4.27 SPILL RISK

This section addresses the spill risk for diesel fuel, natural gas, copper-gold concentrate, chemical reagents, bulk and pyritic tailings, and untreated contact water. The substances analyzed do not include all of the hazardous materials that would be used for the project. A list of hazardous materials that would be used by the project is provided in Appendix K2 under "Mine Site Supplies and Quantities."

Substances analyzed in this section were selected based on their spill potential (probability) and potential impacts (consequences). Probability and consequences are analyzed and addressed separately throughout the section.

Because the potential spill scenarios addressed are hypothetical, this section cannot provide the same level of quantitative impacts analysis as is provided in other sections of the EIS. Quantitative analysis (modeling) is provided for the release scenarios of tailings and untreated contact water.

The "Fate and Behavior" subsections address the probable outcomes that would result from a release into the environment, considering a wide range of potential spill circumstances. The "Historical Data" subsections review data on past spills, where available, including probabilities and consequences. The "Existing Response Capacity" subsections list any organizations or plans that may be available as resources in the event of a spill. The "Mitigation" subsections address design features or practices that would reduce the likelihood of a spill, and/or minimize potential impacts in the event of a spill. The "Scenario" subsections describe seven hypothetical spill scenarios that were selected for impacts analysis, including spill response. The "Potential Impacts" subsections address potential impacts from each of the spill scenarios. Impacts assessments assumed that the spill response as outlined in each scenario would be followed.

4.27.1 Alternatives Analysis

For most of the spill scenarios analyzed in this section, the potential impacts would be similar across all alternatives. Where there is significant variation across alternatives, individual alternatives are addressed as relevant, such as the Diamond Point port alternative, and the Alternative 3—North Road Only transportation corridor, which eliminates the potential for spills from the ferry into Iliamna Lake. Table 4.27-1 summarizes the variation in spill risk across all alternatives.

Table 4.27-1: Summary of Spill Risk by Alternative

Spill Scenarios	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Diesel Spill from Tanker Truck Rollover	Spill risk as analyzed herein for 72 miles of road transport.	Spill risk similar to Alternative 1a, with 65 miles of road transport.	Similar to Alternative 1a, with fewer miles of road transport (53 miles).	The transport of diesel by road under Alternative 3 eliminates the potential for spills of diesel from the ferry into Iliamna Lake. Otherwise, there is a similar/slightly higher diesel spill risk from trucking compared to Alternative 1a, with slightly increased miles of road transport (82 miles) and possibly steeper grades on some road segments.

Table 4.27-1: Summary of Spill Risk by Alternative

Spill Scenarios	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Diesel Spill from Marine Tug-Barge Allision	Spill risk as analyzed in this section.	Same spill risk as Alternative 1a.	The Diamond Point port site generally has thicker sea ice in higher concentrations for longer periods than the Amakdedori port site. The Diamond Point port area has additional biological resources that could be impacted by a spill, compared to Amakdedori.	The Diamond Point port site generally has thicker sea ice in higher concentrations for longer periods than the Amakdedori port site. The Diamond Point port area has additional biological resources that could be impacted by a spill, compared to Amakdedori.
Natural Gas Releases from Pipeline	Spill risk as analyzed in this section.	Same spill risk as Alternative 1a.	The transport of natural gas by overland pipeline from the port eliminates the potential for gas releases into Iliamna Lake.	The transport of natural gas by overland pipeline from the port eliminates the potential for gas releases into Iliamna Lake.
Concentrate Spill from a Truck Rollover	Spill risk as assessed herein for 72 miles of road transport.	Spill risk similar to Alternative 1a, with 65 miles of road transport.	Similar to Alternative 1a, with fewer miles of road transport (53 miles).	The transport of concentrate by road under Alternative 3 eliminates the potential for concentrate spills from the ferry into Iliamna Lake. Otherwise, there is a similar/slightly higher concentrate spill risk from trucking compared to Alternative 1a, with increased miles of road transport (82 miles) and possibly steeper grades on some road segments.
Concentrate Slurry Pipeline Rupture	No concentrate pipeline for Alternative 1a.	No concentrate pipeline for Alternative 1.	No concentrate pipeline for Alternative 2.	The transport of concentrate by road or pipeline under Alternative 3 eliminates the potential for concentrate spills from the ferry into Iliamna Lake. Under the Alternative 3 Concentrate Pipeline Variant return water pipeline option, there would be an additional potential for spills of untreated contact water from the return water pipeline.

Table 4.27-1: Summary of Spill Risk by Alternative

Spill Scenarios	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Reagent Spills	Different ferry routes across Iliamna Lake may have different navigational challenges.	Different ferry routes across Iliamna Lake may have different navigational challenges.	Different ferry routes across Iliamna Lake may have different navigational challenges. If two ferry vessels are needed for summer-only ferry operations, increased ferry traffic could increase the risk of vessel collisions that could result in spills.	The transport of reagents by road under Alternative 3 eliminates the potential for reagent spills from ferry into Iliamna Lake.
Bulk Tailings Delivery Pipeline Rupture	Spill risk as analyzed in this section.	Same spill risk as Alternative 1a.	Centerline versus downstream dam designs may have different spill risk, although built to same FoS (dam design not relevant to scenario).	Same spill risk as Alternative 1a.
Pyritic Tailings South Embankment Release into the SFK	No variation in spill risk across alternatives.	No variation in spill risk across alternatives.	No variation in spill risk across alternatives.	No variation in spill risk across alternatives.
Untreated Contact Water Release Scenario	No variation in spill risk across alternatives.	No variation in spill risk across alternatives.	No variation in spill risk across alternatives.	No variation in spill risk across alternatives.

