port and natural gas pipeline, occurring in the summer when Steller's eiders are absent, there is an overall lack of eiders in the analysis area immediately around Amakdedori port. 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 the presence and operation of vessels in areas around the port or during overflights by aircraft landing at the airstrip 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. However, Steller's eiders are known to become accustomed to the presence of vessels at ports where they winter (USFWS 2012h). In terms of likelihood, impacts would be expected to occur if the project is permitted and the port and pipeline are built.

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). Therefore, 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 power lines 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, jetty, or other elevated structures may pose collisions hazards in an area where there is currently no artificial light. Additionally, 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. As sea ice shifts during the winter, there would be potential for eiders wintering along the western edge of Cook Inlet to fly between protected bays and collide with vessels moored at the various lightering locations.

The USFWS calculated the collision risk for Steller's eiders in the Chukchi Sea based on actual collisions events during exploratory drilling operations in 2012 (USFWS 2016d). Using a similar methodology, Steller's eider collision risk was calculated for the project. Per the project description in Chapter 2, 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. This activity was multiplied by the 20-year life of the project. It was determined that based on this anticipated level of vessel traffic (i.e., 2,700 vessel days), the collision rate for the federally listed Steller's eider would be 0.1 eider collisions over the life of the project. There would also be 30 supply barges annually that dock at Amakdedori port, which would present an additional collision hazard. The rate of collision with the lighted navigation buoys and port structures would likely be lower, because they are closer to shore in an area where fewer eiders have been detected.

Injury or mortality to molting and wintering Steller's eiders is not expected, primarily because construction of the port and natural gas pipeline would occur when Steller's eiders are absent, and the overall lack of eiders in the analysis area immediately around Amakdedori port. The extent of impacts would be limited to the area immediately around the port where eiders may collide with the port causeway, jetty, moored vessels, and lighted navigation buoys, especially during inclement weather. The duration would be for the life of the project. In terms of likelihood, the potential of these impacts if the project is permitted and constructed is unlikely as injury or mortality is not expected.

Habitat Changes

The magnitude and extent of impacts due to the construction of the Amakdedori port would be a loss of potential nearshore water 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 Amakdedori port construction would include an earthen causeway with a sheet-pile jetty structure. The earthen causeway would extend from the port terminal to the jetty. In total, 10.7 acres of potential foraging habitat would be covered with fill material (from the mean high water mark out to and including the sheet-pile jetty structure). The Pile-Supported Dock Variant would involve the placement of piles into the marine environment with a combined footprint of 0.07 acre. Therefore, the magnitude of effects on habitat would be a loss of 10.7 acres of Steller's eiders' foraging habitat; and under the Pile-Supported Dock Variant, the magnitude would be a loss of 0.07 acre. Steller's eiders are expected to eventually habituate to the presence of the port or pile-supported dock, because they have been found to forage around docks. One study in Norway documented Steller's eiders frequently foraging between fishing vessels inside several harbor complexes (Fox et al. 1997). Additionally, 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, and additional habitat may be created as benthic species colonize the riprap along the causeway. The extent of the impacts would be limited to the small in-water footprint of the port, and the duration would be for the life of the project. In terms of likelihood, the loss of habitat would be certain to occur if the project is permitted and constructed.

4.25.3 Alternative 2 – North Road and Ferry with Downstream Dams

4.25.3.1 Cook Inlet Beluga Whale

Cook Inlet beluga whales are expected to occur in similar densities throughout the marine environment across Alternatives 1 and 2; impacts are anticipated to be similar between both alternatives. Because there is no airstrip adjacent to Diamond Point, impacts to beluga whales from aircraft overflights are not expected to occur. Impacts from underwater noise from construction of the Diamond Point port (both earthen causeway and jetty or pile-supported design) would be the same as Alternative 1. The magnitude, duration and extent of impacts from underwater noise due to anchor handling during pipeline installation is similar to Alternative

1, although the pipeline length is shorter under Alternative 2, resulting in 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 greater disturbance than Alternative 1. Unlike Alternative 1, periodic dredging of an area for ships to access the port would be conducted under Alternative 2. The magnitude and extent of this impact would be increased underwater noise and disturbance from dredging vessels, as well as potential increases in turbidity impacting prey species and detection. This acreage is detailed in Table 4.25-2. 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 would be disturbance and changes to forging ability and prey; the duration would be for the life of the project; and extent would encompass the analysis area. In terms of likelihood, the impacts would be expected to occur if Alternative 2 is selected, permitted and built.

4.25.3.2 Humpback Whale

Humpback whales are expected to occur in similar densities in the natural gas pipeline corridor for Alternatives 1 and 2; however, humpback whales have been more frequently sighted along the Alternative 1 natural gas pipeline corridor south of Augustine Island. Because fewer sightings of humpback whales have been observed in marine waters surrounding Alternative 2 (see Section 3.25, Threatened and Endangered Species), the potential for vessel encounters and potential collisions could be lower under Alternative 2. Impacts from underwater noise from construction of the Diamond Point port (both earthen causeway and jetty or pile-supported design) would be similar to Alternative 1, and humpback whales are more frequently observed south of Augustine Island. Impacts from underwater noise from anchor handling during pipeline installation are also similar, although the pipeline length is shorter under Alternative 2, resulting in potentially less disturbance during activities. The lightering location under Alternative 2 is in Iniskin Bay, where there is lower humpback whale presence than the locations under Alternative 1. The magnitude and extent of this impact would be increased underwater noise and disturbance from dredging vessels, as well as potential increases in turbidity impacting prey species and detection. In summary, the magnitude of impacts would be disturbance and changes to forging ability and prey; the duration would be for the life of the project, and extent would encompass the analysis area. In terms of likelihood, the impacts would be expected to occur if Alternative 2 is selected, permitted and built.

4.25.3.3 Fin Whale

Fin whales are considered extralimital for Cook Inlet, and are unlikely to be encountered in the analysis area; therefore, impacts would be similar to Alternative 1. There would be no aircraft traffic associated with Alternative 2, but there would be dredging. 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. 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. Vessels associated with natural gas pipeline installation would be traveling at very 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 as they would be unlikely to occur in the area. Impacts on fin whales from Alternative 2 would not be expected due to the species rarity in Cook Inlet.

4.25.3.4 Steller Sea Lion

Critical habitat for the Steller sea lion does not occur in the analysis area for Alternative 2. Impacts are anticipated to be similar for the two alternatives, except for the potential disturbance from vessel presence in Iniskin Bay and potential disturbance during dredging activities. Because no airstrip is proposed near Diamond Point port, impacts from aircraft overflights are not anticipated to occur. The potential impacts from increased vessel presence are expected to be higher, because the vessels are required to travel longer, along with increased underwater noise disturbance from dredging. The magnitude of impacts would be disturbance and changes to forging ability and prey; the duration would be for the life of the project, and extent would encompass the analysis area. In terms of likelihood, the impacts would be expected to occur if Alternative 2 is selected, permitted and built.

4.25.3.5 Northern Sea Otter

Northern sea otters are expected to occur in similar densities throughout the marine environment across Alternatives 1 and 2; impacts are anticipated to be similar between both alternatives. Impacts from underwater noise from construction of the Diamond Point port (either earthen causeway and jetty or pile-supported design) would be similar to Alternative 1, although sea otters were observed at higher densities in the port area for Alternative 1 than Alternative 2 (Garlich-Miller et al. 2018). The magnitude and extent of impacts from underwater noise from anchor handling during pipeline installation would be similar, although the pipeline length is shorter under Alternative 2, resulting in fewer disturbances during construction activities, and less disturbance to benthic habitat. The lightering location under Alternative 2 is in Iniskin Bay, which is sea otter critical habitat and important foraging habitat, resulting in potentially greater disturbance. Unlike Alternative 1, dredging would be conducted under Alternative 2, resulting 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 Alternative 1, 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; the duration would be for the life of the project, and extent would encompass the analysis area. In terms of likelihood, the impacts would be expected to occur if Alternative 2 is selected, permitted and constructed.

4.25.3.6 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) (Figure 3.25-2). 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). Additionally, eiders winter immediately adjacent to the proposed 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 1, except impacts would be shifted geographically north to Iliamna and Iniskin bays. These bays are narrower, and may offer more suitable winter protection and feeding habitat than Kamishak Bay. Additionally there are no lighted navigation buoys associated with Alternative 2, and therefore no collision hazard for Steller's eiders. All potential impacts detailed above in Alternative 1 (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. Based on estimates for vessel collisions presented under Alternative 1, the magnitude of potential eider collisions is 0.1 over the life of the project. This collision risk is likely to be higher due to the more restricted mouth of Iniskin Bay, 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 winter directly west of Augustine Island. This would reduce the risk of collisions for eiders in Iniskin Bay with the bulk carriers during stormy weather conditions. Overall, impacts to Steller's eiders from Alternative 2 are anticipated to be similar to Alternative 1, but more eiders could be affected since several hundred eiders are known to winter throughout Iliamna and Iniskin bays.

The magnitude and extent of impacts due to construction of the port at Diamond Point would be a loss of potential nearshore marine benthic foraging habitat for Steller's eiders. The port at Diamond Point would be constructed of 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 4.25-2. 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 1, 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 ability and prey; the duration would be for the life of the project; and extent would be limited to the footprint of the port (and dredged area under the Pile-Supported Dock Variant). To offset impacts, additional foraging habitat for eiders may be created as benthic species colonize the sides of the causeway. In terms of likelihood, these impacts would be expected to occur if the project is permitted and constructed and this alternative selected.

4.25.4 Alternative 3 – North Road Only

There are no new geographical areas potentially impacted by this alternative, and therefore, no new information for any TES is presented. All information for this alternative is previously covered by Alternatives 1 and 2 above. There would be no significant difference in the amount or timing of vessel traffic for any of the variants. The Pipeline Concentrate Variant could potentially result in slurry water being discharged into Cook Inlet at Cottonwood Bay. 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. Additionally, under the Concentrate Pipeline Variant, the average road width would increase from 3 to 5 feet, which could negligibly increase impacts in the Iliamna Bay area for Cook Inlet beluga whale, northern sea otter, and other TES. All other impacts are anticipated to be the same as Alternative 2.

4.25.5 Summary of Key Issues

In summary, Table 4.25-2 details the key issues for TES across all three action alternatives. Because potential impacts to TES may only occur in 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 impact on TES. Quantified acreages of impacted habitat are presented where possible.

The magnitude of and extent of impacts on TES from habitat changes generally include the loss of foraging habitat from placement of 10.7 acres of fill into the marine environment for the earthen causeway and sheet pile jetty at Amakdedori port. Under the Pile-Supported Dock Variant of Alternative 1, there would be approximately 0.07 acre of impacts to the marine environment. Some of these impacts would occur to TES critical habitat. Overall, injury and mortality to TES are not expected to occur. Potential noise resulting from the Pile-Supported Dock Variant of Alternative 1 would produce greater sound levels in the water than from constructing a solid fill dock, and could cause greater potential effects to all marine mammal TES, because pile-driving noise may exceed injury thresholds as defined by NMFS.

4.25.6 Cumulative Effects

The cumulative effects analysis area for TES includes the project footprint for each alternative, and the extended geographic area where direct and indirect effects to listed species can be expected throughout the life of the project, which includes all of western lower Cook Inlet. Past, present, and reasonably foreseeable future actions (RFFAs) in the cumulative impact analysis area have the potential to contribute cumulatively to impacts on TES.

4.25.6.1 Past, Present, and Reasonably Foreseeable Future 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 and behavioral disturbance. The past and present human activities affecting 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, most likely by 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 or factors causing the decline was (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).

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 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 outside the analysis area (e.g., Groundhog, community infrastructure projects), which focuses on the marine environment. 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 Mine Expanded Development Scenario – develop 55 percent of the resource over a 78-year period
- Cook Inlet Oil and Gas Development
- Alaska LNG (Liquefied Natural Gas) Project
- Alaska Stand Alone Pipeline (ASAP) Project
- 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 behavior disturbance and/or vessel strikes. 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 Mine Expanded Development Scenario, because it would directly affect the same species in the same location as the proposed project, and would continue those impacts for a long period of time. The location of RFFAs is depicted in Section 4.1, Introduction to Environmental Consequences.

The cumulative effects associated with all the RFFAs, including the Pebble Mine Expanded Development Scenario, are described below. They are organized by project alternative because there are differences in the port location among the alternatives. The impacts of all the RFFAs are discussed under Alternative 1; where effects would differ under Alternatives 2 or 3, they are discussed under those headings.

4.25.6.2 No Action Alternative

The No Action alternative would not contribute to cumulative effects on TES.

4.25.6.3 Alternative 1 – Applicant's Proposed Alternative

The Pebble Mine Expanded Development scenario (and its associated contributions to cumulative impacts) would be the same for all action alternatives at the mine site and the Iniskin Bay port. However, the proposed alternatives differ in their other port locations; which, when considered along with the Pebble Mine Expanded Development scenario, could compound the effects on TES. Alternative 1 includes a port at Amakdedori; while under Alternatives 2 and 3, the port would be at Diamond Point.

The Pebble Mine Expanded Development Scenario that may affect TES would be the new deep-water loading facility at Iniskin Bay for concentrate shipment. Iniskin Bay is in critical habitat for northern sea otter and Cook Inlet beluga whale. In mine year 20, a new deep-water loading facility at Iniskin Bay would be constructed, and would operate concurrently with the Amakdedori port (under Alternative 1). These two ports would be operating concurrently for 78 years. 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.

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 location of potential effects on all six threatened or endangered species 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.

<u>Cook Inlet Beluga Whale</u>

The primary potential future impacts to Cook Inlet beluga whales from the proposed project, in addition to RFFAs, would be from increased vessel traffic at port locations along the western side of Cook Inlet; especially with the addition of the Iniskin Bay port under the Pebble Mine Expanded Development Scenario, which would occur in designated critical habitat. The critical habitat in Iniskin Bay would be impacted by the construction and operation of the port; this would be in addition to the critical habitat affected by the proposed project (the amount of which varies slightly by alternative, and is detailed in Table 4.25-2).

Construction of the ports would cause noise, which is listed as a primary potential stressor for beluga whales in the Cook Inlet Beluga Whale Recovery Plan (NMFS 2016c). Beluga whales are rare in the analysis area during the summer, so they are not expected to be present during summer construction involving pile driving; however, if they did occur, they may experience temporary or permanent threshold shifts in hearing as a result of exposure to noise levels. 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. Other RFFAs are either limited in their effects to cause noticeable impacts on beluga whales, or lack overlap with beluga whale lifecycles and requirements.

The likelihood of cumulative impacts is low, because beluga whales do not commonly occur in the analysis area; the magnitude impacts on beluga whales would include some potential for behavioral disturbance and noise impact, and less likely for vessel strike, provided mitigation measures are implemented during the consultation process with NMFS. Such effects are unlikely to result in population-level impacts on the species. The duration of any impacts would be temporary, and the risk of impacts would be permanent (greater than 20 years) for the duration of the 78-year extended mining/milling period. The extent of the impacts would be local, —in the immediately vicinity of the increased vessel traffic and noise sources.

Humpback Whale

The primary potential future impacts to humpback whales from RFFAs would be from increased vessel traffic at port locations along the western side of Cook Inlet, especially with the addition of the Iniskin Bay port under the Pebble Mine Expanded Development Scenario. Increased vessel traffic could have some effects on humpback whales from disturbance and potential vessel strikes; however, such effects are unlikely to result in population-level impacts on the species in Cook Inlet due to the slow speeds that vessels would be traveling. Other activities are either limited in their effects to produce noticeable impacts on humpback whales, or lack overlap with humpback whale lifecycles and requirements.

In terms of likelihood, there is potential of cumulative impacts, because humpback whales occur in the analysis area, and the magnitude of any impact for behavioral disturbance and vessel strike are unlikely to result in population-level impacts on the species, provided mitigation measures are implemented during the consultation process with NMFS. The duration of any impacts would be temporary, and the risk of impacts would be permanent (greater than 20 years) for the duration of the 78-year extended mining/milling period. The extent of the impacts would be local—in the immediately vicinity of the increased vessel traffic.

Fin Whale

The primary potential future impacts to fin whales from RFFAs would be from increased vessel traffic at port locations along the western side of Cook Inlet, especially with the addition of the Iniskin Bay port under the Pebble Mine Expanded Development Scenario. Increased vessel traffic increases the risk of adverse interactions such as behavioral disturbance or vessel strikes. Considering the rarity of fin whales in the analysis area, the likelihood of any effects is low. Other RFFAs are either limited in their effects to cause noticeable impacts on fin whales, or lack overlap with fin whale lifecycles and requirements.

The likelihood of cumulative impacts is low because fin whales rarely occur in the analysis area; the magnitude any impacts for behavioral disturbance and vessel strike, are unlikely to result in population-level impacts on the species, provided mitigation measures are implemented during the consultation process with NMFS. The duration of any impacts would be temporary, and the risk of impacts would be permanent (greater than 20 years) for the duration of the 78-year extended mining/milling period. The extent of the impacts would be local—in the immediately vicinity of the increased vessel traffic.

Steller Sea Lion

The primary potential future impacts to Steller sea lions from RFFAs would be from increased vessel traffic at port locations along the western side of Cook Inlet, especially with the addition of the Iniskin Bay port under the Pebble Mine Expanded Development Scenario. Steller sea lions may be drawn to spawning herring near the mouth of Iniskin Bay, and may be disturbed by the construction and operation of the port. Increased vessel traffic increases the risk of adverse interactions such as behavioral disturbance or vessel strikes. Other RFFAs are limited in their effects to cause noticeable impacts on Steller sea lions, or lack overlap with lifecycle requirements.

The likelihood of cumulative impacts is moderate because Steller sea lions occur in the analysis area; the magnitude of impacts minor for behavioral disturbance, noise impact, or vessel strike are unlikely to result in population-level impacts on the species, provided mitigation measures are implemented during the consultation process with NMFS. The duration of any impacts would be temporary, and the risk of impacts would be permanent (greater than 20 years) for the duration of the 78-year extended mining/milling period. The extent of the impacts would be local—in the immediately vicinity of the increased vessel traffic and noise sources.

Northern Sea Otter

The primary potential future impacts to northern sea otters from RFFAs would be from increased vessel traffic at port locations along the western side of Cook Inlet, especially with the addition of the Iniskin Bay port under the Pebble Mine Expanded Development Scenario. There is critical habitat in Iniskin Bay that would be affected by the construction and operation of the port; this would be in addition to the critical habitat affected by the proposed project (the amount of which varies by action alternative). Increased vessel traffic increases the risk of adverse interactions such as behavioral disturbance, hazardous material spills, and vessel strikes. Other RFFAs are limited in their effects to cause noticeable impacts on northern sea otters, or lack overlap with northern sea otters' lifecycles and requirements.

The likelihood of cumulative impacts is moderate because northern sea otters commonly occur in the analysis area; the magnitude of impacts for behavioral disturbance, a spill or vessel strike are unlikely to result in population-level impacts on the species, provided mitigation measures are implemented during the consultation process with USFWS. Although the duration of any impacts would be temporary for the individual affected, the risk of impacts to the population would be permanent (greater than 20 years) for the duration of the 78-year extended mining/milling period. The extent of the impacts would be local—in the immediately vicinity of the increased vessel traffic.

Steller's Eider

The primary potential future impacts to Steller's eiders from RFFAs would be from increased vessel traffic at port locations along the western side of Cook Inlet, especially with the addition of the Iniskin Bay port under the Pebble Mine Expanded Development Scenario. More wintering Steller's eiders have been observed in the vicinity of Iniskin Bay and Diamond Point than at Amakdedori, therefore, Alternatives 2 or 3 would be more likely to affect this species. 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. There would also be potential for increased oil, fuel, and other chemicals to spill into the environment during winter months when eiders are present. Cook Inlet Oil and Gas Lease Sales, and increased vessel traffic associated with other resource development projects (such as the Alaska LNG and ASAP projects) could contribute to cumulative impacts. Both the Pebble Mine Expanded Development scenario and the Diamond Point rock quarry project have the potential to directly impact Steller's eiders' wintering habitat from Cook Inlet. All other projects are anticipated to have indirect impacts on Steller's eiders. Finally, potential cumulative issues related to Steller's eiders include increased disturbance from aircraft and vessels in important molting, wintering, and staging areas; and mortality from collisions with towers, various types of infrastructure, and powerlines, especially during periods of low light or reduced visibility (e.g., low-lying fog). Additionally, facilities with lighting can cause birds to be disoriented, and increase the chance of collisions.

Additional development in the Cook Inlet and regions along the Alaska Peninsula has the potential to impact molting and wintering areas for Steller's eiders. Industrial developments can affect species through habitat loss, alteration, disturbance, and direct mortality. Cumulative impacts to other locations of Steller's eiders molting and wintering habitat may incrementally lead to a decrease in fitness for this long-lived species, which does not breed every year.