Notes:
FoS = Factor of Safety
SFK = South Fork Koktuli

4.27.2 Spills Impact Analysis Areas—Affected Environment

The geographic extent of potential impacts of four of the spill scenarios extends beyond the Environmental Impact Statement (EIS) analysis area for other potential impacts analyzed in the EIS. The affected environment for these extended analysis areas is described here for surface water, water and sediment quality, and biological resources.

4.27.2.1 Affected Environment of the Analysis Area for the Diesel Spill from a Marine Tug-Barge in Lower Cook Inlet

The analysis area for the marine tug-barge diesel spill scenario extends from Kamishak Bay across Lower Cook Inlet and northern Shelikof Strait to the shores of Shuyak and Afognak islands, and Cape Douglas.

Surface Water

General surface water conditions, meteorology, and oceanography characteristics in the marine environment of Kamishak Bay and northern Shelikof Strait are comparable to those described for

Lower Cook Inlet in Section 3.16, Surface Water Hydrology. The area has high exposure to wind, often resulting in strong wave action. Wave climate, tides, currents, and storm surge conditions vary widely across the analysis area, depending on local geography, bathymetry, etc. Sea ice conditions vary substantially across Kamishak Bay and Shelikof Strait, both geographically and annually; ranging from sporadic ice cover to compact accumulations of ice in and around Kamishak Bay for several weeks per year.

Water and Sediment Quality

Water and sediment quality in Lower Cook Inlet approaching the entrance to Shelikof Strait are similar to that discussed previously for the area surrounding the marine ports, as addressed in Section 3.18, Water and Sediment Quality. The area has low to moderate turbidity and suspended sediment load, which vary with proximity to input from silt-laden, glacier-fed rivers. Salinity and temperature conditions are also comparable to those previously discussed.

Biological Resources

The biological resources found in this region would be similar to those described in previous sections for the coastal and marine portions of the EIS analysis area. The marine and estuarine waters of Lower Cook Inlet have been described in Section 3.22, Wetlands and Other Waters/Special Aquatic Sites, including nearshore and deepwater habitats. The fish and shellfish of Lower Cook Inlet have been discussed in Section 3.24, Fish Values; and Section 3.6, Commercial and Recreational Fisheries. This information includes the five species of Pacific salmon, resident fish species, and other important commercial and recreational fisheries. Birds, described in Section 3.23, Wildlife Values, include raptors (eagle, falcons, hawks, owls, and corvids), waterbirds (ducks, geese, and swans), landbirds (songbirds), and shorebirds (plovers and sandpipers). The analysis area also includes the habitats of seabirds such as puffins, cormorants, murres, kittiwakes, murrelets, guillemots, and storm-petrels, among others. The habitats of terrestrial wildlife, which includes caribou, moose, black and brown bear, gray wolf, and smaller terrestrial vertebrates (including furbearers), are discussed in Section 3.23, Wildlife Values.

Marine mammals that are not federally listed as threatened or endangered species (TES) under the Endangered Species Act are discussed in Section 3.23, Wildlife Values; and include gray whale (Eastern North Pacific distinct population segment [DPS]), minke whale, killer whale, Dall's porpoise, harbor porpoise, harbor seal, and California sea lion. TES are described in Section 3.25, Threatened and Endangered Species; and include humpback whale (Mexico and Western North Pacific DPSs), fin whale, sei whale, blue whale, North Pacific right whale, gray whale (Western North Pacific DPS), sperm whale, beluga whale (Cook Inlet stock), Steller sea lion (Western DPS), northern sea otter (Southwest Alaska DPS), Steller's eider (Alaska breeding population), and short-tailed albatross. Some of these TES are present or have a potential to occur in the diesel spill analysis area from Kamishak Bay in Lower Cook Inlet south to the Shelikof Strait, including Shuyak and Afognak islands in the Gulf of Alaska. Some whale species occur south of Kodiak Island in the Gulf of Alaska and are not anticipated to be impacted by the spill scenario; these include blue whale and sei whale. These two whale species are not included in the analysis herein because it was determined that under the 300,000-gallon Ultra-Low Sulfur Diesel (ULSD) spill scenario, diesel impacts would not extend to areas where these whale species are normally present. In addition, the short-tailed albatross does not breed, stage, migrate, or regularly feed in the area that may be impacted by this spill scenario, and is therefore not included in the discussion on TES impacts.

There is also a potential for federally designated and proposed critical habitat in lower Cook Inlet for humpback whale, Cook Inlet beluga whale, Steller sea lion, and northern sea otter to experience impacts under this spill scenario.