Steller's eiders' life history strategy is one dependent on long-lived adults that reproduce in select years of high lemming abundance. Therefore, adult survival during the non-breeding season is important to allow the species to recover. For this reason, cumulative impacts to any Steller's eiders molting and wintering areas in Alaska are included in this analysis.

The likelihood of cumulative impacts is moderate because Steller's eiders winter in the analysis area, especially in the vicinity of Iniskin Bay. The magnitude of impacts for behavioral disturbance, potential for injury and mortality, and spill impacts, are unlikely to result in population-level impacts on the species, provided mitigation measures are implemented during the consultation process with USFWS. Although the duration of any impacts would be temporary for the individual affected, the risk of impacts to the population would be permanent (greater than 20 years) for the duration of the 78-year extended mining/milling period. The extent of the impacts would be local—in the immediately vicinity of the increased vessel traffic.

4.25.6.4 Alternative 2 – North Road and Ferry with Downstream Dams and Alternative 3 – North Road Only

Under Alternatives 2 and 3, the new deep-water loading facility at Iniskin Bay would be constructed at mine year 20, and would operate concurrently with a port at Diamond Point rather than Amakdedori. Because Diamond Point and Iniskin Bay are in close proximity to each other, the cumulative noise, disturbance, and collision risk from the increased vessel traffic is expected to have a greater impact on TES than having the ports further apart at Amakdedori and Iniskin bay, proposed under Alternative 1. The close proximity of the two ports would compound the effects, because there would be less nearby habitat for TES to move to quickly when disturbed. The effects of the Diamond Point Rock Quarry, including loss of 25 acres of northern sea otter critical habitat, would also be additive to those of Alternative 2 and Alternative 3. The combination of several actions in the one area increases the magnitude, duration, and extent of impacts.

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4.26 VEGETATION

The following section provides a description of the potential environmental consequences from the project on vegetation.

4.26.1 EIS Analysis Area

The Environmental Impact Statement (EIS) analysis area (hereafter referred to as "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 EIS 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 analysis area for the mine site includes a 330-foot buffer around the direct disturbance footprint and potential drawdown zone from the open pit.

Transportation Corridor and Ports – The analysis area for the transportation corridor and ports includes a 330-foot buffer around the direct disturbance footprint.

Natural Gas Pipeline – The analysis area for the stand-alone sections of the natural gas pipeline is a 30-foot corridor through Cook Inlet and Iliamna Lake, and a 100-foot corridor through overland areas.

4.26.2 Analysis Methodology

Impacts were assessed in the context of regional Alaskan vegetation affected. To calculate direct impact acres for vegetation removal impacts and indirect impact acres for fugitive dust, the project disturbance footprint was overplayed on vegetation types in ArcGIS. See Section 3.26, Vegetation, for details on how field-verified vegetation data (3PPI and HDR 2011a; HDR and 3PPI 2011a) and publicly available land cover type data (Boggs et al. 2016) were applied to provide vegetation type mapping for the entire analysis area. In this section, the term "vegetation type" is applied, as detailed in Section 3.26, Vegetation. As also described in Section 3.26, the "open water" type is not considered part of the affected environment for vegetation, and impacts to open water would not count as an impact to vegetation. The open water type was not included in calculations in this section. For calculations in this section all numbers are rounded. Apparent inconsistencies in sums are the result of rounding.

Scoping comments expressed requested that the EIS analyze impacts to rare and sensitive species (rare or sensitive plant species are defined in Section 3.26, Vegetation), the effects of fugitive dust on vegetation in the project area, and the risk for introduction of invasive species (invasive species are defined in Section 3.26, Vegetation). The following sections detail the impacts that apply to all project components and associated variants.

4.26.3 Direct and Indirect Impacts

Potential direct and indirect effects on vegetation include:

- Direct impacts from vegetation removal (including impacts to rare or sensitive species)
- Indirect impacts from invasive species introduction or spread
- Indirect impacts from fugitive dust
- Indirect impacts from dewatering.

Potential direct and indirect effects to vegetation were assessed for each impact according to four factors: the magnitude (number of acres impacted), 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). Details of how the four factors were assessed for each direct or indirect impact are discussed below.

Vegetation removal – Vegetation removal would require clearing, grading, and removal of vegetation during the construction phase. Vegetation removal can result in changes to vegetation function, structure, or composition; an increased rate of soil erosion from wind or water; increased runoff volumes; removal of rare or sensitive plant species, or rare or sensitive plant species habitat, and changes in wildlife habitat. Detailed information on erosion and sedimentation is found in Section 4.18, Water and Sediment Quality.

The magnitude of impacts from vegetation removal was assessed by the number of acres of disturbance to aboveground vegetation by vegetation type. An expanded definition of vegetation types is provided in Section 3.26, Vegetation.

The duration of impacts would be considered temporary when vegetation functions would be reduced only during the construction phase, and the area would be reclaimed (meaning that vegetative functions would be returned) after the construction phase. The duration of impacts would be considered permanent in locations where removal or disturbance to vegetation would occur during construction and remain free of vegetation through closure.

The extent of impacts would be limited to areas in which vegetation would be directly removed or disturbed; extent is assessed along with magnitude of impacts by number of acres impacted. Reclaimed areas would be expected to return to the vegetative functions that were lost temporarily as a result of vegetation removal. Natural succession would be expected to take place in reclaimed areas. Vegetation reestablishment time varies; trees and shrubs would be expected to begin to re-establish almost immediately in disturbed areas after construction activities cease, and during and after reclamation activities. Alders (*Alnus* spp.), willows (*Salix* spp.), and birch (*Betula* spp.) are generally the first trees and shrubs to re-establish. Reclamation is discussed in more detail in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, while impacts to soil are further addressed in Section 4.14, Soils.

A draft conceptual Compensatory Mitigation Plan developed by PLP is provided in Appendix M. A final plan would include more information on specific reclamation plans and location. Reclamation details would also be detailed in a Reclamation and Closure Plan, which would be developed during feasibility design work to support state permitting. Mitigation is discussed in detail in Chapter 5, Mitigation.

The likelihood of impacts would be certain as vegetation would be removed if the project were to be permitted and constructed. This factor is not further discussed in this section for vegetation removal as there is no difference between the three action alternatives.

Invasive species – Project activities, especially construction and transportation, would potentially cause the introduction and spread of invasive species within the analysis area. Invasive species may adversely affect native plant populations by increasing competition and reducing biodiversity.

The magnitude and duration of impacts from the introduction or spread of invasive species would span the life of the project. No invasive species have been documented in surveys or in published literature in the analysis area. If the project were to be permitted, an invasive species strategy would describe the equipment, methodology, training, and assessment techniques that may be applied to avoid the introduction and spread of invasive species to the project area during permitted activities would be developed prior to construction. The strategy and required best management practices (BMPs) would be outlined specifically during the permitting process. Mitigation is discussed in detail in Chapter 5, Mitigation. These two factors are not further discussed in this section for invasive species as there is no difference between the three action alternatives.

Four invasive species (common dandelion [*Taraxacum officinale*], lambsquarters [*Chenopodium album*], annual bluegrass [*Poa annua*], and pineapple weed [*Matricaria discoidea*] have been documented adjacent to but outside of the analysis area; however, these species are considered to be a low ecological risk (ACCS 2018a). These two factors are not further discussed in this section for invasive species as there is no difference between the three action alternatives.

Fugitive dust – Fugitive dust emissions are a by-product of construction activities. Dust would be caused by vehicle travel on project access roads spurs and other unpaved surfaces, as well as by mining activities. Wind erosion is also expected in areas that do not have vegetation due to the exposed soil surface from vegetation removal. Dust has the potential to collect on vegetation in the vicinity of the dust sources. Windblown dust would potentially affect vegetation well beyond the source, but the effect diminishes with distance and is affected by prevailing winds and topography. The deposition of dust has also been analyzed in Section 4.14, Soils, with information on impacts to wetlands included in Section 4.22, Wetlands/Special Aquatic Sites.

The effects of dust deposited on adjacent vegetation may include:

- Burial or elimination of vegetation in the most heavily impacted zones (Walker and Everett 1987).
- Reduction in vegetation biomass (Auerbach 1997).
- Decreased plant vitality due to reduced photosynthesis.
- Early snowmelt in roadside areas due to lower albedo (Auerbach 1997).
- Early green-up of plants (Walker and Everett 1987).
- Increases in graminoid composition (Auerbach 1997).
- Decreases in sphagnum and other mosses and lichens (Walker et al. 1987).
- Decreases in nutrient levels in soils (Auerbach 1997).
- Decreases in soil moisture.
- Shallower organic horizon.

The magnitude of impacts from fugitive dust is expected to vary depending on proximity of vegetation to the source of the dust and the prevailing wind, and is assessed by acres impacted. Dust may cause variable physiological changes to vegetation, depending on exposure length or level.

The duration of impacts from fugitive dust is typically seasonal for the life of the project because dust is washed off of the vegetation surrounding the project during winter months (or when deciduous species lose leaves), or can occur throughout the duration of project activities. In some cases, impacts may extend beyond project closure, where physiological changes may occur to plants, or where vegetation community changes may take place. This analysis factor is not further discussed in this section for fugitive dust as there is no difference between the three action alternatives.

The extent of fugitive dust is limited to areas adjacent to roads with vehicle traffic or in unpaved surface areas, and in the dust emissions areas, with the highest concentrations of dust closest to the source. For example, vegetation directly along an access road would receive more dust than vegetation 15 feet away from the road when a vehicle drives by, because the dust would settle as it disperses from the road. Extent is assessed along with magnitude of impacts by number of acres impacted.

The likelihood of impacts would be certain as fugitive dust would occur if the project were to be permitted and constructed. This analysis factor is not further discussed in this section for fugitive dust as there is no difference between the three action alternatives.

A fugitive dust control plan would be developed for the project, applying Best Available Control Technology (BACT) and BMPs for fugitive dust management. The plan would describe the equipment, methodology, training, and performance assessment techniques that would be used to control fugitive dust from site activities and wind erosion. Pebble Limited Partnership (PLP) proposes to use covered containers to transport concentrate, essentially eliminating potential for concentrate dust. Although these measures are expected to reduce the amount of fugitive dust produced and dispersed, dust would still affect vegetation. Potential mitigation and minimization measures, including the fugitive dust control plan, are further addressed in Chapter 5, Mitigation.

Dewatering – Construction of the project would lower groundwater or change water availability in some locations in the analysis area. Groundwater lowering may reduce water availability to plant species.

The magnitude of indirect impacts to vegetation from dewatering is expected to be dependent on the individual plant species present, and those species' applicable root depths and water tolerances. The extent to which dewatering would impact vegetation is dependent on the vegetation's location relative to the reduced groundwater levels. Plants with shallow root systems, such as paper birch (*Betula papyrifera*), Alaska blueberry (*Vaccinium alaskaense*), and bluejoint reedgrass (*Calamagrostis canadensis*), require a fairly constant supply of water, and would be impacted to a greater extent than drought-tolerant or deep-rooted species. Impacts to vegetation from reduction in water availability may include stunted growth, greater susceptibility to disease and succession of more drought-tolerant species. These two analysis factors are not further discussed in this section for dewatering as there is no difference between the three action alternatives.

The duration of impacts would also depend on the timing and location of the groundwater lowering and the tolerance of the vegetation types. Impacts to groundwater are discussed in Section 4.17, Groundwater Hydrology. Impacts to wetland vegetation and special aquatic sites are presented and addressed in Section 4.22, Wetlands/Special Aquatic Sites. A CMP would be required to be developed by PLP as part of the CWA Section 404(b)(1) permit (if issued). This plan, in addition to other mitigation and minimization measures, would not completely eliminate impacts, but would be expected to reduce the impacts to vegetation from dewatering. This analysis factor is not further discussed in this section for dewatering as there is no difference between the three action alternatives.

The likelihood of impacts would be certain as dewatering would take place if the project were to be permitted and constructed. This analysis factor is not further discussed in this section for dewatering as there is no difference between the three action alternatives.

4.26.4 No Action Alternative

Under the No Action Alternative, the Pebble Project would not be undertaken. No construction, operations, or closure activities would occur. Therefore, no additional future direct or indirect effects on recreation would be expected. Though no resource development would occur under the No Action Alternative, permitted resource exploration activities currently associated with the project may continue (ADNR 2018-RFI 073). PLP would have the same options for exploration activities that currently exist. In addition, there are many valid mining claims in the area and these lands would remain open to mineral entry and exploration. Current state-authorized activities associated with mineral exploration and reclamation and scientific studies would be expected to continue at similar levels. PLP would be required to reclaim any remaining sites at the conclusion of their exploration program. If reclamation approval is not granted immediately after the cessation of reclamation activities, the state may require continued authorization for ongoing monitoring and reclamation work, as deemed necessary by the State of Alaska.

4.26.5 Alternative 1 – Applicant's Proposed Alternative

4.26.5.1 Mine Site

Vegetation Removal

Construction activities would require clearing, grading, and removing vegetation in areas where the mine pit, tailings storage facility, overburden stockpiles, material sites, water management ponds, milling and processing facilities, access roads, and supporting infrastructure would be located.

For Alternative 1, the duration of impacts to vegetation at the mine site would be considered permanent. 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. All construction roads would continue to serve as site access roads. The magnitude, extent, and duration of impacts during construction of the mine site would be the permanent removal of 8,000 acres of vegetation.

Table 4.26-1 lists acreages by vegetation type in the mine site area that would be affected by clearing, grading, and removal activities during construction.

Table 4.26-1 Mine Site Vegetation Removal Impacts

Vegetation Type	Permanent Impacts (acres)
Open or Closed Tall Shrub	1,093
Open or Closed Low Shrub	1,530
Dwarf Shrub	4,279
Dry to Moist Herbaceous	316
Wet Herbaceous	490
Other	292
Total	**8,000**

Impacts are the same for the Alternative 2 and Alternative 3 mine site.
Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Summer-Only Ferry Operations Variant

With this variant, concentrate would be stored at or near the mine site for up to 6 months per year, resulting in a larger mine site footprint and requiring additional vegetation removal. The mine site permanent footprint would increase by 38 acres, increasing the magnitude and extent of impacts. The majority of this area is dwarf shrub type. Other types include dry to moist herbaceous, open or closed low shrub, and other would also be impacted under this variant. Duration would be the same as Alternative 1.

Fugitive Dust

Fugitive dust emissions are a by-product of construction activities. At the mine site, dust would be caused by vehicle travel on the mine access road and other unpaved surfaces in the mine, ore crushing, loading and unloading of materials, as well as by mining activities at the pit. Wind would also be expected to create dust from areas of the mine site that do not have vegetation as a result of vegetation removal.

During construction, the magnitude and extent of fugitive dust impacts would be the deposition of dust from the mine over 3,007 acres of vegetation. The dominant vegetation types in this area are dwarf shrub and low shrub. Table 4.26-2 lists the acreages of the vegetation types in the mine site area that would potentially be affected by fugitive dust.

Table 4.26-2 Alternative 1 – Mine Site Fugitive Dust Impacts

Vegetation Type	Indirect Impacts (acres)
Open or Closed Forest	1
Open or Closed Tall Shrub	305
Open or Closed Low Shrub	374
Dwarf Shrub	1,853
Dry to Moist Herbaceous	128
Wet Herbaceous	170
Other	175
Total	**3,007**

Impacts are the same for Alternative 3 Mine site.
Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Summer-Only Ferry Operations Variant

With this variant, concentrate would be stored at or near the mine site for up to 6 months per year. The mine site footprint increase would also cause an increase in permanent impacts to vegetation removal, but indirect impacts from fugitive dust would not be expected to increase under this variant.

4.26.5.2 Transportation and Natural Gas Pipeline Corridors

Vegetation Removal

Construction activities in the transportation and natural gas corridors would require clearing, grading, and removal of vegetation in areas where the port access road, ferry terminals, laydown areas, material sites, and buried onshore pipeline would be located. During operations, periodic brushing of the revegetated pipeline corridor would occur. Segments of the natural gas pipeline adjacent to access roads are addressed in this section.

The magnitude, extent, and duration of impacts would be the permanent removal of 1,178 acres of vegetation. Also, a total of 619 acres of vegetation would be temporarily impacted. Table 4.26-3 lists the acreages of the vegetation types in the transportation and natural gas pipeline corridors that would be affected by clearing, grading, and removal activities with construction. Impacts associated with some locations in these components would be considered temporary, because reclamation would occur directly after installation. All temporary construction facilities would be removed after construction; and the sites, unless being used for permanent facilities, would be reclaimed. Temporary facilities associated with the transportation corridor on the western side of Cook Inlet include the camps established at the ferry landings.

The road system would be retained as long as required for the transport of bulk supplies needed for long-term post-closure water treatment and monitoring. The Iliamna Lake ferry facilities would be removed, and all closure-related supplies would be transported across the lake using a summer barging operation.

Table 4.26-3: Alternative 1 – Transportation and Natural Gas Pipeline Corridors Vegetation Removal Impacts

Vegetation Type	Temporary Impacts (acres)	Permanent Impacts (acres)
Open or Closed Forest	70	149
Open or Closed Tall Shrub	135	269
Open or Closed Low Shrub	45	78
Dwarf Shrub	338	627
Dry to Moist Herbaceous	9	19
Wet Herbaceous	9	14
Other	14	23
Total	**619**	**1,178**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Summer-Only Ferry Operations Variant

This variant would not change the impacts to vegetation.

Kokhanok East Ferry Terminal Variant

This variant would increase the magnitude and extent of temporary impacts on vegetation from 619 acres in the transportation and natural gas corridor to 644 acres. The impact would be certain to occur if the project is permitted and the Kokhanok East Ferry terminal is built. The impacted vegetation type is predominately dwarf shrub. Table 4.26-4 lists the vegetation type acres in the transportation and natural gas pipeline corridors that would be affected by clearing, grading, and removal activities with construction for this variant.

Table 4.26-4: Alternative 1 – Kokhanok East Ferry Terminal Variant – Transportation and Natural Gas Pipeline Corridors Vegetation Removal Impacts

Vegetation Type	Temporary Impacts (acres)	Permanent Impacts (acres)
Open or Closed Forest	166	291
Open or Closed Tall Shrub	130	259
Open or Closed Low Shrub	45	81
Dwarf Shrub	252	513
Dry to Moist Herbaceous	15	31
Wet Herbaceous	14	25
Other	13	27
Total	**644**	**1,246**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Fugitive Dust

Because the roads and pipeline cross several watersheds, these impacts are likely to affect a wider geographic area compared to the mine site. However, levels of dust accumulation would be lower along the port and mine access roads, because the dust-producing activities would be less frequent compared to the mine site (vehicles passing rather than ongoing movement of materials), and because of the smaller size of the unvegetated area (road width rather than entire mine site).

During project operations, daily transportation of materials (concentrate, fuel, reagents, and consumables) would require up to 35 truck round-trips per day on the port access road. Section 4.12, Transportation and Navigation, describes the type and amount of vehicles expected to use the roads. Vehicle traffic on gravel roads can produce dust that settles on the roadside. Dust would likely be generated during gravel placement, gravel compaction activities, and from vehicular traffic and equipment operation on gravel roads. 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).

In summer, this dust can increase soil alkalinity, which reduces plant vigor in acidic tundra (Walker and Everett 1987), thereby reducing the insulating effect of the vegetative cover to the underlying soil. During winter, the dust reduces the albedo of roadside snow, which initiates earlier melting and increases the cumulative heat absorption of the active layer. Snow acts as an insulator for the soil as well, and accelerated snowmelt reduces the insulating effect (Auerbach 1997). Loss of surface insulation, either by loss of vegetation or snow, causes earlier spring thaw and earlier freeze-up at the end of summer. Road grading and snowplowing may deposit gravel onto vegetation adjacent to the access roads and pads. Over time, accumulation of gravel may compact or smother vegetation, reducing active layer insulation and increasing thaw. Thin deposits of dark-colored gravel may slightly reduce surface albedo, increase surface soil temperatures, and promote vegetation growth, which would better insulate the active layer. Overall, dust fallout, snow plow deposition, and other gravel spray onto the adjacent vegetation would potentially impact a 35-foot-wide corridor of vegetation on each side of the mine and port access roads. Culvert maintenance and replacement would occur as needed. Potential effects due to culvert replacement during operations would be downstream erosion, and disturbance of the surface vegetation and soils in the work area.

In terms of magnitude and extent of impacts, a total of 6,150 acres of vegetation would be indirectly impacted by dust. The majority of vegetation impacted is open or closed forest. Table 4.26-5 lists the vegetation type acres in the transportation and natural gas pipeline corridor that would potentially be affected by fugitive dust.

Table 4.26-5: Alternative 1 – Transportation and Natural Gas Pipeline Corridors Fugitive Dust Impacts

Vegetation Type	Indirect Impacts (acres)
Open or Closed Forest	719
Open or Closed Tall Shrub	1,434
Open or Closed Low Shrub	560
Dwarf Shrub	3,047
Dry to Moist Herbaceous	100
Wet Herbaceous	132

Table 4.26-5: Alternative 1 – Transportation and Natural Gas Pipeline Corridors Fugitive Dust Impacts

Vegetation Type	Indirect Impacts (acres)
Other	158
Total	**6,150**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Summer-Only Ferry Operations Variant

This variant would not change the impacts to vegetation.

Kokhanok East Ferry Terminal Variant

For magnitude and extent, this variant would replace 1,433 acres of impacts from fugitive dust in the transportation and natural gas corridor with impacts to 1,060 acres of vegetation from fugitive dust. In total, this variant would indirectly impact 5,786 acres of vegetation. The impacted vegetation type is predominately open or closed forest. Table 4.26-6 lists the acreages of the vegetation types in the transportation and natural gas pipeline corridors that would be affected by fugitive dust for this variant.

Table 4.26-6: Alternative 1 – Kokhanok East Ferry Terminal Variant – Transportation and Natural Gas Pipeline Corridors Fugitive Dust Impacts

Type	Indirect Impacts (acres)
Open or Closed Forest	1,183
Open or Closed Tall Shrub	2,568
Open or Closed Low Shrub	523
Dwarf Shrub	2,331
Dry to Moist Herbaceous	176
Wet Herbaceous	139
Other	149
Total	**5,786**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

4.26.5.3 Amakdedori Port

Vegetation Removal

Construction of the port would require clearing, grading, and removal of vegetation in areas along the access road, dredge stockpile area, and where the shore-based facilities would be located, such as facilities for receipt and storage of containers, fuel storage and transfer, power generation and distribution, maintenance, and employee accommodations.

All temporary construction facilities would be removed after construction, and the sites would be reclaimed, unless being used for permanent facilities. Temporary facilities associated with the port include the construction camp; however, this facility would be in an area that would be used for port operations, and would not involve a separate footprint.

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.

In terms of magnitude, extent, and duration, a total of 19 acres of vegetation would be permanently impacted by vegetation removal. For a total of 7 acres of vegetation, duration would be temporary. These impacts would be certain to occur if the project is permitted and the Amakdedori port is constructed. Table 4.26-7 lists the vegetation type acres that would be directly affected by clearing, grading, and removal activities during construction and operation.

Table 4.26-7: Alternative 1 – Amakdedori Port Vegetation Removal Impacts

Type	Temporary Impacts (acres)	Permanent Impacts (acres)
Dry to Moist Herbaceous	1	1
Dwarf Shrub	4	14
Open Closed Tall Shrub	1	1
Wet Herbaceous	<1	<1
Other	1	4
Total	**7**	**19**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Summer-Only Ferry Operations Variant

In terms of magnitude, extent, and duration, an additional 27 acres vegetation would be permanently impacted by vegetation removal under this variant. For a total of an additional 4 acres of vegetation, duration would be temporary. The dominant vegetation type in this area is dwarf shrub. These impacts would occur only if the project is permitted and built, and the Summer-Only Ferry Operations Variant is chosen.

Pile-Supported Dock Variant

This variant would not change the impacts to vegetation as any impacts would occur in the open water type.

Fugitive Dust

Fugitive dust emissions are a by-product of construction activities. No current development exists at the Amakdedori port site. Fugitive dust at this location would mostly be attributed to construction of the terminal. Because no construction would be required during operations, subsequent indirect impacts to vegetation from fugitive dust would likely be limited. With the exception of necessary infrastructure to support shallow-draft tug and barge access to the dock, onshore port facilities would be removed during closure.

In terms of magnitude and extent, during construction, a total of 84 acres of vegetation would potentially be affected by dust deposition from the Amakdedori port. The dominant vegetation types in this area are dwarf shrub and low shrub.

Table 4.26-8 lists the acreages of the vegetation types in the mine site area that would be affected by fugitive dust.

Table 4.26-8: Alternative 1 – Amakdedori Port Fugitive Dust Impacts

Vegetation Type	Permanent Impacts (acres)
Open or Closed Tall Shrub	8
Open or Closed Low Shrub	1
Dwarf Shrub	50
Dry to Moist Herbaceous	11
Wet Herbaceous	2
Other	12
Total	**84**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Summer-Only Ferry Operations Variant

In terms of magnitude and extent, during construction, an additional 8 acres of vegetation would potentially be affected by dust deposition from the Amakdedori port under this variant. The dominant vegetation types in this area are dwarf shrub and low shrub. These impacts would occur only if the project is permitted and built, and the Summer-Only Ferry Operations Variant is chosen.

Pile-Supported Dock Variant

This variant would not change the impacts to vegetation as any impacts would occur in the open water type.

4.26.6 Alternative 2 – North Road and Ferry with Downstream Dams

4.26.6.1 Mine Site

The mine site footprint is the same for all action alternatives. Therefore, the impacts to vegetation types at the mine site are the same for all alternatives, summarized under Alternative 1.

Summer-Only Ferry Operations Variant

There would be no change to impacts to vegetation under this variant.

4.26.6.2 Transportation and Natural Gas Pipeline Corridors

<u>Vegetation Removal</u>

In terms of magnitude, extent, and duration, a total of 1,426 acres of vegetation would be permanently impacted by the transportation and natural gas corridors in Alternative 2. A total of 427 acres of vegetation would be temporarily impacted. Impacted vegetation is composed primarily of forest and shrub types. Table 4.26-9 lists the vegetation type acres in the transportation and natural gas pipeline corridors that would be affected by clearing, grading, and removal activities with construction. Impacts associated with some locations in these components would be temporary, because reclamation would occur directly after installation. These impacts would be certain to occur if the Alternative 2 is selected, permitted, and built.

All temporary construction facilities would be removed after construction, and the sites, unless being used for permanent facilities, would be reclaimed. The road system would be retained as long as required for the transport of bulk supplies needed for long-term post-closure water treatment and monitoring. The Iliamna Lake ferry facilities would be removed, and all closure-related supplies would be transported across the lake using a summer barging operation.

Table 4.26-9: Alternative 2 – Transportation and Natural Gas Pipeline Corridors Vegetation Removal Impacts

Type	Temporary Impacts (acres)	Permanent Impacts (acres)
Open or Closed Forest	177	698
Open or Closed Tall Shrub	70	145
Open or Closed Low Shrub	43	144
Dwarf Shrub	107	350
Dry to Moist Herbaceous	10	31
Wet Herbaceous	5	7
Other	16	51
Total	**427**	**1,426**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Summer-Only Ferry Operations Variant

There would be no change to impacts to vegetation under this variant the concentrate container storage location along the Williamsport-Pile Bay Road is already included in the analysis area.

Fugitive Dust

For Alternative 2, magnitude and extent would be that 4,315 acres of vegetation would potentially be indirectly impacted by dust in the transportation and natural gas corridors. The majority of impacted vegetation is open or closed forest. Table 4.26-10 lists the acreages of the vegetation types in the transportation and natural gas pipeline corridor that would be affected by fugitive dust.

Table 4.26-10: Alternative 2 – Transportation and Natural Gas Pipeline Corridors Fugitive Dust Impacts

Vegetation Type	Indirect Impacts (acres)
Open or Closed Forest	1,702
Open or Closed Tall Shrub	744
Open or Closed Low Shrub	508
Dwarf Shrub	1,039
Dry to Moist Herbaceous	126
Wet Herbaceous	74
Other	122
Total	**4,315**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Summer-Only Ferry Operations Variant

There would be no change to impacts to vegetation under this variant.

4.26.6.3 Diamond Point Port

Vegetation Removal

For magnitude, extent, and duration, a total of 18 acres of vegetation would be permanently impacted by the construction of the Diamond Point port under Alternative 2. Magnitude, extent, and duration would also include a total of 4 acres of vegetation that would be temporarily impacted. Table 4.26-11 lists the acres of the vegetation types that would be directly affected by clearing, grading, and removal activities during construction and operation. These impacts would be certain to occur if Alternative 2 is chosen and permitted and the Diamond Point port is constructed.

Table 4.26-11: Alternative 2 – Diamond Point Port Vegetation Removal Impacts

Vegetation Type	Temporary Impacts (acres)	Permanant Impacts (acres)
Dry to Moist Herbaceous	1	5
Dwarf Shrub	1	1
Open or Closed Forest	1	4
Open or Closed Low Shrub	1	4
Open or Closed Tall Shrub	1	<1
Wet Herbaceous	<1	<1
Other	1	3
Total	**4**	**18**

Impacts are the same under Alternative 3.
Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Pile-Supported Dock Variant

In terms of magnitude, extent, and duration, a total of 40 acres of vegetation would be permanently impacted by the construction of the Diamond Point port under this variant. In addition, a total of 4 acres of vegetation would be temporarily impacted. As described in Section 3.26, Vegetation, the analysis area for the Diamond Point port consists mostly of open water type. Table 4.26-12 lists the acres of the vegetation types that would be directly affected by clearing, grading, and removal activities during construction and operation.

Table 4.26-12: Alternative 2 – Pile-Supported Dock Variant - Diamond Point Port Vegetation Removal Impacts

Vegetation Type	Temporary Impacts (acres)	Permanant Impacts (acres)
Dry to Moist Herbaceous	1	5
Dwarf Shrub	1	1
Open or Closed Forest	1	4
Open or Closed Low Shrub	1	4
Open or Closed Tall Shrub	<1	13

Table 4.26-12: Alternative 2 – Pile-Supported Dock Variant - Diamond Point Port Vegetation Removal Impacts

Vegetation Type	Temporary Impacts (acres)	Permanant Impacts (acres)
Wet Herbaceous	<1	<1
Other	1	12
Total	**4**	**40**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Fugitive Dust

In terms of magnitude and extent, during construction, a total of 45 acres of vegetation would potentially be affected by dust deposition from the Diamond Point port. The dominant vegetation types in this area are tall shrub and low shrub. Impacts at Diamond Point port would mostly occur in the open water type, as noted in Section 3.26, Vegetation.

Table 4.26-13 lists the acreages of the vegetation types in the port that would be affected by fugitive dust.

Table 4.26-13: Alternative 2 – Diamond Point Port Fugitive Dust Impacts

Vegetation Type	Indirect Impacts (acres)
Open or Closed Tall Shrub	7
Open or Closed Low Shrub	12
Open or Closed Forest	4
Dwarf Shrub	5
Dry to Moist Herbaceous	5
Wet Herbaceous	<1
Other	11
Total	**45**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Pile-Supported Dock Variant

In terms of magnitude and extent, during construction, a total of 65 acres of vegetation would potentially be affected by dust deposition from the Diamond Point port under this variant. The dominant vegetation types in this area are tall and low shrub. Impacts at Diamond Point port would mostly occur in the open water type, as noted in Section 3.26.

Table 4.26-14 lists the acres of the vegetation types in the port that would potentially be affected by fugitive dust.

Table 4.26-14: Alternative 2 – Pile-Supported Dock Variant - Diamond Point Port Fugitive Dust Impacts

Vegetation Type	Indirect Impacts (acres)
Open or Closed Tall Shrub	25
Open or Closed Low Shrub	12
Open or Closed Forest	4
Dwarf Shrub	5
Dry to Moist Herbaceous	5

Table 4.26-14: Alternative 2 – Pile-Supported Dock Variant - Diamond Point Port Fugitive Dust Impacts

Vegetation Type	Indirect Impacts (acres)
Wet Herbaceous	<1
Other	12
Total	**65**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

4.26.7 Alternative 3- North Road Only

4.26.7.1 Mine Site

The mine site footprint is the same for all action alternatives. Therefore, the impacts to vegetation types at the mine site are the same for all alternatives, summarized under Alternative 1.

Concentrate Pipeline Variant

With this variant, the mine site footprint and associated vegetation removal impact acres would be increased by approximately 1 acre of permanent impacts to dwarf shrub. Indirect impacts to vegetation from dust would be the same under this variant.

4.26.7.2 Transportation and Natural Gas Pipeline Corridors

Vegetation Removal

Segments of the natural gas pipeline that do not follow the access road corridors are included here (from the Diamond Point port to Ursus Cove; and from Ursus Cove across the Cook Inlet to the compressor station near Anchor Point on the Kenai Peninsula).

In terms of magnitude and duration, a total of 1,751 acres of vegetation would be permanently impacted by the transportation and natural gas corridors. In addition, a total of 636 acres of vegetation would be temporarily impacted. These impacts would be certain to occur if the project is permitted and built. The vegetation impacted is predominately open or closed forest and mixed shrub. Table 4.26-15 lists the acres of the vegetation types in the transportation and natural gas pipeline corridors that would be affected by clearing, grading, and removal activities with construction. Impacts associated with some locations in these components would be temporary, because reclamation would occur shortly after installation.

Table 4.26-15: Alternative 3 – Transportation and Natural Gas Pipeline Corridors Vegetation Removal Impacts

Vegetation Type	Temporary Impacts (acres)	Permanent Impacts (acres)
Dry to Moist Herbaceous	10	28
Dwarf Shrub	108	349
Open or Closed Tall Shrub	84	165
Open or Closed Forest	368	1,009
Open or Closed Low Shrub	45	141
Wet Herbaceous	5	6

Table 4.26-15: Alternative 3 – Transportation and Natural Gas Pipeline Corridors Vegetation Removal Impacts

Vegetation Type	Temporary Impacts (acres)	Permanent Impacts (acres)
Other	17	53
Total	**636**	**1,751**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Concentrate Pipeline Variant

This variant would slightly increase the north access road corridor width due to the concentrate pipeline and the optional return water pipeline that would be co-located in a single trench, with the gas pipeline at the toe of the north road corridor embankment, increasing the average width of the north access road corridor by 3 feet. The increase would be less for the concentrate pipeline without a return pipeline. The increase in width would be less than 10 percent of the total of Alternative 3 acres under typical construction (PLP 2018-RFI 066), so a separate calculation was not performed for this variant as acres and impacts would be expected to be the same as Alternative 3.

Fugitive Dust

In terms of magnitude and extent, a total of 6,733 acres of vegetation would be indirectly impacted by dust in the transportation and natural gas corridors. The majority of impacted vegetation is open or closed forest. Table 4.26-16 lists the acreages of the vegetation types in the transportation and natural gas pipeline corridor that would potentially be affected by fugitive dust.

Table 4.26-16: Alternative 3 – Transportation and Natural Gas Pipeline Corridors Fugitive Dust Impacts

Vegetation Type	Indirect Impacts (acres)
Open or Closed Forest	3,917
Open or Closed Tall Shrub	891
Open or Closed Low Shrub	526
Dwarf Shrub	1,039
Dry to Moist Herbaceous	122
Wet Herbaceous	109
Other	130
Total	**6,733**

Source: Boggs et al. 2016; 3PPI and HDR 2011a; HDR and 3PPI 2011a; HDR 2018c

Concentrate Pipeline Variant

The slight increase in area of impacts under this variant would not change the impacts from fugitive dust.

4.26.7.3 Diamond Point Port

The Diamond Point port footprint would be the same as Alternative 2, described previously. Therefore, both direct and indirect effects would be the same.

Concentrate Pipeline Variant

There would be no changes to impacts under this variant.

4.26.8 Impact Summary

Depending on the alternative, the magnitude and extent or impacts from project construction, operations, and closure at the mine site would be the removal of between 9,823 to 10,409 acres of vegetation, including habitat that supports the fish and wildlife resources in the analysis area.

Table 4.26-17 summaries the key issues for vegetation across all three alternatives. When possible, acreages of habitat that would be directly or indirectly impacted are included.

Table 4.26-17: Summary of Vegetation Key Impacts

Impact	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Vegetation Removal	**Mine Site** Permanent loss of 8,000 acres of vegetation. ***Summer-Only Ferry Operations Variant*** *Additional 40 acres of permanent loss.* **Transportation and Natural Gas Pipeline Corridors** Permanent loss of 1,178 acres of vegetation. Temporary impacts to 619 acres of vegetation. ***Kokhanok East Ferry Terminal Variant*** *Permanent loss of 1,246 acres of vegetation.* *Temporary impacts to 644 acres of vegetation.* **Port** Permanent loss of 19 acres of vegetation. Temporary loss of 7 acres of vegetation. ***Summer-Only Ferry Operations Variant*** *Permanent loss of 46 acres of vegetation.* *Temporary loss of 11 acres of vegetation.*	**Mine Site** Same as Alternative 1. **Transportation and Natural Gas Pipeline Corridors** Permanent loss of 1,426 acres of vegetation. Temporary impacts to 427 acres of vegetation. **Port** Permanent loss of 18 acres of vegetation. Temporary loss of 4 acres of vegetation. ***Summer-Only Ferry Operations Variant*** *Permanent loss of 40 acres of vegetation. Temporary loss of 4 acres of vegetation.*	**Mine Site** Same as Alternative 1. ***Concentrate Pipeline Variant*** *Increase in permanent impacts of 1 acre.* **Transportation and Natural Gas Pipeline Corridors** Permanent loss of 1,751 acres of vegetation. Temporary impacts to 636 acres of vegetation. ***Concentrate Pipeline Variant*** *Increase of less than 10% would be expected to have the same impacts as Alternative 3.* **Port** Same as Alternative 2.

Table 4.26-17: Summary of Vegetation Key Impacts

Impact	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Fugitive dust	**Mine Site** Indirect impacts to 3,007 acres of vegetation. **Transportation and Natural Gas Pipeline Corridor** Indirect impacts to 6,150 acres of vegetation. ***Kokhanok East Ferry Terminal Variant*** *Indirect impacts to 5,786 acres of vegetation.* **Port** Indirect impacts to 84 acres of vegetation. ***Summer-Only Ferry Operations Variant*** *Indirect impacts to 92 acres.*	**Mine Site** Same as Alternative 1. **Transportation and Natural Gas Pipeline Corridor** Indirect impacts to 4,315 acres of vegetation. **Port** Indirect impacts to 45 acres of vegetation. ***Summer-Only Ferry Operations Variant*** *Indirect impacts to 65 acres*.	**Mine Site** Same as Alternative 1. **Transportation and Natural Gas Pipeline Corridor** Indirect impacts to 6,733 acres. **Port** Same as Alternative 2.

4.26.9 Cumulative Effects

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

4.26.9.1 Past, Present, and Reasonably Foreseeable Future Actions

<u>Past and Present Actions</u>

Past and present actions that have, or are currently, affecting vegetation in the analysis area are minimal, because most of the vegetation in the area is undisturbed. 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, are currently having minimal impacts on vegetation. These impacts include vegetation removal, dust impacts, changes in plant community diversity, and the risk of introduction or spread of invasive species.

These actions have removed some vegetation, and are likely to have resulted in the introduction and spread of invasive species. Although these actions affected localized areas, they are additive to other vegetation-removing actions, increasing the total acreage affected. As discussed previously, ground-disturbing activities increase the likelihood of invasive plant species introduction or spread; more exposed soil means a greater risk. Dust effects can also be additive, because more dust-producing actions are implemented a greater area of vegetation is affected.

Several of the RFFAs detailed in Section 4.1, Introduction to Environmental Consequences, are considered to have no potential for cumulatively impacting vegetation in the analysis area.

These include off-shore–based developments such as oil and gas lease sales, in-river hydroelectric projects, and non-industrialized point source activities that are unlikely to result in any appreciable impact 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 eliminate infrastructure co-use by other parties (e.g., Donlin Gold, Copper Joe).

RFFAs that could contribute cumulatively to vegetation impacts, and are therefore considered in this analysis, are those activities that would occur in the analysis area, and may have impacts on vegetation similar to the project. RFFAs, combined with natural events, have the potential to contribute to such adverse effects on vegetation as vegetation removal, dust impacts, changes in plant community diversity, and the risk of introduction or spread of invasive species.

The following RFFAs, identified in Section 4.1, Introduction to Environmental Consequences, were carried forward in this analysis based on their potential to impact vegetation in the analysis area:

- Pebble Project buildout – develop 55 percent of the resource over a 78-year period
- Pebble South/PEB*
- Big Chunk South*
- Big Chunk North*
- Fog Lake*
- Groundhog*
- Diamond Point Rock Quarry
- Lake and Peninsula/Kenai Peninsula Transportation and Community Infrastructure

**Indicates exploration activities only.*

These projects are anticipated to include vegetation removal, resulting in a net loss of vegetation and changes in vegetation communities, as well as dust deposition and increased risk of invasive plant species.

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 direct removal, and indirectly through dust deposition and increased likelihood of introduction and spread of invasive plant species. Road projects have high potential to cause invasive species impacts; not only during construction, but also during operations; vehicles can also easily carry seeds from one area to another. Although BMPs can reduce the risk, the potential for impacts remains as long as the road is in operation.

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 small areas of 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 or spread of invasive 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, as there would not be expected to be much activity.

The cumulative effects from past, present, and RFFAs would be consistent across project alternatives, except for the Pebble Mine Expanded Development Scenario. A discussion of impacts associated with this scenario is provided below.