4.27.2.2 Affected Environment of the Analysis Areas for the Bulk and Pyritic Tailings, and Untreated Contact Water Releases

The analysis areas for the bulk and pyritic tailings spill scenarios extend about 230 river miles downstream from the mine site to the Nushagak River Estuary. The analysis area for the untreated contact water spill scenario extends downstream along the Koktuli River to just above the confluence with the Swan River, approximately 45 river miles downstream of the mine site. The analysis area for the untreated contact water release is contained in the analysis area for the tailings releases, so they will be addressed together. Maps of the analysis areas for the bulk tailings release, pyritic release, and untreated contact water release are provided under their respective sections below.

A bulk tailings release and an untreated contact water release would both follow the North Fork Koktuli (NFK) into the mainstem Koktuli, while a pyritic tailings release would follow the South Fork Koktuli (SFK) into the mainstem Koktuli. The affected environment of the NFK and SFK are fully described in Section 3.16, Surface Water Hydrology. This additional analysis area for the spill scenarios extends from the mainstem Koktuli (where the NFK and the SFK meet), into the Mulchatna River, and finally into the Nushagak River Estuary, which feeds into Nushagak Bay, part of greater Bristol Bay. The affected environment for this extended analysis area is described below.

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). It is unknown/not documented if private users use surface water as a drinking water source. Extensive mitigation measures would be in place to protect surface water for drinking water use (see Section 4.18, Water and Sediment Quality).

Water and Sediment Quality

Water and sediment quality in the extended analysis area are generally comparable to that described for the NFK and SFK (Section 3.18; Water and Sediment Quality, and Appendix K3.18). Groundwater quality meets drinking water standards and is used by several downstream communities (ADEC 2018f).

Biological Resources

The biological resources found in this extended analysis area would be similar to those described for the terrestrial portions of the EIS analysis area (detailed in Section 3.23, Wildlife Values), with the addition of species associated with the Nushagak River drainage, including the Nushagak River Estuary.

Wetlands and waterbodies, including vegetated wetlands, ponds, lakes, streams, and rivers, have been described in Section 3.22, Wetlands and Other Waters/Special Aquatic Sites. Resident and anadromous fish species and their spawning, rearing, and migratory habitats are discussed in Section 3.24, Fish Values. The Nushagak River system (which includes the main stem of the Koktuli River), supports eight anadromous species, including five species of Pacific salmon, 16 resident species, and four estuarine species. The system provides quality spawning and rearing habitat for Pacific salmon and supports one of the largest Chinook salmon runs in the world. A large portion (24 percent) of the Nushagak River Chinook salmon population spawn in the Koktuli River watershed (Schwanke 2007). A description of the commercial and recreational fisheries in the Mulchatna and Nushagak rivers is provided in Section 3.6, Commercial and Recreational Fisheries.

The Nushagak River area vegetation is primarily composed of tundra, mixed coniferous forests, and an abundance of willow, cottonwood, and alder riparian vegetation. Above approximately 900 feet, bare rock, heath tundra, and alpine meadow dominate the watershed area. At the lowest elevations, wet tundra marsh is common, and a large tidal estuary exists at the mouth of the Nushagak River.

Birds in the region around the project are described in Section 3.23, Wildlife Values, and include raptors (eagles, falcons, hawks, owls, and corvids), waterbirds (ducks, geese, and swans), landbirds (songbirds), and shorebirds (plovers and sandpipers). The Nushagak River watershed provides important staging, nesting, molting, and year-round habitat for many bird species, including waterfowl, shorebirds, songbirds, seabirds, and raptors, among others.

Common mammals in this analysis area would be similar to those described in Section 3.23, Wildlife Values. The area provides quality habitat for numerous terrestrial mammals, including moose, brown and black bears, caribou, wolves, wolverine, fox, and multiple small mammals. Beaver are common throughout most streams and lakes in the area. The wood frog is the only amphibian species known to occur in the area. Brna and Verbrugge (2013) developed a thorough list terrestrial vertebrate species that have been documented seasonally and year-round in the Nushagak River watershed.

There are no federal TES that occur in the terrestrial portions of the mainstem Koktuli, Mulchatna, and Nushagak river drainages. Several TES occur in the greater Bristol Bay region outside of the extended analysis area and are not discussed in this section.

Marine mammals that swim up and feed in the Nushagak River and estuary have a potential to be impacted. The non-federally listed Bristol Bay stock of beluga whales is known to swim at least 18 miles up the Nushagak River and occurs year-round in Bristol Bay, and may be impacted by a tailings release (Citta et al. 2016). Other marine mammals that occur near the mouth and in the Nushagak River include harbor seals and killer whales (Limpinsel 2013). There are additional marine mammal species that occur farther away from the mouth of the Nushagak River in Bristol Bay, outside of the extended analysis area, and are not discussed herein.

4.27.3 Spill Preparedness, Prevention, and Response Measures

The Applicant would implement a variety of spill preparedness, spill prevention, and spill response measures, discussed below, that would apply to spills addressed herein (PLP 2019-RFI 126). Additional details related to individual substances are provided throughout this section. The Applicant has committed to specific remedial actions in the event of a tailings spill; these actions are included in the bulk and pyritic tailings release scenarios in the "Spill Response" subsections (see Chapter 5, Mitigation). These measures would apply to all alternatives, as relevant.