4.26.9.2 Pebble Mine Expanded Development Scenario

The Pebble Mine Expanded Development Scenario is described in Section 4.1, Introduction to Environmental Consequences. The Pebble Mine expansion would increase the amount of vegetation removal, fugitive dust, and likelihood of invasive species introduction or spread, and these impacts would be additive to those of the project. Approximately 21,546 acres of additional vegetation removal would occur at the mine site. It is assumed that the vegetation types affected would be similar to those affected by the project (shrub and herbaceous).

As shown in Table 4.26-18, the amount of vegetation removal associated with other project components would vary by alternative. The removal would occur along the same route transportation/pipeline route as the Alternative 3, and it is expected to affect similar vegetation types (predominantly dwarf shrub).

The magnitude of vegetation impacted by removal, dust, and risk of invasive species would be higher; with the extent of impacts limited to the immediate vicinity of the disturbance footprint, except in the case of invasive species, which could spread beyond the footprint. The duration of impacts would be extended as processing of low-grade ore and potentially acid-generating (PAG) waste material would continue for another 20 to 40 years past the end of mining. This would delay the reclamation of vegetation affected by the low-grade ore and PAG material storage areas, and extend the duration of impacts from dust and risk of invasive species.

A discussion of cumulative effects is provided below for each project alternative.

Table 4.26-18 – Pebble Expanded Development Footprint by Alternative

Project Component	Alternative 1		Alternative 2		Alternative 3	
	Proposed Project	Estimated Pebble Expanded Development footprint	Proposed Project	Estimated Pebble Expanded Development footprint	Proposed Project	Estimated Pebble Expanded Development footprint
Mine Site	8,086 acres	29,632 acres	8,241 acres	29,632 acres	8,086 acres	29,632 acres
Port	30 acres at Amakdedori port	Additional compressor station at Amakdedori port – 3 acres	112 acres at Diamond Point port	Additional compressor station at Diamond Point port – 3 acres	112 acres at Diamond Point port	Additional compressor station at Diamond Point port – 3 acres
Concentrate and diesel fuel pipeline to Iniskin Bay	N/A	1,022 acres	N/A	194 acres	N/A	194 acres
Iniskin Bay Port	N/A	30 acres	N/A	30 acres	N/A	30 acres
Total	8,116 acres	30,717 acres	8,535 acres	29,971 acres	8,198 acres	29,971 acres

4.26.9.3 No Action Alternative

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

4.26.9.4 Alternative 1 – Applicant's Proposed Alternative

Expanded development and associated contributions to cumulative impacts would be the same for all action alternatives at the mine site and the Iniskin Bay port; however, there would be differences in the transportation, pipelines, and natural gas compressor station footprints. As shown in Table 4.26-18, under Alternative 1, the additional compressor station would be located at the Amakdedori port, and the concentrate and diesel fuel pipelines to Iniskin Bay would include an adjacent service road (because the north access road would not have been constructed).

Under Alternative 1, the total pebble mine expanded development scenario project footprint would directly impact approximately 30,717 acres, compared to 8,116 acres under Alternative 1, increasing the acreage of vegetation loss by 22,571 acres. As shown in Table 4.26-18, this scenario (Alternative 1 plus expanded mine development) would cause the most impacts to vegetation among the project alternatives. This is because the ground disturbance associated with the diesel and concentrate pipelines, and associated service road, would be constructed in an area not affected by the Proposed Alternative. There would be two pipeline/road corridors operating between the mine site and Cook Inlet, rather than the one corridor that would exist under this scenario with either Alternatives 2 or 3; one in the south associated with the proposed project, and an additional one in the north associated with the expanded development.

The magnitude of impacts from this alternative would be the highest, because it would affect the most acres of vegetation of all the action alternatives. The duration of impacts would be extended by another 20 to 40 years past the end of mining, delaying the reclamation of affected vegetation. 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 the footprint. With two (rather than one) road/pipeline corridors, effects would cover a large area—potentially extending any effects of invasive species. The extended duration of impacts also increases the likelihood of impacts from invasive species.

4.26.9.5 Alternative 2 – North Road and Ferry with Downstream Dams

As shown in Table 4.26-18, 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 under Alternative 2, the acres of disturbance resulting from the Pebble mine expansion would be fewer under Alternative 2 than under Alternative 1.

The expanded development scenario project footprint would impact approximately 29,971 acres, compared to 8,116 acres under Alternative 1, increasing the acreage of vegetation loss by 21,855 acres.

The magnitude of impacts from this alternative would be the lower than Alternative 1, but higher than Alternative 3. The duration of impacts would be extended by another 20 to 40 years past the end of mining, delaying the reclamation of affected vegetation. The geographic 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 the footprint. The extended duration of impacts also increases the likelihood of impacts from invasive species.

4.26.9.6 Alternative 3 – North Road Only

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

The Pebble mine expanded development scenario project footprint would impact approximately 29,971 acres, compared to 8,116 acres under Alternative 1, increasing the acreage of vegetation loss by 21,855 acres. This is the least amount of vegetation affected among the three action alternatives.

Under Alternative 3, the cumulative effects of these activities would be similar to those discussed above. As shown in Table 4.26-18, under Alternative 3, 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 north access road (Concentrate Pipeline Variant). Because the natural gas pipeline and most of the road would already exist under Alternative 3, the amount of additional disturbance resulting from the expanded mine scenario would be less than the same scenario under Alternative 1.

The magnitude of impacts from this alternative would be the lower than Alternative 1 or Alternative 2. The duration of impacts would be extended by another 20 to 40 years past the end of mining, delaying the reclamation of affected vegetation. The geographic 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 the footprint. The extended duration of impacts also increases the likelihood of impacts from invasive species.

4.27 SPILL RISK

This section addresses the spill risk 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 proposed project. These substances were selected based on their spill potential and potential spill consequences.

The Fate and Behavior sections address the probable outcomes that would result from a release into the environment, considering a wide range of potential spill circumstances. The Historical Data sections review data on past spills, where available, including probabilities and consequences. The Existing Response Capacity sections list any organizations or plans that may be available as resources in the event of a spill. The Mitigation sections 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 sections describe seven hypothetical spill scenarios that were selected for impacts analysis, including spill response. The Potential Impacts sections 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 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.

4.27.1.1 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 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 deep-water habitats. The fish and shellfish of Lower Cook Inlet have been discussed in Section 3.24, Fish Values, and 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 3.23, Wildlife Values, include raptors (eagle, falcons, hawks, owls, and corvids), waterbirds (ducks, geese, and swans), landbirds (songbirds), and shorebirds (plovers and sandpipers).

This analysis area extending into Lower Cook Inlet and Shelikof Strait would also include seabirds, such as puffins, cormorants, murres, kittiwakes, and storm-petrels, among others. 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, minke whale, killer whale, Dall's porpoise, harbor porpoise, and harbor seal. TES are described in Section 3.25, Threatened and Endangered Species; and include Cook Inlet beluga whale, humpback whale, fin whale, Steller sea lion, northern sea otter, and Steller's eider. These TES are present in the diesel spill analysis area from Kamishak Bay in Lower Cook Inlet south to the Shelikof Strait.

4.27.1.2 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 within the analysis area for the tailings releases, so they will be addressed together herein.

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.

Surface Water

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.

Water Use/Drinking Water

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).

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 main stem of the Koktuli River supports all five species of Pacific salmon, rainbow trout, and numerous resident species, including Arctic grayling, northern pike, and Dolly Varden. 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.

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). 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 Nushagak River watershed provides important staging, nesting, molting, or year-round habitat for many bird species, including waterfowl, shorebirds, songbirds, seabirds, and raptors, among others. One reptile, the wood frog (*Lithobates sylvaticus*), is also discussed in this section. There are no federal TES that occur in the mainstem Koktuli, Mulchatna, and Nushagak river drainages.

The Nushagak River system supports 13 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.

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.

4.27.2 Diesel Spills

Ultra-Low Sulfur Diesel (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 International Standards Organization (ISO)-approved tanks for transport to the ferry terminals and the mine site (PLP 2018d). Storage tanks at the port would be in secondary containment, as required by the Alaska Department of Environmental Conservation (ADEC). 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 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 18 miles long, and is expected to take 1.5 hours in open water, and 3 hours during ice conditions.

The use, containment, and transport of diesel by Pebble Limited Partnership (PLP) would be in accordance with ADEC regulations, and would follow approved Oil Discharge and Prevention Contingency Plans (ODPCPs) and Facility Response Plans (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.

4.27.2.1 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.

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. Floating diesel quickly disperses, especially under the influence of strong waves, wind, tides, and currents. Wave action can also emulsify, or break up, the oil into small droplets that stay suspended in the water column.

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). 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.

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 will eventually dissolve. When dissolution occurs in an isolated body of water where dilution and dispersion are limited, the dissolved constituents will 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. Over 90 percent of diesel from a small spill (less than 5,000 gallons) will evaporate or naturally disperse within hours to days of a spill; therefore, oil from such small spills is generally not recoverable (NOAA 2018i). 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 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 within 4 days; during spring conditions, 89 percent would evaporate 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.

4.27.2.2 Historical Data on Diesel Spills

Spill Frequency and Volume

Over 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 over 3,000 gallons; and rare marine vessel incidents, which have released over 300,000 gallons. 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).

Due to the remote nature of the proposed 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 a data analog to diesel transport on PLP's proposed 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 & Pubic Transportation (ADOT&PF). 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 is proposing to haul diesel tanks on three separate 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 over 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).

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 X 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).

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 Williston Transporter, which operates in British Columbia, Canada, is considered the best analog to the proposed 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-RFI052). See the Transportation Spill Scenario Probabilities Memo (AECOM 2019a) for statistical analysis on the probabilities of diesel spills from ferries.

4.27.2.3 Existing Response Capacity

Pebble Limited Partnership (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 additionally 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).

In the event of a project-related diesel spill, PLP would follow response procedures as described by the ADEC Spill Tactics for 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 oil spill removal organization (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).

4.27.2.4 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.

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 oils 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). In the event of flooding of one or more compartments, 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 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.
- 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.
- Backup operating station in the engine control room (in the event that the wheelhouse is not operational).
- Remote monitoring and/or remote control capabilities, as needed, from a remote operations center.
- 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).
- Corner castings on the outer frames of the ISO tanks 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.

Please see Chapter 5, Mitigation, for complete design/safety specifications.

4.27.2.5 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.

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 66 miles of PLP's proposed mine and port access roads.

No studies have been identified that analyze fuel spill rates on private, controlled-access industrial roads, such as the proposed 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. 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 is 2.0×10^{-7} spills per truck mile traveled, or 0.011 spills per year over the 66 miles of Alternative 1 road transport (55,433 truck miles traveled per year). 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).

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. 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 proposed 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. 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 not 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.

Spill Response

PLP would have an ODPCP plan in place that would detail the measures to prevent, respond, contain, report, and clean up diesel spills. 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, but fuel recovery rates could be higher, because diesel would be less likely to permeate soil surfaces and disperse in waterbodies during frozen conditions.

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.

The potential for a tanker truck rollover could vary slightly by alternative; road corridor lengths and road conditions, such as grade, would vary between alternatives. Alternative 1 would include 66 miles of total road transport to haul diesel; 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 more steep topography in the southern and eastern portions of the road corridor. Final road design, including proposed grades, has not yet been determined.

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 hydrocarbon levels of impacted soils would exceed regulatory levels. 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 best management practices (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.

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 oil could concentrate into a thicker sheen in these environments. 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 oil 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, although the magnitude of impact may not be measurable. Sediment that is contaminated would be diluted by surrounding clean sediment, and may or may not exceed sediment quality guidelines. 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 within sediments could also re-contaminate overlying surface water at a later time, although this impact would likely not be measurable 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 Alaska Administrative Code [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. Diesel would be unlikely to spread long distances underground, so that the extent of groundwater contamination would be localized to areas near the spill site.

During frozen conditions, diesel would be less likely to penetrate soils, and would likely pool up on the surface and not reach groundwater resources, facilitating recovery efforts.

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-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 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

Approximately 13 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 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). 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). Spills that occur when vegetation is dormant are also not as likely to result in vegetation mortality.

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 document 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 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, and effectiveness of cleanup efforts. Overall impacts from a diesel spill are anticipated to be at a lower magnitude than a heavy oil spill, and have a short duration (1 to 12 months), 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) and specific location of the spill (upland versus wetland habitat).

If a terrestrial spill occurs in upland vegetated environments, impacts are anticipated to be of low magnitude, short duration (1 to 12 months), 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 may not be able to immediately vacate the area during the spill. There is the potential for acute toxicity over a brief time span before the diesel evaporates and dissipates. Acute toxicity is anticipated to occur only to small mammal species (such as mice, voles, lemmings, and shrews) 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 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, and 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 vegetation is known to recover post-oil spills (USFWS 2010). For terrestrial mammals that might be exposed, numbers of individuals are expected to be small, with no population-level effects.

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 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. Any species in the immediate vicinity may experience acute toxicity, especially if freshwater vegetation becomes covered in diesel. This is unlikely, given the characteristics of diesel (evaporation rate) and deployment of cleanup personnel. Most terrestrial wildlife is anticipated to vacate the area during the spill and cleanup activities. Additionally, spill response equipment would be kept at the mine site, both ferry terminals, and Amakdedori port to enable rapid response to a spill anywhere along the transportation corridor.

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 permit more efficient spill response and cleanup, and limit the spread of diesel, and therefore are anticipated to have localized, and temporary impacts. 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 Iliamna Lake seals 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 Iliamna Lake seals to be temporarily disturbed while cleanup activities occur; however, the lake 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, 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 would have vacated the area, and only a few resident species remain year-round. Additionally, 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 duck 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 oil 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 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 (1 to 12 months), depending on the amount of time to clean up and/or allow the diesel to fully decompose. No population-level impacts from a single spill event are anticipated for any species.

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). The extent and duration of impacts 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 federal TES that occur in the terrestrial portion of the project. Any spills that occur on land are anticipated to be dissipated prior to reaching the marine environment of Cook Inlet, where TES occur. Therefore, a diesel spill from a tanker truck roll-over along the transportation corridor is anticipated to have no impact on TES.

Marine Mammals

Any diesel spills that occur on the road corridor would not reach the marine environment of Cook Inlet, where marine mammals occur. Therefore, a diesel spill from a tanker truck roll-over along the transportation corridor is anticipated to have no impact on marine mammals.

Needs and Welfare–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 10 years, the average value per harvested sockeye was $6.16 in real terms.

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, because adult and juvenile fish are relatively mobile, and large-scale mortality events are not expected, the potential for longer-term impacts is extremely low.

Subsistence

A diesel spill resulting from a tanker truck rollover could have impacts on subsistence. The effects would be localized and temporary because fuel would evaporate, become diluted, and be cleaned up. A tanker truck release would not have population-level effects on subsistence resources, although animals and subsistence users may temporarily avoid the area of the spill. Quick response and containment of the spill 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. Invisible contamination cannot be easily determined, which creates 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 (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 (such as 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 would likely 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). See AECOM 2019a for details on the statistical analysis and review of relevant data.

On release of the diesel into Lower Cook Inlet, the oil 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 oil 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

Oil 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 oil 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 oil from entering a sensitive area.

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 populations of marine mammals, birds, or other vulnerable species are present and at risk of oiling.

The potential for a marine tug-barge allision could vary somewhat by alternative. 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). 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).

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

A marine spill of diesel is unlikely to have impacts on soils that would require remedial action. 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 oil 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.

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 oil 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 oil would vary with weather and sea conditions. The ULSD would naturally evaporate and disperse after approximately 10 to 20 days (AECOM 2019a; SL Ross 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 oil.

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 be measurable due to dilution.

On-Shore Environment – A marine spill of diesel is unlikely to have measurable impacts on the water quality of 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). 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.

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 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 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, 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 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. 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.

Wildlife

Impacts from a 300,000-gallon spill of diesel into Lower Cook Inlet are anticipated to have impacts on terrestrial wildlife that would not likely require remedial action. 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, 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 and intensity of the spill remain 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. These species may be consumed by terrestrial mammals foraging along the shore, but are not likely to cause mortality to species that consume them. Overall impacts on terrestrial wildlife are anticipated to be localized and of short duration (1 to 12 months). 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 any diesel that comes in contact with the shore would be cleaned up during spill response efforts (though 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.

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. Generally, no population-level impacts are anticipated for terrestrial wildlife species, and the diesel is not anticipated to persist in the environment for longer than 1 to 2 months.

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, 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.

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 to the population 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 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.

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 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).

Non-TES marine mammal species could be impacted by this diesel spill scenario. If individual, small, or large groups of marine mammals were exposed to large amounts of fresh oil from a spill, especially through inhalation of highly toxic aromatic fractions, they might be seriously injured or die from such exposure. However, marine mammals considered in this analysis are common in the Gulf of Alaska; therefore, population-level effects are unlikely. The extent of potential impacts would be localized to the immediate area of the spill, and generally represent a small portion of the available habitat in Cook Inlet. The duration of potential impacts is expected to be temporary (until the diesel has evaporated and broken down by microbes). The likelihood that a spill presented in this scenario would affect marine mammals is low, because potential impacts would be minimized by project design measures outlined above. If a large diesel spill occurs, marine mammals would be deterred away from contaminated areas.

Birds

The assessment of oil spill impacts to migratory birds is based on 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). It is important to remember, based on the Cook Inlet Maritime Risk Assessment: Spill Baseline and Accident Casualty Study (Glosten 2012), that diesel is not very adhesive to substrates; readily evaporates; and is considered relatively nonpersistent 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 has acute toxicity due to evaporating volatile components in the oil, which can be breathed in, with toxicity decreasing with decreased temperature. 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) and EPA (1999b).

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 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 birds are based on heavy oils, and the text may describe a worst-case scenario. Impacts from ULSD would have components similar to impacts from heavy oils, but at a reduced magnitude.

Oil harms birds through physical contact, poisoning through ingestion or inhalation, and destruction of food sources or habitat, and can cause long-term reproductive problems. Physical contact with oil destroys the insulation value of feathers, causing birds to die of hypothermia or lose buoyancy. In cold climates, a 1-inch-diameter oil droplet can be sufficient to kill a bird (NOAA 2014b). 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, 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, but remains on the water surface for only a brief time, and is rapidly diluted (NOAA 2018i). Although small diesel spills can affect marine birds by direct contact, experience across several hundred small diesel spills in Alaska over the past decade has resulted in few birds directly affected by diesel spills from fishing vessels. If small spills occur adjacent to large nesting colonies, or diesel is transported into high bird concentration areas, impacts can be more serious, because more birds may be impacted (NOAA 2018i).

During most oil spills (which are generally heavier compared with diesel), seabirds are harmed and killed in greater numbers than other kinds of creatures (NOAA 2014b). 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 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). 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), and therefore a spill that impacts these areas along western Cook Inlet may impact several hundred foraging rock sandpipers, but is not anticipated to have a population-level impact.

The spill under this scenario may occur at any time of year, but would be most intense and have the greatest impacts to birds during the summer breeding season, when large numbers of breeding seabirds are present 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 more vulnerable to adverse impacts due to their temporary inability to fly. 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. Additionally, there are many seabird colonies around Shuyak and Afognak islands, which may be impacted if diesel is permitted to spread that far south (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 higher, 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 seaducks have a relatively low capacity for population growth (Stehn and Platte 2000).

This spill scenario impact on birds would vary in intensity depending on the timing of the spill, 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. 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). 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 birds.

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). Several direct effects to fish or benthic invertebrates could occur in the spill footprint in littoral or intertidal zones, including:

- 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 foodweb 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.

Threatened and Endangered Species

Cook Inlet Beluga Whale – The magnitude of potential impacts from the proposed 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. 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 impacts would be short (10 to 20 days), because diesel rapidly evaporates, disperses, and is broken down unless the whale comes in direct contact with newly spilled diesel. 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 –The number of humpback whales in Cook Inlet is fairly low, and detrimental impacts to a low number of whales are not anticipated to have population-level effects. 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, over 80 miles to the southeast of the proposed spill location (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 potential direct impacts from the diesel spill would be short (10 to 20 days), because diesel rapidly evaporates, disperses, and is broken down. However, the duration may last longer due to consumption of contaminated prey, and a temporary reduction of localized prey populations.

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 will largely have dissipated. The duration of impacts would be short (10 to 20 days), 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 populations, 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.
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.

Additionally, 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 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. Additionally, sea otter density in Kamishak Bay is high (Klein, pers comm. 2018), and a potential spill could cause displacement of sea otters from their habitat, which was observed after the *Exxon Valdez* Oil Spill (Burn 1994). 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 located (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). The duration of direct impacts would be short (10 to 20 days), because diesel rapidly evaporates, disperses, and is broken down; however, if sea otters come into direct contact with spilled diesel, the duration of impacts may potentially cause long-term, chronic effects to some individuals.