4.27.3.1 Spill Preparedness Measures

The Applicant would develop Oil Discharge Prevention Contingency Plans (ODPCPs), Spill Prevention, Control, and Countermeasure (SPCC) Plans, and Facility Response Plans (FRPs) to prevent and respond to fuel and hazardous spills at the Pebble Project. Because of the overlap between the different regulations that govern ODPCP, SPCC, and FRP plans, the Applicant may consider combining the plans into one larger plan that encompasses all the requirements. Such considerations would take place on completion of detailed project regulatory and compliance planning review. Other required plans, such as Stormwater Pollution Prevention Plans, also have roles in spill prevention. As applicable, the plans would describe:

- Spill prevention actions, including inspection and maintenance programs; training programs and requirements; secondary containment; substance abuse policies; medical monitoring; analysis of potential spill volumes and conditions increasing the risk of discharge; and description of discharge detection systems for above-ground storage tanks and piping.
- Spill response actions, including spill notification, safety and communications procedures; spill response resource deployment and cleanup strategies; procedures to stop a discharge; fire prevention; discharge tracking; identification of environmentally sensitive areas for priority protection sites; and wildlife protections plans.

The Applicant has committed to the following:

- Provide annual training for fuel and hazardous material-handling personnel in equipment operation and maintenance to prevent discharges; discharge procedures protocols; applicable pollution control laws, rules, and regulations; general facility operations; and the contents of applicable spill response plans.
- Establish an Incident Management System (IMS) to respond to emergency situations, including large spills.
- Require emergency response personnel to participate in regular emergency response and spill drill exercises.
- Contract the services of an Oil Spill Removal Organization (OSRO) that could provide resources to contain, control, and clean up spills. Pebble Limited Partnership (PLP) is currently a member of Alaska Chadux, an OSRO with headquarters in Anchorage, Alaska. Chadux currently maintains 17 equipment response hubs throughout Alaska, including locations at Anchorage, Dillingham, Homer, King Cove, and Nikiski.
- Establish additional spill response equipment storage hubs at the mine site, north and south ferry terminals, and the port site to ensure a timely response and minimize environmental impacts from a spill.

- Ensure spill response supplies are on hand at fuel and hazardous substances storage sites, and during any transfer or handling of fuel or hazardous substances. The quantity and type of supplies would be sufficient and appropriate to respond to the most probable spill volume.
- Ensure that spill response supplies at the port include kits for wildlife hazing, bird capture, otter captures, and otter pens.
- Require that containment booms be available at the ferry terminals, the port, and on vessels, consistent with 33 Code of Federal Regulations (CFR) Part 154.1045.
- Conduct regular inventories and maintenance of spill equipment at each location to ensure its response readiness.

4.27.3.2 Spill Prevention Measures

The Applicant has committed to the following:

- Provide secondary containment for the storage of fuel and hazardous substances, sized as appropriate to the container type and according to governing regulatory requirements in 18 Alaska Administrative Code (AAC) 75 and 40 CFR Part 112. Containers with an aggregate storage capacity greater than 55 gallons that contain fuel or hazardous substances would not be stored within 100 feet of a waterbody or within 1,500 feet of a current surface drinking water source.
- Install secondary containment consisting of a bermed and dual-lined area designed to meet regulatory requirements for bulk storage fuel tanks at the mine site, the port site, and the south ferry terminal. Sump and truck pump-out facilities would be installed to handle any spills.
- During equipment storage or maintenance, protect the site from leaking or dripping fuel and hazardous substances by placing drip pans or other surface liners designed to catch and contain fluids under the equipment, or by creating an area for storage or maintenance using an impermeable liner or other suitable containment mechanism.
- During fuel or hazardous substance transfer, place a secondary containment or a surface liner under all containers or vehicle fuel tank inlet and outlet points, hose connections, and hose ends.
- Prohibit vehicle refueling in the annual floodplain, except as addressed and approved in relevant spill plans. This measure does not apply to water-borne vessels.
- Label all fuel and hazardous substance containers to clearly identify their contents.
- Develop a program for and conduct integrity testing, and routinely inspect above-ground bulk storage containers with a capacity of 55 gallons or more and their associated piping.
- Implement a drug and alcohol abuse prevention program for employees and contractors involved in all phases of the project, including personnel handling fuel and hazardous materials.
- Require all fuel barges to be double-hulled and have multiple isolated compartments to reduce the risk of a spill.
- Prepare written procedures for fuel transfer between vessels and facilities to ensure that all fuel transfer equipment and procedures specified in 18 AAC 75.025 and 33 CFR Parts 155 and 156 are followed, including:
    - Require vessels to be securely moored.