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., Elizabeth and Shaw islands to the south of the analysis area, described in further detail in Section 3.25, Threatened and Endangered Species). 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 impacts would be short (10 to 20 days), 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 proposed 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. 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 is 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 500 individuals [USFWS 2012]). Alaska Chadux's wildlife response team would be deployed to assist in cleaning up any oiled birds, and it is not expected that the spill would result in a large number of mortalities.

It is thought the Steller's eiders exist near the limits of their energetic thresholds, and 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 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). Additionally, 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 impacts would have a short duration (1 to 12 months), 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.

Needs and Welfare–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 brief, 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.

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, and impacts would last for a short period of time. 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 communication with local communities would help mitigate these concerns.

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 (HEC 4). Human health impacts would be short term (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 shoreline, but would increase in intensity as volume of diesel spilled and 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 proposed ferry would be custom-built specifically for Iliamna Lake conditions, and for hauling diesel, concentrate, and other mine materials. Fuel tanks would be required to be stored in secondary containment on the ferry. 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.

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 (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 proposed lake ferry was judged to be significantly less than the historic spill probability for marine barges. The estimated annual probability of occurrence of $1.5x10^{-4}$ 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, the Chadux oil response group would be mobilized for spill response, as discussed above for a release from a marine tug-barge.

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. SCAs are federally required to contain 110 percent of the largest tank volume. Alaska state regulations additionally 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.

4.27.3 Natural Gas Releases from Pipeline

Natural gas is primarily composed of methane, which is a colorless, odorless, tasteless gas. Natural gas releases can be hazardous when gas accumulates in a confined space, wherein high concentrations of gas can be an asphyxiant; or if exposed to an ignition source, can lead to fire or explosion. The proposed 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 located 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 ADOT&PF Pipeline and Hazardous Materials Safety Administration (PHMSA), 49 Code of Federal Regulations (CFR). See Chapter 2, Alternatives, for pipeline design and safety features.

4.27.3.1 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 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, however, reducing the risk of pipeline rupture. See Section 4.15, Geohazards, 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, for a complete discussion of volcanic hazards.

4.27.3.2 Fate and Behavior of Released Gas

Potential gas leaks from the proposed 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 does not accumulate in water, and would not have an impact on water quality. 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 measurable impacts on soil quality 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.

4.27.3.3 Spill Response

PLP would have a spill response plan in place that would cover potential leaks/releases of natural gas.

4.27.4 Concentrate Spills

Ore concentrate (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 proposed 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.

4.27.4.1 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 by truck and ferry to the port, for a total of 876,000 wet tons per year (PLP 2018-RFI 065). At the mine site, copper-gold concentrate would be loaded into specialized heavy-steel bulk shipping containers with locking lids (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 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 Alternatives 1 and 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.

For Alternative 3, truck/trailer combinations would haul concentrate from the mine site to the Diamond Point port along the north access road. Alternative 3 does not include a ferry crossing on Iliamna Lake. The Alternative 3 Concentrate Pipeline Variant considers the concept of delivering copper and gold concentrate from the mine site to Diamond Point port using a pipeline instead of trucking along the north access road. The concentrate pipeline would be mostly buried, except where attached to bridge infrastructure at major stream crossings. The pipeline is described in Chapter 2, Alternatives.

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. To minimize the potential for over-water spills of concentrate or release of fugitive dust, the containers are 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. See Mitigation, below, 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.

With the Alternative 3 Concentrate Pipeline Variant, the lightering system would use bulk handling (i.e., conveyers) of concentrate to load the bulk carriers, with appropriate controls to address the potential for concentrate dust emissions associated with storage, loading, and unloading.

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).

Sources: PLP 2018-RFI 045

US Army Corps of Engineers®

COPPER-GOLD CONCENTRATE SHIPPING CONTAINER

4.27.4.2 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 Mitigation, below, for a summary of avoidance and minimization/design features to reduce the likelihood of concentrate spills.

4.27.4.3 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 that 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 several 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, sandy 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, requiring in-water recovery efforts.

Under the Alternative 3 Concentrate Pipeline Variant, concentrate would be transported from the mine site to Diamond Point port via concentrate slurry pipeline. At the mine site, contact water would be added to the fine-grained concentrate solids to create a slurry 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 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 slurry would behave the same way, in that they are both PAG and capable of ML over time, depending on conditions.

Sedimentation and TSS

Concentrate particles would mostly be clay- and silt-sized, with a very small fraction of fine sand (Knight Piésold 2018q). 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 out of the watershed.

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.

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.

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 air, 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 water), conditions prevent oxidation, and sulfuric acid cannot be formed. 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). However, metallic minerals in the concentrate would not be immediately soluble in water, and the leaching of metals into the environment would likely require years to decades.

4.27.4.4 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 proposed 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 proposed 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.

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. Most spills have been recorded as impacting land only, and report full recovery/recycling of spilled material. A truck rollover 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. 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. 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).

Concentrate Pipelines

Very few concentrate pipelines are in operation, and no published failure rates are available. Most of the available pipeline failure data comes 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 increases over time. Based on a 20-year operational lifetime of this proposed pipeline, external corrosion leading to failure would be very unlikely. 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 below under Mitigation, the concentrate pipeline would have a full internal liner that would protect against both internal and external corrosion.

Mechanical damage to the pipeline by vehicles would also not be likely during the proposed 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 deep-water 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 (ADEC 2018h).

PLP's proposed method of overwater transfer of concentrate into bulk carrier vessels, as described above under Mitigation, would also greatly reduce the potential for spills and/or fugitive dust generation. The proposed 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 proposed 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.

4.27.4.5 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.

4.27.4.6 Mitigation

Spill-Prevention Measures: Copper-Gold Concentrate

(PLP 2018-RFI 045)

- Bulk cargo containers 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 lid 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

From one of the alternative ports, 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. This process has the potential to generate fugitive dust from the material falling and generating dust on impact at the bottom of the hold. This potential would be minimized with the following measures:

- A barge-mounted crane with a specialty spreader unit would lower containers deep within the open hold of the vessel; and only at that point, the system would unlock the lid and turn the container upside-down to release the concentrate into the ship's hold.
- 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.
- 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).

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

(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.
- Pressure-based leak detection system would monitor pipeline for leaks.
- Rupture discs and pressure monitoring would protect the pipeline from overpressure events.
- Above-ground 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 ADF&G Habitat Division.

4.27.4.7 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. Additionally, only copper-gold concentrate has been proposed 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 proposed access roads.

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.

No studies have been identified that analyze trucking-related spill rates on private, controlled-access industrial roads, such as the proposed 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, the estimated annual spill rate for a trucking-related concentrate spill in the proposed project is 0.78 $x10^{-6}$, which equates to an average of 0.4 trucking-related concentrate spills per year for the 66 miles of Alternative 1 road transport. 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; or an average of one spill every 2.5 years (AECOM 2019a). The spill size of 80,000 pounds is representative of the range of typical concentrate spills from Red Dog between 1995 and 2017.

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 the particles would mostly settle out as deltaic deposits. There are numerous stream crossings along the proposed 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. 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 collect on top of frozen soil or the surface of frozen waterbodies, facilitating recovery.

The potential for a concentrate haul truck rollover would vary somewhat by alternative; road corridor lengths and road conditions, such as grade, would vary between alternatives. Alternative 1 would include 66 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 proposed grades, has not yet been determined.

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 measurable impacts on soil quality.

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 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 spilled into flowing water would become suspended in the water, causing the water to become turbid, with elevated TSS. 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.

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 – Sulfide minerals in the concentrates, which would be deposited in limited areas, would slowly dissolve over years to decades. However, to produce acid, the sulfur needs to be oxidized; that is, combine with oxygen gas. A small amount of oxygen gas can be held in flowing water, and almost no oxygen gas would be present in still water. As long as concentrates remain under water, no measurable acid would be generated, and acidic conditions would not result.

Any residual concentrate remaining on dry land for multiple years could potentially generate acid. The acid could be flushed into surface water, potentially reducing the pH of waterbodies. The rate of acid production is so slow, however, and surface water so abundant, that any acid produced would be rapidly diluted, so that no measurable reduction in surface water pH would be likely.

Metals Leaching – 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. If concentrate is not recovered, however, some of the metallic minerals would slowly dissolve over years to decades, potentially leaching metals into the water. 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.

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.

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. Assuming the spill response as included in the scenario, any fugitive dust produced would likely not have measurable impacts on air quality.

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

Approximately 13 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 over 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 harder 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.

Although the concentrate is not expected to affect wetlands through acid generation or ML, wetlands and waters could be affected by sedimentation. Concentrate could bury wetland plants and alter the substrate of exposed waterbodies. As described in the Water and Sediment Quality section, 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 buried.

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. This is because winter spills are easier to clean up.

The duration of impacts is also related to the timing of the spill; spills during the open-water season would require more time for wetlands to recover, maybe several growing seasons. Spills that occur during the winter would have less impact and recovery would be faster.

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, the majority of the concentrate would be removed, thus 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 the majority 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 would not be likely to have measurable impacts on wildlife.

If a concentrate spill occurs and enters flowing water, concentrate would be carried rapidly downstream and dispersed. Leaching of metals from concentrate would likely require years to decades (see “Fate and Behavior of Spilled Concrete” section, above). Additionally, copper does not bioaccumulate (EPA 2014), and therefore does not pose a consumption risk to bears (*Ursus* species), gray wolves (*Canis lupus*), and other terrestrial wildlife that consume salmon.

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 impact a small fraction of the total salmonid eggs in a stream, which would not result in any measurable impacts on future salmon populations on which wildlife depend.

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 allow for more efficient spill response and clean up, and limit the spread of concentrate. Winter spills would therefore be anticipated to have a low to negligible impact.

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. No population-level impacts from a single spill event are anticipated for any species.

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 in close proximity to 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, and have no population-level impacts.

Fish

If released into an enclosed waterbody like a pond or a lake, 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. Additionally, 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 duration of impacts would not extend longer than 1 year, or until the concentrate is cleaned up 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, and have no population-level impacts.

No measureable impacts via metals toxicity would occur on fish and aquatic invertebrates, if spilled concentrate is promptly removed from the impacted waterbody. This is because acid generation and ML from the copper-gold concentrate would not occur within the timeframe of the recovery. Residual concentrate particles would be flushed downstream and deposited in low-energy areas, while 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. In addition, in the timeframe of these slow releases, the natural buffering capacity of the stream water would further limit the acidification; and the metal binding phases such as natural organic matter would render the metals to be less bioavailable. Due to these factors, reduction in stream water pH and increases in metals concentrations relative to the baseline conditions would likely not be measurable. Therefore, impacts via metals toxicity to fish would not occur under the concentrate spill scenario being evaluated.

Threatened and Endangered Species

Potential impacts to federal TES from a concentrate spill would not likely require remedial action. 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 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 Alternatives 2 and 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 belugas from other populations (NMFS 2016b). The Cook Inlet Beluga Whale Recovery Plan concludes that the magnitude of the pollution threat to Cook Inlet belugas and the relative concern of known and tested contaminants to Cook Inlet belugas are most likely low (NMFS 2016b). Similar to beluga whales, other marine mammal TES species 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 Alternatives 2 and 3 transportation corridor between Iliamna Bay and Diamond Point port is also low. The majority is likely to spill along the roadway or on adjacent riprap supporting the road; 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. Additionally, 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 Alternatives 2 and 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 would result in increased employment opportunities in the region. Cleanup crews would be small, and likely consist of only PLP employees and specialized contractors.

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, given the lack of population-level effects on 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 of a limited duration with no population-level impacts, the study expects similarly limited effects on commercial salmon harvest values.

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.

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 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 could cause stress to community members in close proximity from real or perceived risks of contamination, and potentially impact human health. Invisible contamination cannot be easily determined, which creates 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). 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). 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, and the surrounding isolation valves would be closed within 5 minutes (PLP 2018-RFI 066). During the initial 5 minutes after rupture, approximately 700 ft^3 of slurry (42,000 lbs; 21 tons) of concentrate would be released (PLP 2018-RFI 066). After the isolation valves are closed, the static head (pressure) in the pipeline would cause additional release of slurry, on the order of 200 ft^3 (12,000 lbs; 6 tons). This scenario includes a total release of 900 ft^3 (54,000 lbs; 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 (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 cm, ~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 proposed 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 aboveground sections of the proposed concentrate pipeline (PLP 2018-RFI 066) also decreased the selected pipeline failure rate (AECOM 2019a).

With consideration of the length of the proposed 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 proposed 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 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 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 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 would likely be transported into Iliamna Lake, and be deposited as deltaic deposits where the stream feeds into the lake.

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. Concentrate within the stream would not be susceptible to acid generation, because the water would prevent oxidation of the sulfide minerals. Concentrate that may remain on the banks of the stream, however, could generate 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.

Spill Response

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 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 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 would simply look like typical very fine sand. 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 1, 2, and 3 would not use a concentrate pipeline, so there would be no potential spill from a concentrate pipeline rupture for these alternatives.

Potential Impacts of a Concentrate Slurry Spill due to Pipeline Rupture

This section addresses potential impacts of a concentrate 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 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 spilled onto soils in this scenario would be recovered so that there would be no impact. Historical data from Red Dog Mine show that concentrate spills that impact land only and do not enter surface water have a nearly 100 percent rate of recovery. Assuming the spill response as described in the scenario, residual concentrate 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, 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 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. Finally, the duration of the impacts would likely be longer, because the larger volume of concentrate would take longer to clean up and/or be naturally flush out of the drainages.

No impacts to groundwater quality would be expected from 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 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 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 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 this dispersed concentrate 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 could be transported downstream into Iliamna Lake or Iliamna Bay, where it would settle out as deltaic deposits.

Acid Generation – Impacts from acid generation would be the same as those described above for the truck rollover scenario.

Sulfide minerals in the concentrates would slowly dissolve in the subaqueous environment over years to decades. However, to produce acid, the sulfur would need to be oxidized; that is, to combine with oxygen gas. Only trace amounts of oxygen gas are held in flowing water, and almost no oxygen gas is present in still water. Acid generation from subaqueous concentrates is therefore not likely.

Any residual concentrate remaining on dry land for multiple years could potentially generate acid. 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 – Impacts from ML would be the same as those described above for the truck rollover scenario.

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. After years to decades, however, if concentrate is not recovered, the minerals 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.

Ore concentrates may also contain residues of chemical reagents. See the Natural Gas Releases from Pipeline section above 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 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. Assuming the spill response as included in the scenario, any fugitive dust produced would likely not have measurable impacts on air quality.

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

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 may pile up beneath the bridge and immediately downstream at volumes high enough to bury the existing riparian vegetation. As the concentrate is carried downstream, smaller amounts of it will likely be deposited along the streambanks, covering the existing vegetation.

Depending on the location of the spill, some of the concentrate 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 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.

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 season the spill occurs and effectiveness of the spill response; spills that occur in the open-water season are likely to affect a larger area than those that occur during the winter.

The duration of impacts is also related to the timing of the spill; spills during the open-water season would require more time for vegetation and wetlands to recover; potentially, several growing seasons. Spills during frozen conditions would have less impact and recovery would be faster.

Wildlife

Under a spill scenario where concentrate enters a flowing river, the primary impact would be to terrestrial wildlife prey populations such as salmon and freshwater invertebrates. An immediate release of concentrate 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 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 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 not be noticeable.

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 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 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. Additionally, 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.

Fish

Impacts to fish from this scenario would be expected to be similar to those impacts noted above for a concentrate release to a waterbody.

Threatened and Endangered Species

Impacts to TES species 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 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 is spilled, especially during cleanup activities.

Needs and Welfare–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 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 pipeline concentrate spill on land or on a frozen waterbody would not be expected to affect commercial or recreational fishing, because it would not affect regional or localized fish population. A spill into a river or steam 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. Any reduction in the value of the fishery is expected to be extremely limited under this scenario, given the presumption of cleanup or spill incorporation into the bedload.

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 is cleaned up, 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.

Subsistence

A concentrate pipeline rupture 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 is cleaned up or incorporated into the bedload. Wildlife would also be hazed from the impacted area during cleanup activities. The concentrate 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 could cause stress to community members in close proximity from real or perceived risks of contamination, and potentially impact human health. Invisible contamination cannot be easily determined, which creates 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. The duration of impacts would be short term (1 to 12 months).

4.27.4.8 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 above under Mitigation, 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.

4.27.4.9 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.

In the event of a spill of concentrate from a marine vessel, either a lightering barge or a bulk vessel, the fine-grained material would contribute to localized, short-term sedimentation in Kamishak Bay. Sandy material from the spilled concentrate would be quickly deposited and/or dispersed within a matter of hours, and would likely not be a measurable impact.

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. Sulfide minerals would not be oxygenated in the marine environment, and therefore, no acid would be generated.

A spill of concentrate into Kamishak Bay between the port and the lightering locations could be recoverable, due to the shallow (diveable) water depths. Extreme tides, currents, winds, and difficult logistics, however, could create too great of a safety risk involved in salvaging the spilled material, and the action may not be justified.

4.27.4.10 Iliamna Lake Ferry Rupture

The probability of a spill of concentrate from the proposed 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 proposed 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 (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, but any leached metals would be strongly diluted, and it is unlikely that there would be any measurable impacts. Sulfide minerals would not be oxygenated in the subaqueous lake environment, and therefore, no acid would be generated.

Diving crews could recover the spilled concentrate. 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.

4.27.5 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 proposed for the project is provided in Table 4.27-1 (from PLP 2018d).

Table 4.27-1: 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 percent) 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 percent 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 (NaHS)	Copper depressant used in the copper-molybdenum separation processes.	Pelletized reagent shipped in 1-ton bags. Mixed with process water to form 20 percent solution and stored in the NaHS storage tank.

Table 4.27-1: Processing Reagents and Materials

Reagent	Use	Shipping/Preparation
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 percent 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 percent 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.
Polyacrilic acid	Anti-scalant for the lime production process.	Viscous pale amber liquid shipped in 35-cubic-foot specialized container tanks within 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.

Source: PLP 2018d

Note that no mercury or cyanide would be used for the proposed project. Mercury is naturally present at low levels in some rock formations within 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).

4.27.5.1 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 floatation 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.

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 not expected to bioaccumulate in view of its ionic character (PLP 2018-RFI 052).

Sodium ethyl xanthate gives off carbon disulfide gas as a byproduct, 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 apparati (Australian Government Publishing Service 1995).

The EPA reports that the presence of xanthate would render the tailings slurries toxic; but that if released in a spill, degradation and dilution would render the downstream waters non-toxic (EPA 2014).

Fuel Oil (Diesel)

Diesel is also used in the flotation process. The potential impacts of small diesel spills are addressed in Section 4.18, Water and Sediment Quality; and large diesel spills are addressed in Section 4.27.1, Diesel Spills.

Sodium Hydrogen Sulfide

Sodium hydrogen sulfide would be shipped as pellets. If spilled on land, it would be recovered and placed back into containment. Sodium Hydrogen Sulfide (NaHS) is very soluble, and if spilled into water it would dissolve, and give off nitrogen oxides and sulfur oxides (PLP 2018-RFI 052). NaHS would be mixed with water and stored as a liquid in the NaHS storage tank.

Carboxy Methyl Cellulose

Carboxy methyl cellulose would be shipped as pellets. This reagent is soluble and inherently biodegradable. No hazardous byproducts or reactions are known to occur under typical conditions (PLP 2018 – RFI 052).

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 Materials 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 and is soluble. At a pH greater than 6, the polymer degrades due to hydrolysis to more than 70 percent in 28 days (PLP 2018 – RFI 052).

Polyacrilic Acid

Polyacrilic 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).

Nitrogen

Nitrogen would be produced on site, and would not be transported.

4.27.5.2 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.

4.27.5.3 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.

4.27.5.4 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.

4.27.6 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 can also contain residual chemical reagents or other chemicals from ore processing. Reagents to be used in the proposed project are addressed in under the "Reagent Spills" section, above. Chemical reactions can take place within 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 "tailings ponds" or "lagoons," some of which maintain subaqueous storage of the tailings in perpetuity to prevent oxidation of sulfide minerals and generation of acid rock drainage (ARD). Some of these facilities have experienced failures of the dams or embankments that contain the tailings.

PLP is proposing a method of tailings storage for the proposed project that would eliminate the need for a traditional tailings pond that would exist in perpetuity. PLP is proposing to separate mine tailings into bulk tailings, which are relatively inert; and pyritic tailings, which have higher potential to produce acid and leach metals. The bulk and pyritic tailings would comprise approximately 88 and 12 percent, respectively, of the total tailings (PLP 2018d). The two types of tailings would be stored in two separate facilities and would have distinct fates during post-closure. 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, addresses the geotechnical aspects of the TSFs and their embankments.

4.27.6.1 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 (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. Both embankments would be on bedrock foundations. See Chapter 2, Alternatives, for a full discussion of centerline and downstream dams. See Section 4.15, Geohazards, 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 at the perimeter and lower towards the center. 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. Therefore, the main (north) embankment of the bulk TSF is proposed to operate as a pervious, 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). The south embankment 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 water management pond (main WMP). Tailings in the beach area, especially on the northern side of the facility, would be well-drained and relatively dry; while tailings deeper within the facility would remain fluid-saturated. The bulk TSF would remain as a pervious structure in perpetuity, 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.

Aqueous chemistry of the bulk tailings supernatant 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 WQCs.

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 WQCs.

4.27.6.2 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 size (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 store approximately 155 million tons of pyritic tailings, 160 million tons of PAG waste rock, and an operating supernatant pond, with additional storage capacity for the required IDF (equal to the probable maximum flood) and additional freeboard (Knight Piésold 2018p). The three embankments would be zoned rockfill and earthfill dams constructed with the downstream method on a foundation of bedrock. See Chapter 2, Alternatives, for a description of the downstream dam construction; and Section 4.15, Geohazards, for geotechnical aspects of the dam design.

The PAG pyritic tailings would require subaqueous storage with a minimum 5 feet of 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 WQCs: 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 WQCs.

The contact water used to make up the pyritic tailings slurry is also likely to contain elevated concentrations of some metals and other constituents.

4.27.6.3 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 could be deposited on uplands, wetlands, or in stream drainages. 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 downstream, which would impact downstream habitat until the tailings are completely recovered or naturally flushed from the drainage. 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. 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) season and weather conditions; and 8) mode of release.

1. **Location of Release** – A spill of tailings onto dry land could be recovered relatively easily with excavation, while 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 metals in the bulk tailings, however, the risk of acid generation and ML from a spill of bulk tailings is low. Any acid or metals generated from the bulk tailings would be produced on such a slow timescale (years to decades), and would be so diluted by precipitation and surface water, that impacts may not be measurable. 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 within 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 1.3 miles downslope (MEND 2017). If deeper fluid-saturated tailings were to be released, they would flow readily as a liquid slurry. 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. **Summer versus Winter** – 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.
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, 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. Previous studies suggest that thickened tailings are capable of flowing approximately twelve 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 1.3 miles. The area downstream of the bulk TSF could be covered by fine tailings. 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 be carried downstream as suspended sediment. The flood waters would recede in a matter of hours/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.

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 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, as long as 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 out of the watershed.

Sand-sized particles are heavier, and are more likely to sink within 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. 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 the rock type, mineralogy, local climate conditions, etc. Geochemical studies on rocks from the proposed mine site indicate that PAG material present in the tailings may require up to 40 years under local conditions to generate acid (SRK 2018a). (See Section 3.18, Water and Sediment Quality, for discussion of PAG geochemistry.)

Stagnant water, such as that in 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. Flowing water such as streams also contains limited DO, so that a very small amount of oxidation can occur from exposed PAG materials in streams over timescales of decades to centuries.

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 within the tailings would have elevated metals concentrations, as described above. 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 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.

Tailings Solids

Tailings solids could contribute to elevated metal concentrations downstream over a period of decades if they are not recovered. However, timely and effective recovery of spilled tailings would prevent such impacts.

ML is a natural process in which metallic minerals dissolve through chemical weathering, releasing the metals into the water. However, metallic minerals are not readily soluble in water, 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, but would likely require decades of chemical weathering to render it sufficiently bioavailable to impact benthic invertebrates and fish. In acidic water, ML of copper and other metals is accelerated. Therefore, the potential for ML would depend on acid generation from the tailings. 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.

<u>Contamination from Process Chemicals</u>

In the past, public concern has been expressed with mining-related spills of mercury and cyanide, which have led to mortality of fish and other aquatic organisms. The proposed project does not include the use of mercury or cyanide in the project area.

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 reagents.

4.27.6.4 Historical Examples of Tailings Releases

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. 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 2018). Examples of some historic failures include:

- November 1974, Bafokeng, South Africa: 3 million m^3 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 slurry released.

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 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, even modern dams have experienced failures that are generally attributed to human error in design, construction, and operations, 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 a lack of foresight in planning for dam raising, improper/insufficient observation [surveillance], and maintaining a high water level within the facility. Other recent tailings dam failures in China, Mexico, and Australia demonstrate that modern, well-engineered tailings facilities are subject to failure.

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 gold, copper, 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, silver, lead, 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 proposed project would likely be recovered to conditions in compliance with state regulations.

4.27.6.5 Probability of Failure

The number of tailings dams in the world is estimated at over 3,500 (ICOLD 2018). From 1987 to 2007, there was an average of 1.7 tailings dam failures per year (Peck 2007, as reported in EPA 2014); from 1995-2001, the rate of major incidents was two per year (ICOLD 2018); while another author quotes two to five major tailings dam failures per year between 1970 and 2001 Davies 2002). 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).

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.

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.

Regarding dam failure rates and height of dams, higher dams 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.

One study actually 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. (2008) 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. Yet 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).

Evaluation of historical data shows that the probability of TSF failures depends on many factors, including the quality of the dam design, construction methods, geotechnical conditions of the facility site (the type of bedrock or soils the dam is built on), control of fluid levels in the facility (water management), and accordance with regular inspections and regulatory protocols.

The only common factor in all major TSF failures has been human error, including errors in design, construction, operations, maintenance, and regulatory oversight. 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 operational lifetime. The Alaska Dam Safety Program (ADSP) would require periodic technical review throughout the life of the proposed facilities (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 2018). Data also show that failures of tailings embankments under dry storage conditions (with no ponded water above tailings) after mine closure is small compared to dams in active operations with ponded water (Donlin Gold EIS 2018). Therefore, the probability of a failure of the bulk TSF in closure would be expected to be even lower than the estimates above (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 proposed bulk TSF and pyritic TSF (as well as the main Water Management Pond) were therefore considered in a risk assessment specific to the proposed project.

4.27.6.6 Risk Assessment for the Proposed Embankments

A Failure Modes and Effects Analysis (FMEA) is a risk assessment tool commonly used for assessment of failure risk of large dams. A typical FMEA workshop uses a facilitated panel of experts in dam design, construction, and operations to assess the probability of failure and level of consequences for a proposed dam/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.

The current level of embankment design for the proposed 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 proposed 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).

The expert panel 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. It should be noted that the potential failure modes analyzed did not reflect any specific weakness in the design or any actual probabilities of failure, but were developed for the sole purpose of estimating potential release volumes to analyze impacts of a hypothetical release.

In accordance with National Environmental Policy Act (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 what would be 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).

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 expert panel 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. See the EIS-Phase FMEA Report for a full discussion of scenario selection (AECOM 2018l).

4.27.6.7 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 out of the watershed 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.

4.27.6.8 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.
- ADNR approval is required 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 be required to 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 (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 guidelines, 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 (Sections 3.15 and 4.15, Geohazards).
- Both TSFs would be designed and constructed with a static Factor of Safety (FoS) of 1.9 to 2.0 (minimum 1.5 FoS required by USACE).

See Section 4.15, Geohazards, and Appendix K4.15, Geohazards, for further discussion of seismic stability design for TSFs.

Bulk TSF

Data on dam failures around the world demonstrate that dams designed with downstream construction methods are less likely to fail than dams using centerline construction methods, especially under seismic shaking (ICOLD 2018). The centerline construction method was selected for the bulk TSF north embankment to limit the footprint and volume of materials required for construction (PLP 2018-RFI 075). Alternative 2 – North Road and Ferry with Downstream Dams, considers downstream construction for the bulk TSF north embankment. See Chapter 2, Alternatives, for a description of the downstream dam alternative; and Section 4.15, Geohazards, for geotechnical comparisons of centerline and downstream dam designs.

Bulk TSF Design Features

- The main embankment of the bulk TSF is planned to be a 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 within the tailings pile, the tailings would be fluid-saturated. Bulk tailings that are not water-saturated are resistant to flow.
- Supernatant fluid would be maintained in a small 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).
- Define filters/drains/gravel blanket that would provide continual drainage even during post-closure.

<u>Pyritic TSF</u>

Pyritic TSF Design Features

- 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.
- Synthetic liner would reduce the risk of embankment failure due to seepage and piping.
- Synthetic liner beneath pyritic TSF would be protected with processed materials to protect liner from punctures or damage during PAG waste rock material placement (PLP 2018 – RFI 055).

4.27.6.9 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 the 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).

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.

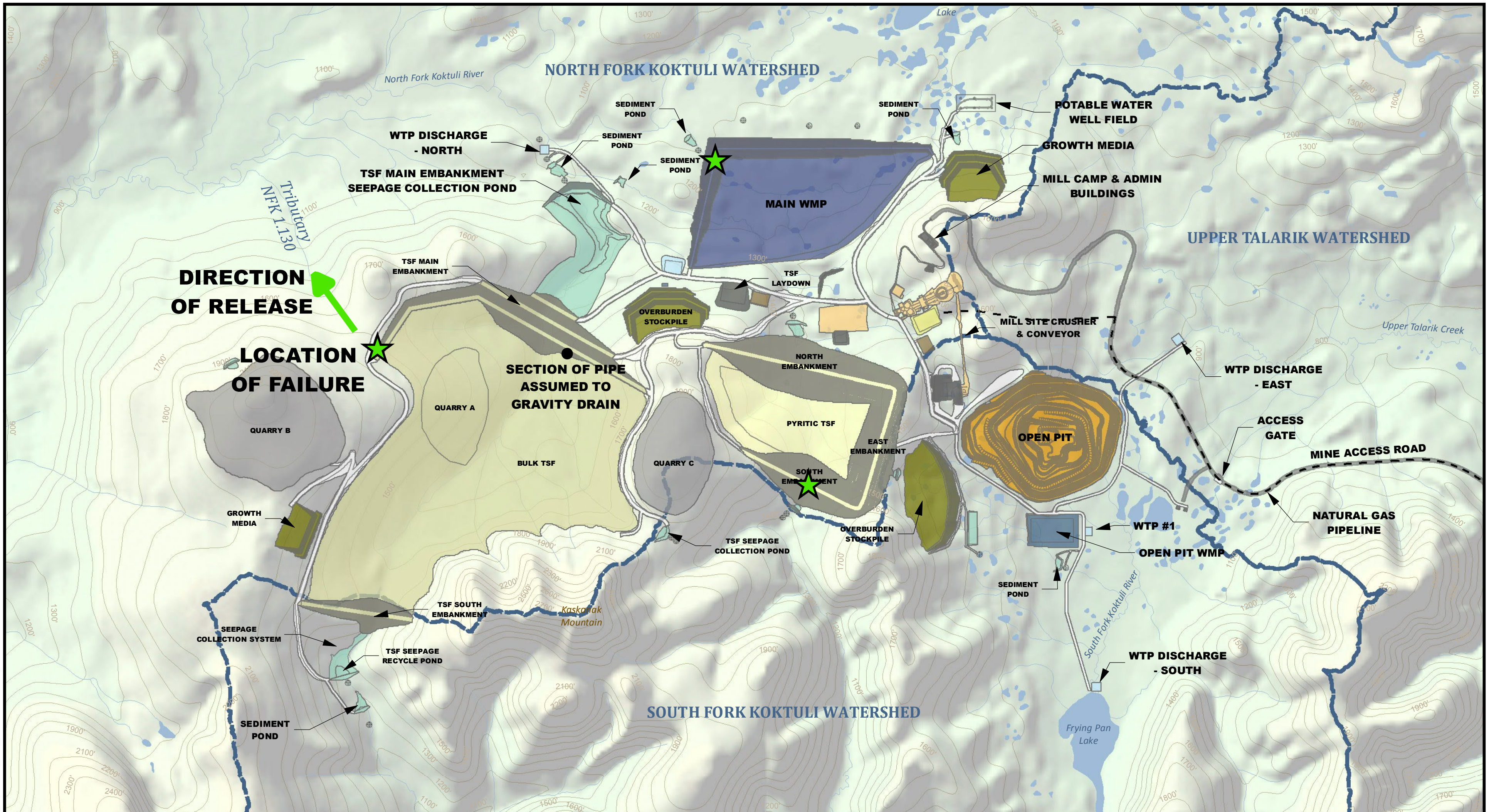
In this scenario, it is assumed that it would take 6 hours for the leak to be detected and for the tailings slurry delivery pumps to be shut off. By this time, 1.5 million ft^3 of tailings slurry would have been released. The pipeline would continue to drain an additional 60,000 ft^3 of slurry after 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 (bankful 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 at the confluence of the NFK and the Nushagak (Figure 4.27-3). See Surface Water Impacts, below, for full details on flow attenuation, arrival time, and duration of increased failure flows.



Sources: KP 2018o; PLP 2018

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

Mine Site Infrastructure

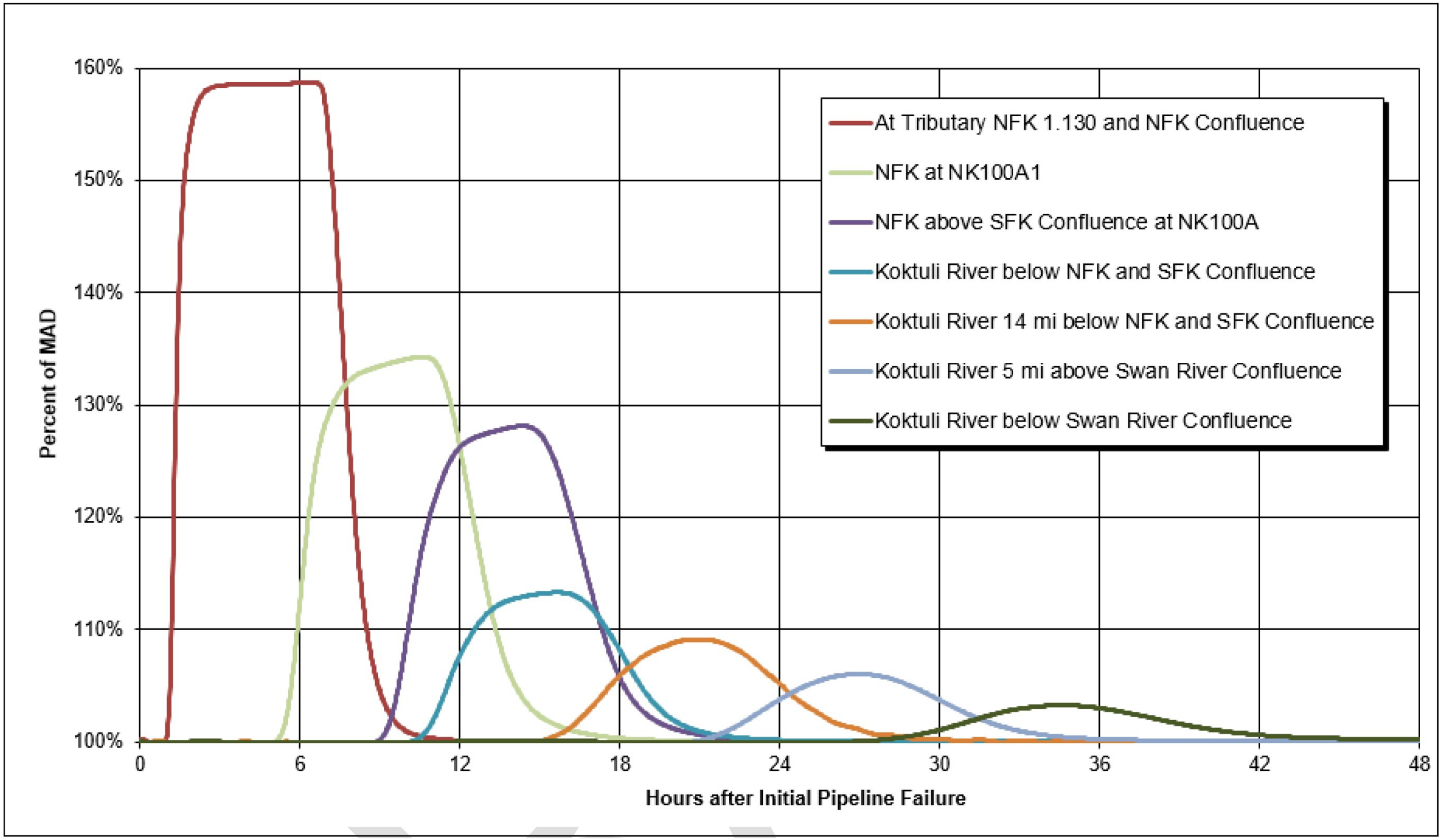
- Bulk Tailing Storage Facility
- Main Water Management Pond
- Mill Site Power Plant
- Mine Site Infrastructure
- Mineral Processing Facilities
- Onsite Access Roads
- Open Pit
- Pyritic Tailings Storage Facility
- Quarries
- Sediment/Seepage Collection Systems
- Stockpiles
- Waste Management Facilities
- Water Management Pond
- Water Treatment Plants

Other Features

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

BULK TAILINGS RELEASE LOCATION

FIGURE 4.27-2



Sources: KP 2018o

US Army Corps of Engineers®

HYDROGRAPHS DOWNSTREAM OF BULK TAILINGS RELEASE

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 some 60 percent of the bulk tailings solids, are light; and would stay suspended in the water and 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

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.

Remedial actions under this failure scenario would initially include (from Knight Piésold 2018o):

- 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:

- Repair and replacement of 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 controls 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.

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 within 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. Modeling results indicate that 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 impacted soil 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 in side 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.

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.

No measurable 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 (bankful 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.
- At the confluence of the NFK and the Swan River, 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, 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 River, 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 be elevated above WQC for at least half a day; while TSS in the lower Nushagak near Bristol Bay, they would be elevated for multiple days to weeks (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, additional 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.

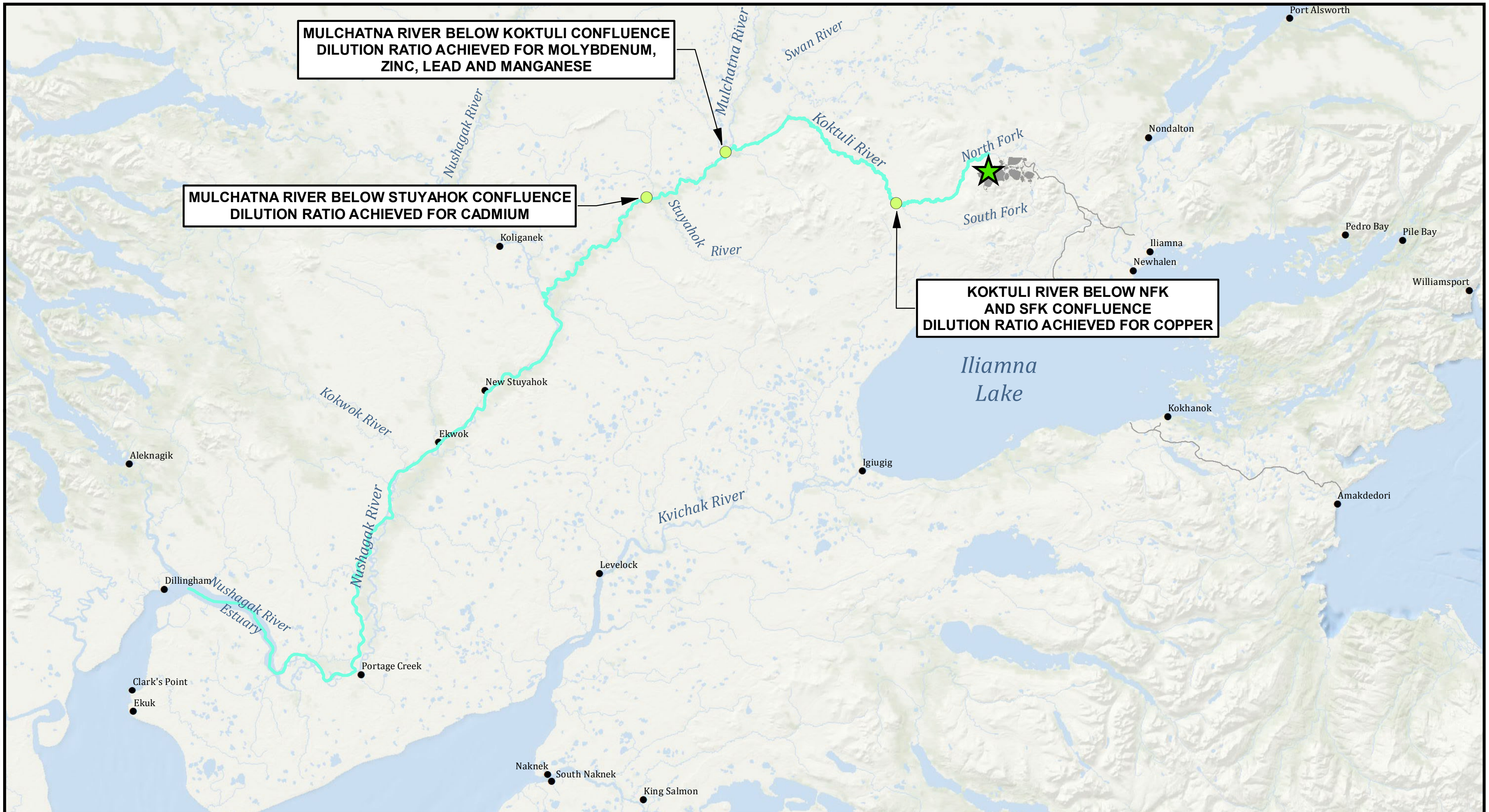
Acid – This bulk tailings release scenario would not be expected to impact water quality due to acid. The released fluid would have a relatively neutral pH (Knight Piésold 2018a).