  - Ensure that the transfer connector (e.g., hose, loading arm, or transfer piping) would be long enough to allow the vessel to move to the limits of its mooring without placing strain on the transfer connector.
  - Ensure that the end of each hose not connected to the transfer would be blanked off using closure devices.
  - Ensure that each overboard discharge or sea suction valve that is connected to the vessel's transfer or cargo tank system would be sealed or lashed in the closed position.
  - Ensure that the sequence of transfer operations, transfer rate, and procedures to ensure the transfer pressure does not exceed the maximum allowable working pressure for each of the equipment components is communicated and acknowledged. The volume/quantity to be transferred would be verified and agreed on by the responsible person on each vessel/facility, including the system of measurement (e.g., gallons).
  - Confirm that the prevailing weather conditions (sea state, ice, and winds) would not prevent the deployment of spill containment booms and oil recovery vessels from carrying out an effective response in the event of a spill. If pre-booming is not possible, alternative options are to delay the transfer until pre-booming is possible, or to transfer at a rate below 500 gallons per minute (gpm).
  - Ensure that required secondary containments (33 CFR Parts 154.530 and 155.310) would be in place and periodically drained to provide required capacity.
- Place containment booms around vessels engaged in fuel or oil transfer operations greater than 10,500 gallons (250 barrels) or during high-flow fuel transfer, typically greater than 500 gpm. The vessel would be surrounded by an oil-spill containment boom during the entire transfer operation to help minimize any adverse effects from a fuel spill. The transfer of smaller quantities of fuel would be exempt from pre-booming, but would be required to have booming material in the immediate vicinity of the fuel transfer operations.
- Equip fuel dispensing lines with automatic shutoff devices.
- Operate a special International Standards Organization (ISO)-approved tank for the overland and ferry transport of fuel. The frames of ISO-approved tanks are equipped with corner castings, allowing them to be loaded and locked into place on trailers or on vessel decks in the same manner as standard shipping containers. The stainless-steel construction is resistant to corrosion, and the outer frame provides strength to allow the tanks to be safely transported when full, as well as offering impact protection. The ISO tanks would be top-loading and unloading, and the valves would be fitted with a blanking plate during transport to prevent accidental opening.
- Store or park ISO-approved tanks or other hazardous materials in designated areas.
- Ship hazardous materials in original, approved containers that are appropriate for transport, and transport the materials in closed shipping containers, with appropriate placarding as required by US Department of Transportation (USDOT) regulations.
- Equip trucks with spill kits containing plugs, trenching tools, and sorbent materials that can be used to stop fuel leaks and limit damage to the environment.
- Equip the vehicle fleet, including fuel transport trucks, with real-time GPS location communication devices and verbal in-cab driver coaching alerts for speed exceedances to ensure safe driving practices. This system would also allow rapid identification of the precise location in the event of an incident.

- Manage truck driver fatigue by capping the number of hours per day and week drivers work and by mandating break times. Drivers would be instructed to take a break when necessary if they feel fatigued.
- Prohibit the use of distraction devices, such as mobile phones and electronic devices, when operating equipment, vehicles, and vessels.
- Establish environmental factor and weather condition parameters that would require a temporary halt to road traffic on a section(s) or entire access corridor, or vessel operations, during potentially dangerous conditions (e.g., limited visibility due to snow or fog, icy road conditions, wildlife presence).
- Implement a communication system that includes road hazard signage, safety briefings, and vehicle-to-vehicle communication to alert vehicle operators of potential road hazards,.

4.27.3.3 Spill Response Measures

The Applicant has committed to the following:

- In the event of a spill of fuel or hazardous material, personnel and contractors would follow established notification procedures, and take prompt action to control, contain, and clean up spills commensurate with the volume of the spill, type of material, and receiving environment, as defined in applicable spill response plans.
- Releases of a hazardous substance or oil would be reported to the State of Alaska Department of Environmental Conservation (ADEC) and/or US Coast Guard, consistent with mandated regulatory requirements.
- Satellite tracking and monitoring of trucks on the road to enable rapid identification of the precise location in the event of an incident.
    - Computerized load/container tracking from the consolidation facility to the mine site would allow for rapid identification of possible contaminants in the event of an incident.
- Project personnel would immediately contain and control the spill and seek approval of cleanup and disposal plans to be used for the release. After obtaining approval of clean up and disposal plans, the Applicant would perform a cleanup of the discharge or release and disposal plans per the approved plan.
    - Appropriately trained staff would be on site for all shifts to respond to incidents.
    - Pre-positioned response equipment would be at all major project facilities to allow for rapid response to incidents.

4.27.4 Diesel Spills

ULSD (or diesel) fuel is a refined petroleum product that has been the US Environmental Protection Agency (EPA)-mandated industry-standard diesel fuel since 2010. ULSD is a relatively light, thin oil with low viscosity that readily evaporates into the atmosphere, disperses quickly in water compared to heavier oils, and is naturally degraded by microbes. It can be toxic to organisms, but has only a moderate concentration of soluble compounds (NOAA 2018i). Diesel is used globally and transported regularly over land and water without incident. Minor diesel spills occur frequently in Alaska and globally and are difficult to contain. Impacts of historic diesel spills have ranged from negligible to severe.

The Pebble Project would use approximately 16 million gallons of diesel annually to operate mine site vehicles, haul trucks, and the ferry; as well as for use in explosives (combined with ammonium nitrate), and other miscellaneous mining needs. Diesel fuel would be delivered to the port by double-hulled fuel barges with approximately 4 million gallons of diesel distributed across 12 to 14 compartments, with an estimated 300,000 gallons of diesel held in each compartment. Four barge-loads of diesel would be required annually, each requiring approximately 3 days to unload, with fuel barges in port for approximately 12 days each year (PLP 2018-RFI 060).