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.

Metals – 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 WQCs: 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.

As summarized below and on Figure 4.27-4, modeling results indicate that concentrations of several metals would exceed applicable WQCs in the downstream drainages following the spill (Knight Piésold 2018o). The metals that would be present in the highest concentration would be cadmium, molybdenum, zinc, lead, and manganese (Knight Piésold 2018o). Copper was also considered in the modeling due to the abundance of copper in the area (Knight Piésold 2018o).



Sources: KP 2018o; PLP 2018

US Army Corps of Engineers

Location of Release
Dilution Ratio Achieved
Modeled Rivers
Mine Site
Transportation Corridor

10 0 10 20
Miles

MODELED EXTENT OF ELEVATED METALS DOWNSTREAM OF BULK TAILINGS RELEASE

PEBBLE PROJECT EIS

FIGURE 4.27-4

- 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.
- Molybenum, zinc, lead, and manganese 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 WQCs for several days, likely no more than a week, while the flows are flushed downstream.

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.

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. The EPA reports that the tailings slurries 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).

Bulk tailings would not contain residue from blasting agents (explosives). Explosives used during mining would consist of ammonium nitrate/fuel oil (ANFO) mixtures manufactured on site (PLP 2018d). This rock would be monitored until explosive residues have been leached (PLP 2018-RFI 021c).

Sediments

Some downstream streambed sediments/substrate could be partially buried by deposited tailings particles, especially in the backwater 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.

In low-energy segments of downstream drainages, a small volume of tailings could potentially intermingle with and become incorporated into deposits of naturally occurring sediments. These tailings would be more likely to remain in the drainage for a longer period of time prior to being flushed out. It is not anticipated that this small volume of tailings would remain in the drainage long enough to measurably leach 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.

Any acid and metals generated by tailings solids that may remain within 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 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 bulk tailings release scenario would cause bank erosion and limited burial of lowlying 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 (Knight Piésold 2018o).

Assuming the spill response as described for the scenario, spilled tailings would be removed and the duration of impacts would be brief, potentially on the order of weeks. If tailings 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).

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, intensity, geographic extent, and duration would be lower, because many of the terrestrial wildlife species have reduced activity levels, and some are in hibernation or have reduced activity. 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. Although the tailings themselves are not toxic to wildlife, they may indirectly impact wildlife 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. This would impact species that feed on these life stages of salmonids, and may cause lower salmon populations in subsequent years, depending on the extent of the spill. Additionally, contact water in the tailings slurry may cause acute toxicity in fish. Any impacts to fish populations, 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*). Additionally, 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 populations in the NFK may disrupt local cycling of nutrients temporarily in the immediate vicinity of the spill; however, no population-level impacts of salmon are anticipated from the proposed scenario. 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 proposed 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.

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, and tailings are not anticipated to impact avian prey populations. Impacts on birds would likely be negligible; and once migratory species return in spring, impacts would not be noticeable. 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.

A variety of avian species rely on various life stages of salmonid populations 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 have an effect on 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 proposed scenario, some fish life stages may experience acute toxic levels from elevated metals in the tailings slurry contact water. Impacts to bird populations through localized impacts on salmonid populations may occur (by needing to find other foraging locations), but are unlikely to result in noticeable effects on local avian populations. There is an abundance of suitable foraging habitat both above and below the potential spill location into the NFK; and although cleanup activities may disturb local breeding species, no population-level impacts are anticipated. 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 salmonid populations are anticipated to be restricted to the immediate vicinity of the spill, and downstream where eggs and alevin (if present) are smothered by tailings. Overall impacts to avian populations are anticipated to be low-magnitude, of limited geographic extent, and of short duration (a few weeks to months) while cleanup occurs, affected vegetation recovers, and sediment is transported downstream.

Fish

Under this spill scenario, impacts on stream hydrology and several stream water quality parameters (TSS and metals concentrations) would occur generally simultaneously within similar spatial extents and duration (see Water and Sediment Quality section above). 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 populations of 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 WQCs for copper, lead, manganese, molybdenum, and zinc (see above). 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 would not be susceptible to acid generation, because the water would prevent oxidation of the sulfide minerals. 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.

The WQCs exceedances are expected for only several days under this scenario. A greater discussion of impacts via metals toxicity is provided for the next scenario. 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. However, site-specific toxicity tests (as discussed subsequently) are indicative of limited impacts on fish species. An undiluted aqueous sample from the mine site was used in aquatic toxicity studies (Nautilus Environmental 2012). The bioavailability of metals in the test sample may be representative of the tailings fluids released under this spill scenario. As described subsequently, the toxicity tests did not demonstrate acute and chronic toxicity to fish species, including rainbow trout (*Ochorhynchus mykiss*) and fathead minnow (*Pimephales promelas*) in 4- and 7-day exposures, respectively. Although no impact was observed on survival of water flea (*Ceriodaphnia dubia*) neonates, their reproduction was adversely affected when exposed to 12.5 percent or higher aqueous sample (by volume); i.e., at 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. However, under this current spill scenario and assuming 100 percent bioavailability, the WQCs 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 (only for 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.

Threatened and Endangered Species

There would be no impacts to federal 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. 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. It is unlikely that impacts to salmon populations would be noticeable in the marine environment in terms of available marine mammal prey. Salmon in the NFK and downstream would be impacted. The duration would last until affected spawning and rearing habitat is restored and salmon populations are no longer impacted, and the geographic extent would stretch from the spill location in the NFK downstream for tens of miles until metals are diluted.

Needs and Welfare–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 recreation 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 10 years, the average value per harvested sockeye was $6.16 in real terms, and an additional $7.22 per sockeye in additional first wholesale value. A reduction in the NFK spawning biomass that permanently altered 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 labelling 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. Because a spill is not expected to have population-level impacts, 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. 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.

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. 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, located 105 miles downstream from the mine site. 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 Surface Water Impacts above).

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 subsistence foods may affect community concerns about access to, quantity, and quality of subsistence foods, and extend throughout the extended spills analysis area. A tailings release in winter could impede snowmachine travel by subsistence hunters.

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), and communications and precautions about both acute and chronic exposures would help allay public concerns. Subsistence may be impacted, with potential perceptions of subsistence food contamination that extend throughout the area (HEC 4). Impacts would vary in duration; be limited to the area of the spill; and would vary in intensity depending on the season.

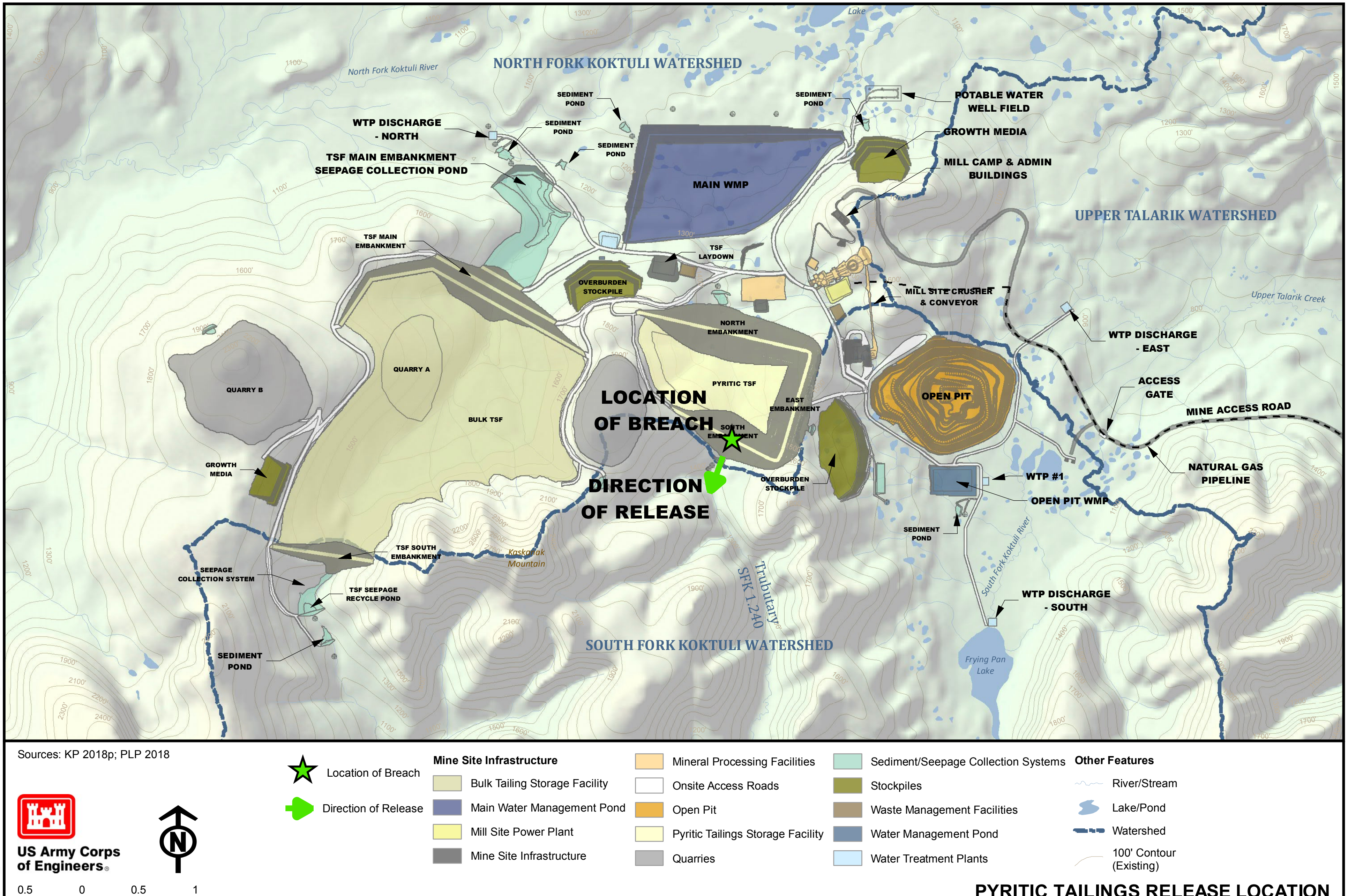
Scenario: Pyritic Tailings South Embankment Release into the SFK

In this scenario, operational error(s) and lift construction difficulties result in an overtopping failure, which results in a partial breach (6 feet down-cutting/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. 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 located 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 the Tributary SFK 1.240 would overtop the banks during the first 2 days of the release (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 arrives at the mainstem of the SFK, about 1 mile downstream (Knight Piésold 2018p).

The flooding would cause erosion in the existing stream channel, and potentially on surrounding soils in areas of overbank flooding (Knight Piésold 2018p).



PYRITIC TAILINGS RELEASE LOCATION

PEBBLE PROJECT EIS

FIGURE 4.27-5

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[1]. 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).

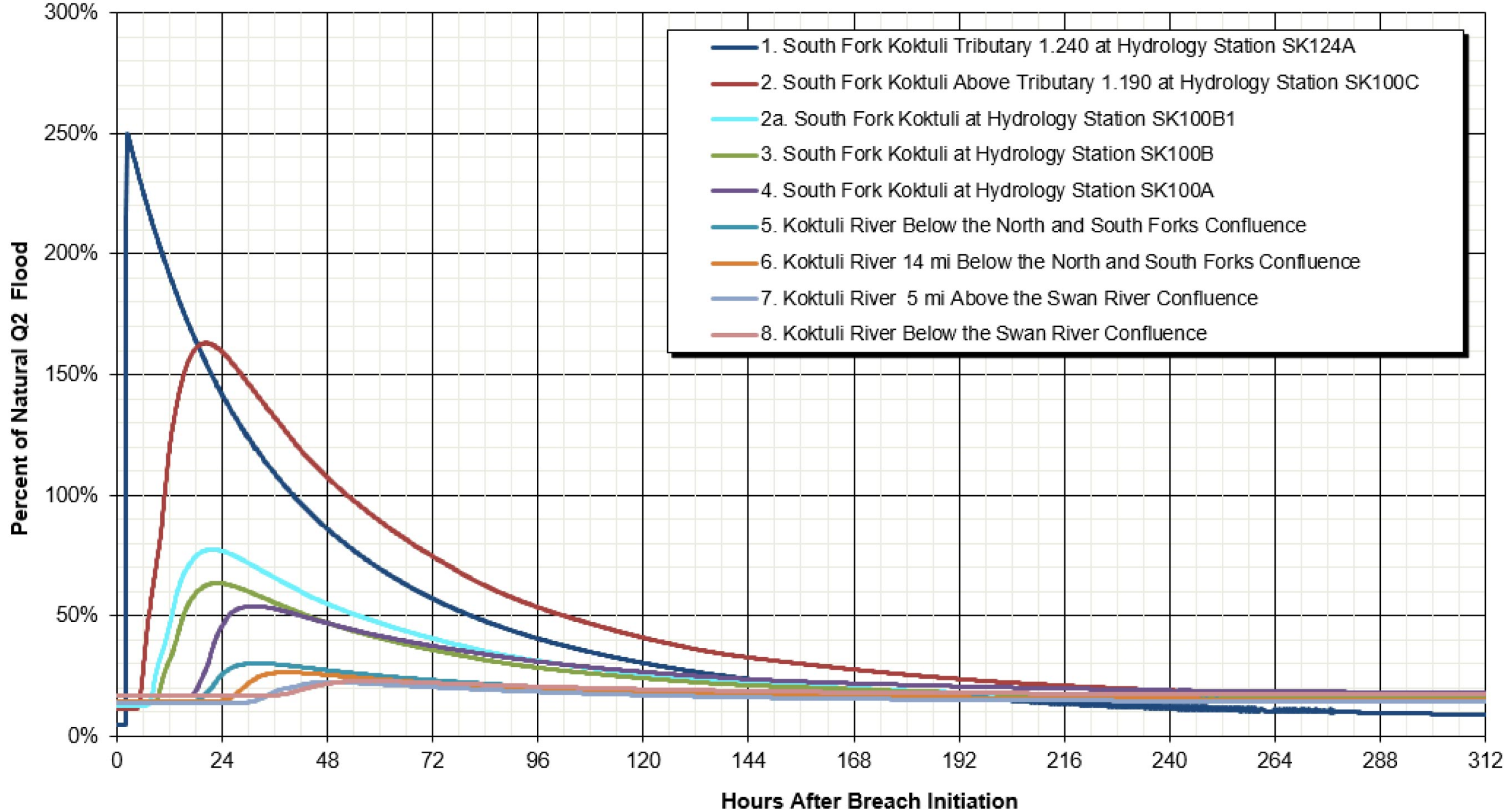
In this scenario, on-site mine operations teams would be unable to stop the flow of fluid exiting the breach, but would be expected to stop the flow after an approximately 1-foot depth of tailings escapes.

Suspended Tailings

The pyritic tailings are 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 backwater 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.

[1] 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

US Army Corps of Engineers

HYDROGRAPHS DOWNSTREAM OF PYRITIC TAILINGS RELEASE

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.

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

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.

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 and/or damage to vegetation that may exceed the impacts of the tailings remaining in place. 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.

Remedial actions under this failure scenario would include (from Knight Piésold 2018p):

- Pumping water from the supernatant pond to the Main WMP following the initial breach to reduce the overall release volume.
- 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 will 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.

<u>Potential Impacts of a Pyritic Tailings South Embankment Release into the SFK</u>

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.

No measurable 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

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 within 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 streamwater, 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 measures 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 within the waterbody. Recovery of these fine particles from the pond may not be practicable.

Acid – fImpacts 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.

Pyritic tailings would contain a high percentage of sulfide minerals 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.

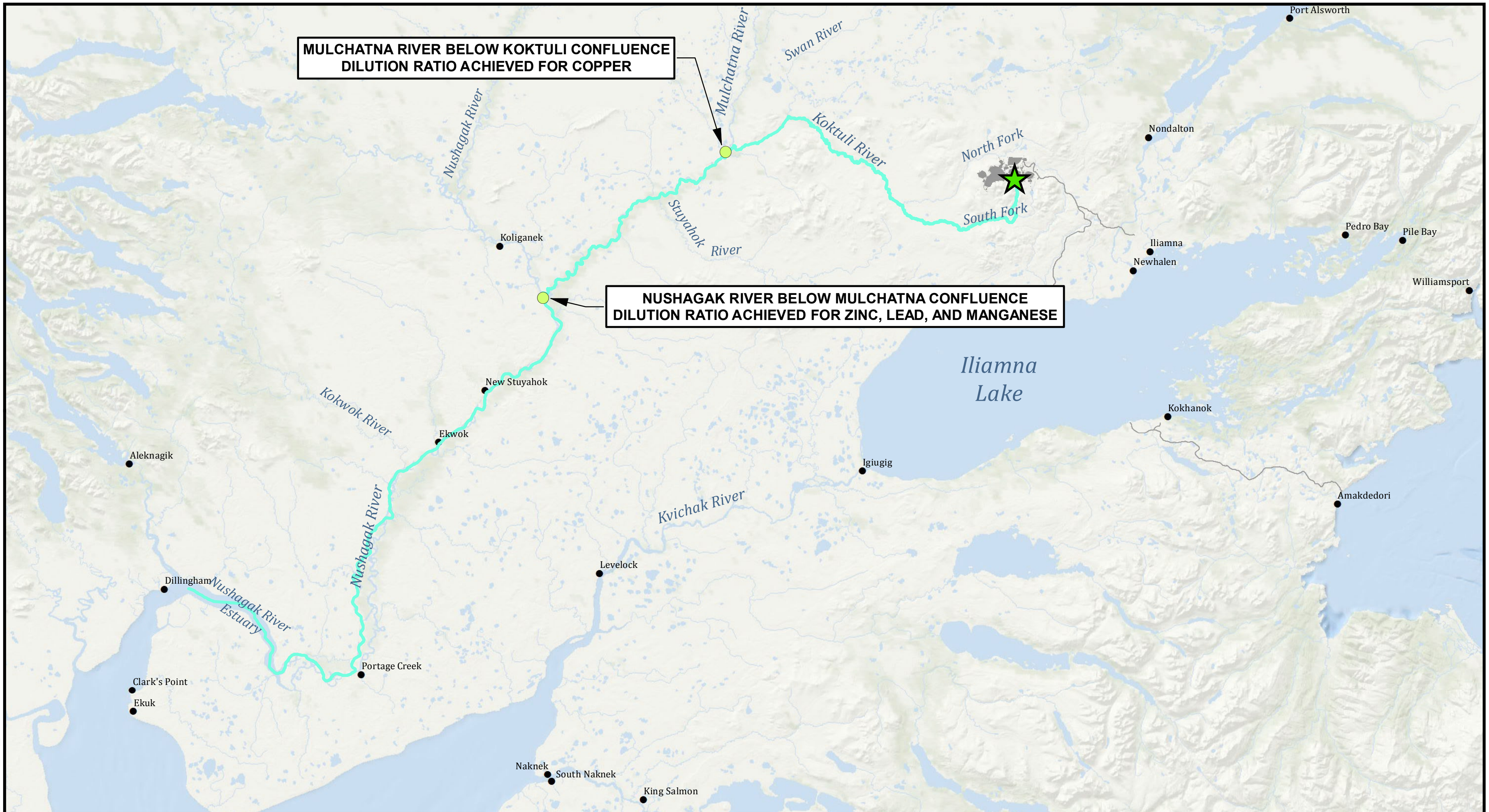
Metals – Under this scenario, pyritic tailings fluid (the supernatant and pore water) with elevated metals concentrations would be released to Tributary SFK 1.240, and transported downstream (Knight Piésold 2018p). Pyritic tailings fluid is predicted to contain the following metals above the most stringent WQCs: antimony, arsenic, beryllium, cadmium, cobalt, copper, lead, manganese, mercury, molybdenum, selenium, silver, and zinc (Knight Piésold 2018a) (Appendix K3.18, Tables K3.18-1 and 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.

As summarized below and in Figure 4.27-7, modeling results indicate that concentrations of several metals would exceed applicable WQCs in the downstream drainages following the spill (Knight Piésold 2018p). The metals that would be present in the highest concentration would be cadmium, molybdenum, zinc, lead, and manganese. 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.
- Zinc, lead, and manganese 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 where it enters Nushagak Bay, part of the greater Bristol Bay, about 230 miles downstream from the mine site.

These metals would remain at elevated levels above WQCs for several weeks while the flows are flushed downstream.



Sources: KP 2018p; PLP 2018

US Army Corps of Engineers®

10 0 10 20
Miles

Location of Release

Dilution Ratio Achieved

Modeled Rivers

Mine Site

Transportation Corridor

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

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 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 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.

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.

Tailings would not contain residue from blasting agents (explosives). Explosives used during mining would consist of ANFO mixtures manufactured on site (PLP 2018d). Rock exposed to explosives would be monitored until explosive residues have been leached (PLP 2018-RFI 021c).

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 within 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 factor so strong, that no measurable ML would be anticipated. PAG tailings would not generate 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 from 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.

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. No measurable impacts to groundwater would be expected beyond several miles downstream of the mine site.

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 the 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 ft3 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).

Metals-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. The elevated levels would last for a few weeks while the flows are flushed downstream. Remaining contaminants would then be flushed out of the watershed 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 be measureable.

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.

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 located 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 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 located within 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 populations 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 salmonid populations 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 water may cause acute toxicity to fish, especially young salmon that are rearing in the upper reaches of the SFK. Acute toxicity of salmonid species may result in wildlife species seeking other locations for feeding. The magnitude of impacts would be high, because wildlife habitat and salmonid populations 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 salmonid populations would last longer, until enough flushing reduces acute and chronic toxicity levels to permit salmon rearing again. It may take several 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 salmonid populations are no longer impacted. Despite local disturbance to species using Tributary SK 1.140, no population-level impacts to wildlife species are expected.

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 when 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.

Impacts to avian prey populations (invertebrates, resident fish, and some salmonid life stages) would be affected. Some prey populations would be washed downstream, while others may suffer mortality through smothering. 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 salmonid populations are no longer impacted. The duration of impacts would last until avian prey populations return to pre-spill conditions, which may take several years.

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 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 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 WQCs in the downstream areas, including cadmium, copper, lead, manganese, molybdenum, and zinc. The WQCs for cadmium, copper, lead, and zinc are associated with the protection of aquatic life, whereas those for manganese and molybdenum are associated 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 populations.

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 results 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. Implications of such sub-lethal effects on activities such as feeding, reproduction, avoidance of predators, and returning to natal streams are acknowledged, but their impacts on populations are unknown. 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 and at population levels 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 WQCs 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 Appendix K3.18, Table K3.18-1). This assumed hardness may underestimate the hardness resulting from the spill. Therefore, realistic exceedances of WQCs for these metals would be more limited (in extent and duration) than those predicted on Figure 4.27-7. The most stringent WQCs 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 is 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 WQCs 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 WQCs were more protective. Based on uncertainties regarding metals bioavailability in the current evaluations, the impacts of the predicted exceedances of metals WQCs 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 WQCs 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 (*Ochorhynchus mykiss*) and fathead minnow (*Pimephales promelas*). One hundred percent of the juvenile rainbow trout survived when exposed to undiluted "Non-Gold Plant Process Water" (representative of tailings fluids) for 96 hours (Nautilus Environmental 2012). One hundred percent of fathead minnow neonates survived when exposed to undiluted aqueous sample for 7 days, and their growth was not inhibited (Nautilus Environmental 2012). Survival of water flea (*Ceriodaphnia dubia*) neonates was also not adversely affected when exposed to undiluted aqueous sample for 7 days. However, reproduction was adversely affected when exposed to 12.5 percent or higher aqueous sample (by volume), i.e., at 8 times dilution or less. 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, but likely less so on fish species.

In conclusion, the results of the aquatic toxicity tests on waterflea, fathead minnow, and rainbow trout indicate that acute impacts (lethality) on fish due to metals toxicity would not occur within the predicted time frame and extent of WQCs exceedances. Sub-lethal impacts could occur to sensitive aquatic invertebrates in the upstream areas beyond a couple of weeks, where lower dilution to metals concentrations would occur. Sub-lethal impacts on fish is 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. Therefore, long-term persistent population-level impacts to fish would not occur.

Threatened and Endangered Species

There would be no impacts to federal 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. Therefore, no impacts to TES are anticipated.

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 would be diluted prior to reaching the marine environment. 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 is unlikely to cause noticeable impact on the prey base for several marine mammals. Salmon in the SFK and downstream would be impacted. The duration would last until affected spawning and rearing habitat is restored and salmon populations 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.

Needs and Welfare–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. 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 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, over the last 10 years, the average ex-vessel value per harvested sockeye was $6.16 in real terms, which then leads to an additional $7.22 per sockeye in additional first wholesale value. 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 would not 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. Because a spill is not expected to have population-level impacts, 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.

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, located 113 miles downstream. 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 subsistence foods may affect community concerns about access to, quantity and quality of subsistence foods, and extend throughout the extended spills analysis area.

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), and communications and precautions about both acute and chronic exposures would help allay public concerns.

Subsistence may be impacted, with potential perceptions of subsistence food contamination that could extend throughout the area (HEC 4). Impacts would vary in duration and be limited to the area of the spill.

4.27.6.10 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 within 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).

4.27.7 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 Sections 4.18, Water and Sediment Quality, and Appendix K4.18).

Contact water would be stored in several facilities, including the main WMP, the open pit WMP, and six seepage collection ponds (SCP) adjacent to (downstream of) the TSFs. Supernatant ponds within the TSFs and fluid within 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.

4.27.7.1 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 located 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 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 inflow design flood (IDF) (equal to the Probable Maximum Flood) and additional freeboard (Knight Piésold 2018q). The very high capacity allows for storage of excess contact water from the bulk TSF, to maintain a minimal supernatant pond.

The proposed embankment would be a rockfill/zoned earthfill dam with a full geomembrane face liner. 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, for details on the seismic stability and other geotechnical features of the embankments.

4.27.7.2 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.

4.27.7.3 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 waste water 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 waste water 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.

4.27.7.4 Probability of Release/Spill Frequency and Volume

Water reservoir dams are generally built to last for decades to centuries. Water management ponds and other water storage facilities at mine sites are generally not built to last beyond the operational life of a mine, and are therefore generally constructed with earthen materials instead of cementitious materials.

Most mine water management ponds are generally much smaller than the proposed main WMP. There are no known precedents for such a large lined WMP; therefore, there are no reliable statistics on their failure rates.

4.27.7.5 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. Please see the full discussion of the FMEA process above under Risk Assessment for the Proposed Embankments.

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 proposed 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.

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.

4.27.7.6 Existing Response Capacity

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.

4.27.7.7 Mitigation

- Dam/embankment safety is regulated by 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.
- 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.)
- As per ADSP guidelines, 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).
- The main WMP would be constructed with an FoS of 1.9 to 2.0 (minimum 1.5 FoS required by USACE).

See Section 4.15 and Appendix K4.15, Geohazards, for further discussion of seismic stability design for the main WMP.

4.27.7.8 Contact Water Release Scenarios

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.

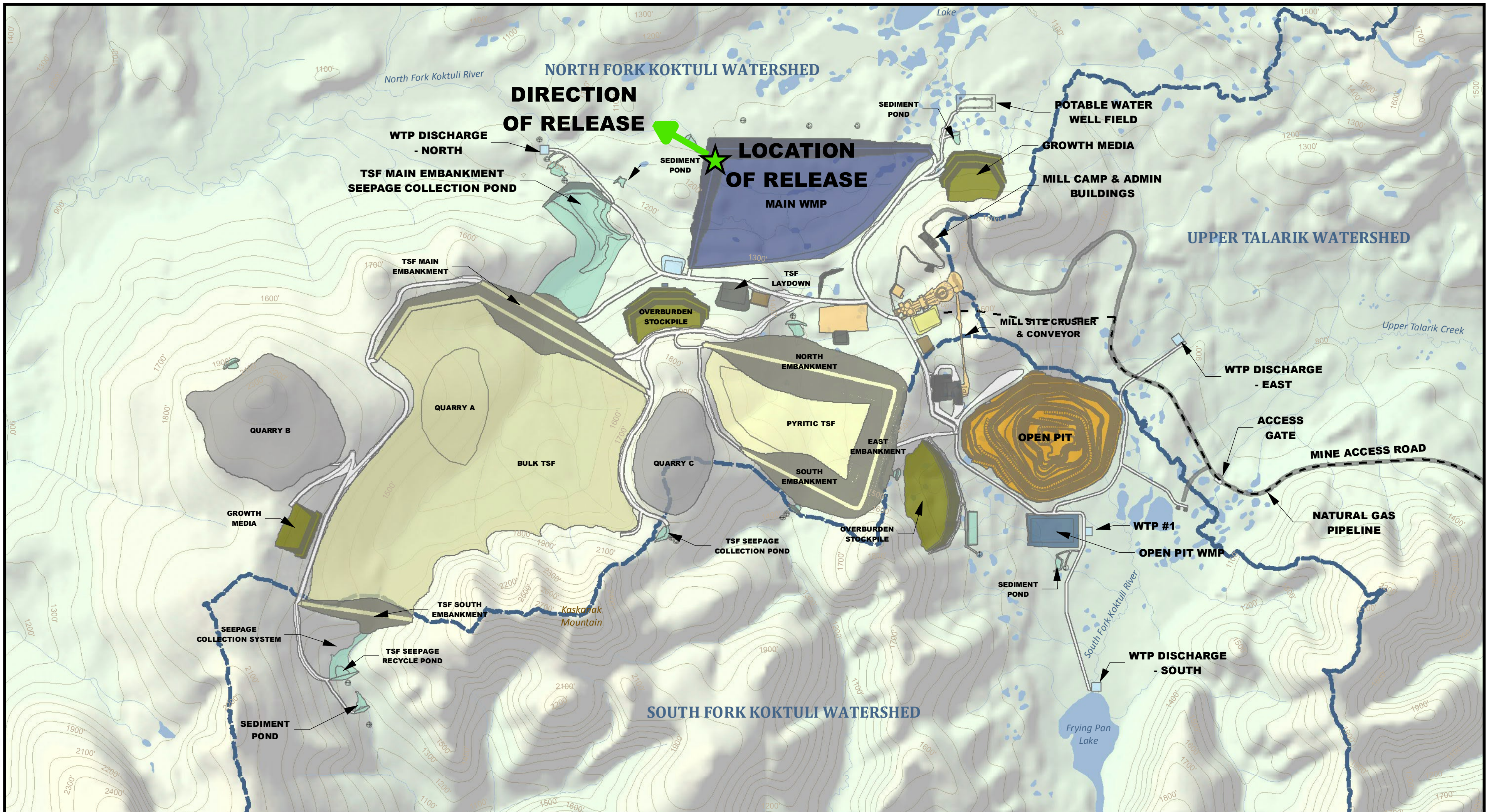
Released contact water would flow into Tributary NFK 1.120, which feeds into the NFK. The NFK joins with the SFK to form the Koktuli River, which is a tributary of the Mulchatna River; which in turn, is a tributary of the Nushagak River that flows into Nushagak Bay, part of the greater Bristol Bay, about 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.



Sources: KP 2018q; PLP 2018

Location of Release
Direction of Release

Mine Site Infrastructure
- Bulk Tailing Storage Facility
- Main Water Management Pond
- Mill Site Power Plant
- 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 Pond
- Water Treatment Plants

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

US Army Corps of Engineers

0.5 0 0.5 1
Miles

UNTREATED CONTACT WATER RELEASE LOCATION

PEBBLE PROJECT EIS

FIGURE 4.27-8

Spill Response

Any soils impacted by the elevated metals from the contact water could be removed, and the impacted habitats could be restored.

Remedial actions under this failure scenario would include:

- 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.

The potential for a release of contact water as described in the scenario would be the same for all alternatives.

4.27.7.9 Potential Impacts of 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.

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.

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; Tables K3.18-1 and 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 WQCs in the downstream drainages following the spill. The metals that would be present in the highest concentration would be molybdenum, cadmium, lead, zinc, and manganese. 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 WQCs as follows: (downstream distances estimated from Figure 4.27-9).

- Molybdenum for about 15 to 45 miles downstream.
- Cadmium 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; so concentration of these metals would exceed their WQCs 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 WQCs for a month or more during and after the release.

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

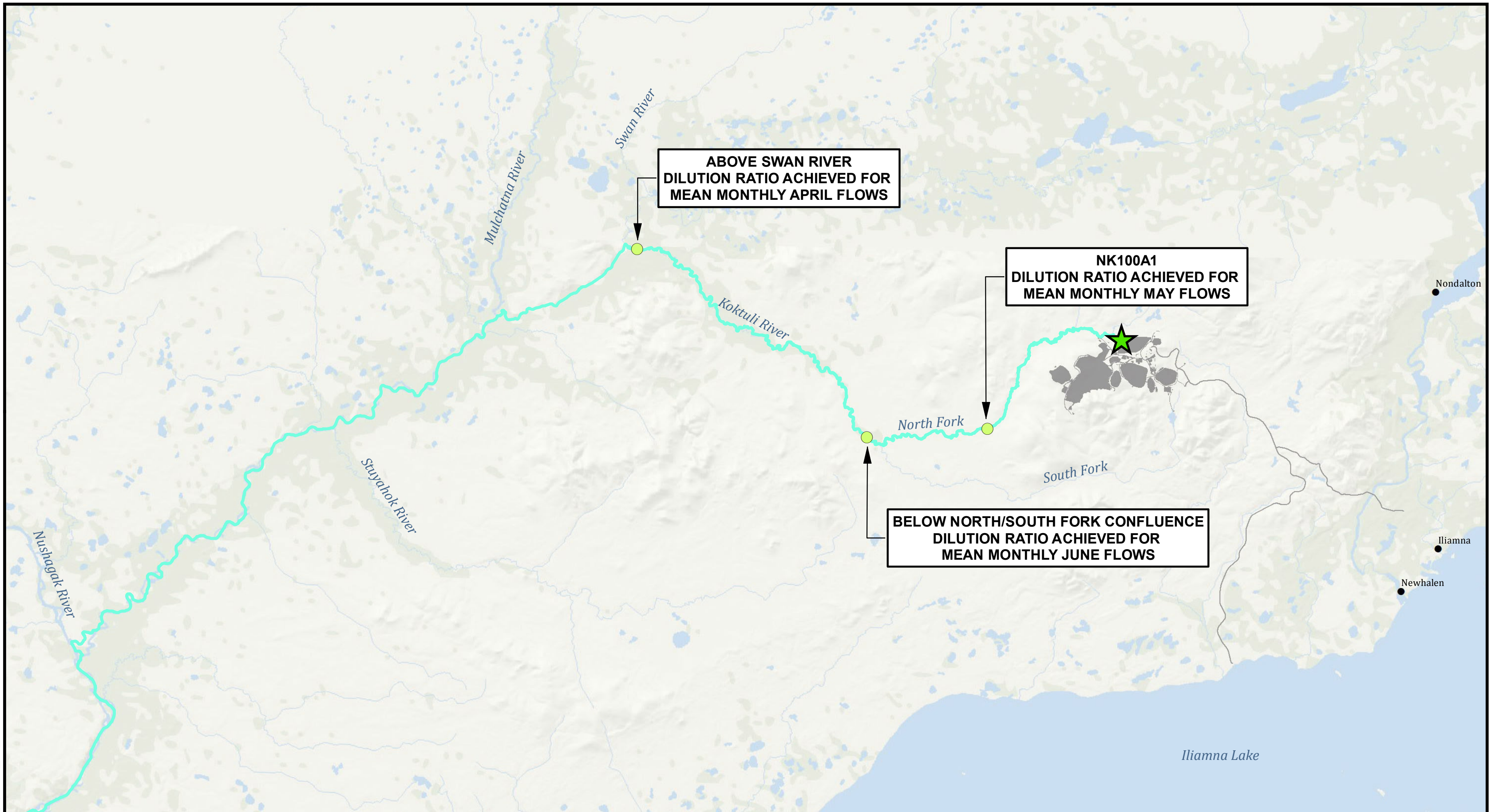
There is potential for shallow groundwater to be contaminated with elevated levels of metals from the month-long release of untreated contact water. There are numerous shallow aquifers throughout the downstream area, and many losing segments of downstream drainages where surface water enters groundwater. Metals present in the released contact water could potentially permeate through soils and sediments into shallow groundwater during the month-long release. However, 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. Measurable impacts to groundwater quality are not likely from this scenario.

Noise

No impacts.

Air Quality

No impacts.



Sources: KP 2018q; PLP 2018

US Army Corps of Engineers

5 0 5 10
Miles

Location of Release
Dilution Ratio Achieved
Modeled Rivers
Mine Site
Transportation Corridor

MODELED EXTENT OF ELEVATED METALS DOWNSTREAM OF UNTREATED CONTACT WATER RELEASE

PEBBLE PROJECT EIS

FIGURE 4.27-9

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.

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.

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 populations may result in impacts to these species. Impacts may include altered foraging locations (if fish levels are reduced) and 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 *in* Sánchez-Bayo 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.

Molybdenum, the metal with the highest concentration in the released contact water, 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 a disease known as 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 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, lead, zinc, manganese, and copper. 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. Additionally, 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, and 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 biomagnifys 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 *in* Sánchez-Bayo et al. 2011). Species such as river otters and bears can bioaccumulate mercury from fish (Mann et al. 2011 *in* Sánchez-Bayo 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 populations. Generally, carnivorous species show higher biomagnification compared to herbivorous species (Mann et al. 2011 *in* Sánchez-Bayo 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 populations. 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 populations. Therefore the extent to which salmonid populations 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. The magnitude of impacts would be highest during spring and summer, 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. Birds such as waterfowl, predators, and scavengers are especially vulnerable to lead poisoning through ingestion of lead shot and fragments that are embedded in carcasses, or that persist in the gizzards of birds, though data on lead toxicity due to lead shot and fragments may have limited relevance to this scenario (Mann et al. 2011 *in* Sánchez-Bayo et al. 2011). Lead poisoning in waterfowl has led to several population declines, and 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 *in* Sánchez-Bayo et al. 2011). Therefore, the potential duration of impacts may extend beyond the initial period of exposure to elevated levels of selenium.

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 *in* Sánchez-Bayo et al. 2011) (such as bald eagles).

In summary, avian populations 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, and rearing habitat, but the impacts are not anticipated to result in population-level effects.

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 WQCs exceedances are more limited than in the previous scenario, but the duration of exceedances are longer (months compared to weeks). The overly conservative nature of the WQCs, 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) is also representative of the contact water. The toxicity tests did not demonstrate acute and chronic toxicity to fish species, including rainbow trout (*O. mykiss*) and fathead minnow (*P. promelas*). Although no impact was observed on survival of water flea (*C. dubia*) neonates, 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 in the above considerations, acute toxicity due to metals would not occur. However, prolonged exposure (beyond months) to metals concentrations in slight exceedance of WQCs may result in sub-lethal effects. 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.

Marine Mammals

No direct impacts to marine mammals are anticipated, because metal concentrations would be diluted to within water quality standards on 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 populations may extend the duration, depending on the amount of time necessary for salmonid populations to recover; however, it would be difficult to determine if there is a correlation between reduced salmonid populations and marine mammal populations in Nushagak Bay.

Needs and Welfare–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.

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 within 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 subsistence foods may affect community concerns about access to, and quantity and quality of subsistence foods, and extend throughout the extended spills analysis area.

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 may be impacted, with potential perceptions of subsistence food contamination that could extend throughout the area (HEC 4). Impacts would vary in duration and be limited to the area of the spill.

4.27.8 Cumulative Effects

4.27.8.1 Past 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. Any past or present spills that have had an impact on the physical, biological, and social environment have been addressed in Chapter 3 sections for specific resources that have been affected.

4.27.8.2 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 RFFA; and where they are analyzed, quantitative information on the mode of failure, probability, and volume of potential spills have not been available, or are based on assumptions that are not relevant or have not been substantiated. This section provides a qualitative analysis of potential spills associated with RFFAs.

No Action Alternative

The No Action Alternative would not contribute to cumulative effects related to spill risk.

All Alternatives

Pebble Mine Expanded Development Scenario – The probabilities and potential impacts of spills associated with PLP's proposed alternatives and alternative variants have been addressed previously in this section for the following substances: diesel fuel, natural gas, copper-gold ore 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 proposed facilities over an operational life that extends an additional 78 to 98 years through 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.

There are additional facilities that have not been previously discussed under PLP's proposed alternatives and variants: construction of two waste rock storage facilities (WRF), two WRF collection ponds, and construction of a diesel pipeline. Portions of the North WRF and North WRF Collection Pond would be located 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 UTC under mine expansion. Potential diesel spills from the diesel pipeline could result from pinhole leaks, involving small quantities of diesel; 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.

In summary, the cumulative effects of unintentional releases associated with Pebble mine expansion would be similar to those discussed previously in this section, but potentially involve larger volumes over a slightly larger geographic area.

Other Mineral Exploration, Oil and Gas Exploration, Road Improvement, and Community Development Projects – There would be no contribution from alternatives to the cumulative effects related to spill risk associated with mineral exploration, oil and gas exploration, road improvement, and community development projects.