At the port, diesel would be pumped from the barge holding tanks into four 1.25-million-gallon tanks for storage at the port (Owl Ridge 2018b), and also into 6,350-gallon stainless-steel ISO-approved tanks for transport to the ferry terminals and the mine site (PLP 2018d). ADEC oversees storage tank compliance. Diesel storage tanks at the port would be in dual-lined and bermed secondary containment, sized as appropriate to the container type, and according to governing regulatory requirements in 18 AAC 75 and 40 CFR Part 112. Storage tanks would not be within 100 feet of a waterbody or within 1,500 feet of a current surface drinking water source. Fuel dispensing lines would have automatic shutoff devices, and spill response supplies would be stored and maintained on site wherever fuel would be dispensed. Sump and truck pump-out facilities would be installed to handle any spills (PLP 2019-RFI 126).

Individual ISO tanks would be enclosed in a steel outer frame with the same dimensions as a 20-foot shipping container. The ISO tanks inside the frames would be loaded onto trailers to be transported by fuel haul trucks to Iliamna Lake for the ferry crossing. Trucks would haul three trailers per trip, with one 6,350-gallon ISO tank per trailer, for a total of 19,050 gallons of diesel per haul-truck trip. Haul trucks would average two to three round trips per day, for an approximate total of 840 haul-truck trips annually (PLP 2018-RFI 060).

Alternative 1a and Alternative 1 would use the ice-breaking ferry for one round trip across Iliamna Lake per day to haul diesel and other mining supplies on the north-bound trip, and to haul ore concentrates on the south-bound trip. Each north-bound ferry trip would carry diesel fuel from two or three haul-truck loads (three trailers per load), for a total of between 38,100 and 57,150 gallons of diesel crossing Iliamna Lake each day (PLP 2018-RFI 060). The ferry crossing is approximately 28 miles long for Alternative 1a. The ferry crossing is 18 miles long for Alternative 1. The Alternative 1 crossing would be expected to take 1.5 hours in open water, and 3 hours during ice conditions, while Alternative 1a route would likely take longer. Under the Alternative 1 Summer-Only Ferry Operations Variant, additional storage of fuel would be needed at the mine site and the port site.

The use, containment, and transport of diesel by PLP would be in accordance with ADEC regulations and would follow approved ODPCPs and FRPs. Spill response supplies would be maintained at the mine site, ferry terminals, fuel storage sites, and on vessels and fuel tanker trucks; and crews would be trained in spill response. See Chapter 5, Mitigation, and below for a summary of design features to reduce the risk of diesel spills and spill response information (also see the “Spill Preparedness, Prevention, and Response Measures” subsection). The tanker truck and marine tug-barge spill scenarios provide more details on spill response.

4.27.4.1 Fate and Behavior of Spilled Diesel

This section describes the general fate and behavior of spilled diesel for a wide range of hypothetical releases. Specific impacts from the selected release scenarios are presented below.

When diesel is released into the environment, it naturally begins to degrade through a variety of weathering processes. Some components of diesel may persist in the environment after most components have weathered. Toxic components of diesel can also be entrained in turbulent water such as stream riffles, river rapids, or tidal areas.

Diesel is lighter than water, and when released into a marine or aquatic environment, it floats on the water surface, spreading out to leave a thin film, or sheen. Diesel cannot sink to the bottom of a waterbody and accumulate as free oil (NOAA 2019d). Floating diesel quickly disperses, especially under the influence of strong waves, wind, tides, and currents. Wave action can also emulsify, or break up, the diesel into small droplets that stay suspended in the water column (NOAA 2018i, 2019d).

Diesel is moderately volatile, and readily evaporates into the atmosphere. After a few days floating on marine water, about two-thirds of the volume of a small diesel spill (less than 5,000 gallons) is lost to the atmosphere, even in cold water (NOAA 2018i, 2019d). A Cook Inlet Maritime Risk Assessment (Glosten 2012) was conducted to determine the potential risk from oil spills in the greater Cook Inlet area. The spill rate projections as presented in Glosten (2012) are based on incidents and vessel traffic from the greater Cook Inlet Region and are not specific to the area of the Amakdedori/Diamond Point ports or to the anticipated level of vessel traffic from the project. The risk assessment, however, is the most relevant, site-specific data available for oil spill risk assessment for marine operations of the project. Glosten (2012) predicts that after 24 hours, 16 percent of a spilled diesel volume would evaporate at 1 degree Celsius (°C; project area winter temperature range), while 34 percent would evaporate at 15°C (project area summer temperature range; Glosten 2012 Technical Appendix C). This equates to approximately half the spilled diesel evaporating after a few days during the winter, and the majority of the spilled diesel evaporating after a few days in the summer. Evaporation rates would vary with the volume of the spill and with the temperature, with evaporation rates lower during freezing and below-freezing conditions.

Diesel can adsorb, or adhere, to particles (e.g., silt) suspended in the water column. Over time, some of these particles may eventually settle to the bottom of the waterbody, so that small amounts of diesel can accumulate in the substrate beneath a waterbody.

Dissolution is not a dominant weathering process for diesel, although some constituents of diesel would eventually dissolve. When dissolution occurs in an isolated body of water where dilution and dispersion are limited, the dissolved constituents would increase the level of water contamination.

Photodegradation, or the breakdown due to light, can be a substantial weathering process on sunny days. Diesel can become more soluble after photodegradation, increasing the toxic impacts.

For spills in marine waters, evaporation and dispersion are the dominant weathering processes. Most diesel from a small spill (less than 5,000 gallons) would evaporate or naturally disperse within hours to days of a spill, especially in windy conditions; therefore, diesel from such small spills is generally not recoverable (NOAA 2018i, 2019d). For a large diesel spill on the order of 300,000 gallons in cold water with no recovery efforts, a conservative estimate suggests that the fuel would be fully evaporated and dispersed after a maximum of 10 to 20 days (AECOM 2019a; SL Ross et al. 2003). A site-specific oil spill trajectory analyzing a 300,000-gallon spill during winter conditions estimates that 67 percent of the diesel would evaporate or disperse within 4 days; during spring conditions, 89 percent would evaporate or disperse within 4 days (Owl Ridge 2018c).

Diesel washed onto a beach or spilled on land can “oil” the land by leaving an oily sheen on the surface. Wave action on a beach may help to flush the diesel off of the wet sediments (NOAA 2018i). Diesel that pools up on land can penetrate porous soil and sediments and become trapped in sediment pore spaces. Naturally occurring microbes present in the soil can degrade diesel oil from a small spill on land within 1 or 2 months (NOAA 2018i), although this rate would vary locally depending on the presence of microbes and would be a slower process in cold climates.

Diesel that percolates down into soils and sediments can potentially reach shallow aquifers. The diesel would float on top of the groundwater surface (water table) and contaminate the groundwater. Travel times for diesel to reach shallow aquifers are variable and could be on the order of months to years. For minor spills, microbial activity would likely degrade the diesel prior to it reaching groundwater.

Note that impacts from diesel cannot be compared directly to those of heavier fuels, such as the crude oil that was released in Alaska's 1989 *Exxon Valdez* oil spill. Crude oil and heavy distillates can persist for months to years if not recovered, whereas diesel is naturally flushed and biodegraded much more readily.

Diesel fuel is extremely flammable and can pose a serious fire hazard if not contained.

Fate and behavior of a diesel spill can also be influenced by water salinity, air and water temperatures, and weather and season conditions. During ice-free conditions, spilled diesel can readily permeate soil and sediments, and be transported by moving water. During frozen conditions, diesel is more likely to pool up on frozen ground and frozen waterbody surfaces. Diesel can permeate into frozen materials to a limited depth. Snow may slow the spread of spilled diesel on land.

4.27.4.2 Historical Data on Diesel Spills

Spill Frequency and Volume

More than 15,000 diesel spills have been reported across Alaska since 1995. The vast majority are minor spills of 1 to 10 gallons. There are also infrequent (less than 1 per year) truck rollovers that release more than 3,000 gallons; and rare marine vessel incidents, which have released more than 300,000 gallons. Smaller spills have a higher probability/frequency of occurrence, while larger spills are less probable/frequent.

Diesel currently accounts for more than half the volume of all spills in Alaska. Common causes of diesel spills include mechanical failure, human error (especially overfill of tanks), and vessel or trucking accidents. From 2003 to 2018, 165 diesel spills in Alaska were considered to have the potential to significantly impact human health, public safety, or the environment, warranting a spill response effort from the ADEC (ADEC 2018d).

Tanker Trucks

Nationwide data on oil spills from various sources show that small and very small spills are quite common, while high-volume spills are rare. The probability of oil spills from vehicles is high, but the volumes of such spills are generally low (Etkin 2006). Low-volume, high-probability spills of hydrocarbons and other toxins are addressed in Section 4.14, Soils; and Section 4.18, Water and Sediment Quality.

Due to the remote nature of the mine and port access roads, and Alaska's challenging weather and road conditions, Alaska-specific historical data are considered most relevant. The transport of diesel by tanker trucks along the Dalton Highway in Northern Alaska can be considered as an analog to diesel transport on PLP's road corridor. The Dalton Highway is a 414-mile-long public road between Livengood and Deadhorse, Alaska, used primarily for hauling industrial supplies to oil exploration and production facilities on the North Slope. The highway is a rough, narrow, two-lane, gravel and paved road (BLM 2018), and is maintained by the Alaska Department of Transportation & Public Facilities (ADOT&PF). Conditions on the Dalton Highway can be challenging, especially under extreme winter weather conditions, with icy roads, high winds, low visibility from blowing snow, and other large trucks present on the road. Diesel is currently hauled in ISO-compliant fuel tanks of approximately 10,000-gallon capacity by trucks with single trailers.

ADEC reported 22 trucking-related diesel spills (averaging one per year) on the Dalton Highway, including at least seven truck rollovers, between 1995 and 2017 (ADEC 2018h). Spill volumes ranged from 1 gallon to 3,000 gallons, with an average spill volume of 400 gallons. Most diesel spills on the Dalton Highway report successful cleanup operations, with most of the spill volume recovered (ADEC 2018h).

Colville Transport, LLC is currently the primary fuel delivery company transporting diesel on the Dalton Highway. Colville trucks about 15 to 20 million gallons of diesel up the highway every year, requiring up to 2,000 trips per year (Colville 2018; Simton 2018). Between 2011 and 2017, Colville reported two trucking-related diesel spills on the Dalton Highway: a spill of 100 gallons, and a truck rollover that released 2,800 gallons (ADEC 2018h). This equates to about 105 million gallons transported over 7 years; and 14,000 trips, totaling over 5.7 million miles of transport, releasing 2,900 gallons.

Due to challenging road conditions on the Dalton Highway, ADOT&PF restricts cargo to set weight limits; for a fuel truck, the maximum weight that can be hauled is a single trailer with 10,000 gallons. Double trailers are used elsewhere in Alaska, while triple trailers are rare. The ADEC spills database does not provide information on the number of trailers involved in trucking-related spills. PLP would haul diesel tanks on three separate trailers, which may increase spill risk compared to single or double trailers. Triple trailer loads are uncommon in Alaska; therefore, incident data are not available. Incident rates for the triple trailer loads may not be directly comparable to incident rates for trucks hauling single or double trailers.

Marine Tanker Vessels

Data from the US Department of Interior Bureau of Ocean Energy Management (BOEM) for Oil-Spill Occurrence Rates for Oil-Spill Risk Analysis (OSRA; BOEM 2016) support the general well-established trend that minor diesel spills from marine vessels are a common occurrence around the world, while high-volume releases are rare. Alaska-specific data from the ADEC show that this trend is also true in Alaskan waters. State data also show that spills from State-regulated facilities, which include marine tank vessels, occur much less frequently than spills from unregulated facilities, such as fishing boats (ADEC 2018h).

Globally, the rate of oil spills from marine barges has decreased in recent years (Owl Ridge 2018b), possibly due to the increased use of double-hulled barges. Double-hulled barges transport fuel in segregated compartments in a secondary inner hull, providing an extra layer of protection from any potential damage to the outer hull. This reduces the likelihood of spills from groundings or collisions (USACE 2018d). One study on global rates of shipping-related oil spills showed that out of 105 accidents involving single-hulled fuel barges/tankers, 14 spills resulted, releasing more than 70 million gallons; while out of 53 accidents involving double-hulled barges/tankers, four spills resulted, releasing 115,000 gallons (DeCola 2009, as cited in Owl Ridge 2018b). PLP has committed to transporting diesel in double-hulled barges.

In Alaska, between 2003 and 2018, the ADEC responded to five diesel spills from barges that had the potential to significantly impact human health, public safety, or the environment. Of these five spills, the volumes for four of them were small/unknown quantities, while one barge grounding released approximately 6,000 gallons of diesel (ADEC 2018h). Between January 1995 and July 2013 (the most recent year available when the study was completed), no oil spills greater than 10,000 gallons occurred from barges in Alaska (ERM 2017; ADEC 2018h).

Studies of oil spill risk from tank barges, specifically in Cook Inlet, show that the overall risk of any oil release is very small (Nuka and Pearson 2015). In addition, a recent project-specific study on maritime oil spill risk assessment (Owl Ridge 2018c) found that the overall risk of a significant marine oil spill in Lower Cook Inlet is low, and that the highest risk is from allision (i.e., collision with a stationary object) and errors during transfer operations.

Data suggest that a diesel spill from a marine tug-barge would be small or very small, but there is a slight possibility that a high-volume spill could occur (AECOM 2019a). Based on the most recent data from BOEM for Oil-Spill Occurrence Rates for OSRA (BOEM 2016), the probability of a spill of between 42,000 and 420,000 gallons is 2.5×10^{-4} per year, or a 0.025 percent chance of occurring in any given year. This equates to an average recurrence rate of 4,000 years, or a probability of occurrence of 0.50 percent in 20 years, or 1.9 percent in 78 years (AECOM 2019a). These probability data are based on the Cook Inlet area north of the project area, and are not specific to Kamishak Bay. The probability of large oil spills on the approach to Amakdedori and Diamond Point ports may be different than for the broader Cook Inlet region. Both Amakdedori and Diamond Point ports have nearby rocky shoal outcrops that could pose a hazard to ships (see Section 3.15, Geohazards and Seismic Conditions). The Diamond Point port site generally has thicker sea ice in higher concentrations for longer periods than the Amakdedori port site (see Section 3.16, Surface Water Hydrology).

Ferries

The spill rates discussed above for marine barges appear consistent with the available historic data for lake ferries operating in arctic or sub-arctic conditions, which appear to indicate zero spill rates over the period of record.

Ice-breaking vessels are used in northern Canada to supply mining operations and transport ore concentrate. Three examples were provided by PLP. The 32,000-tonne icebreaking bulk carrier Umiak 1 transports concentrate 1,100 nautical miles from a mine in northern Labrador to Quebec City, navigating through ice up to 5 feet thick and making 12 trips per year (PLP 2018-RFI 052). The similar ice-breaking bulk carrier MV Arctic has supported mines in the High Arctic since 1978. No incidents associated with either of these two vessels are logged in the Transportation Safety Board of Canada database (TSB Canada 2018). The Nunavik is a similar ice-breaking bulk carrier that transports fuel, supplies, and ore concentrate in northern Quebec. It sustained damages from a collision with another bulk carrier in 2016. No injuries or pollution releases were reported (TSB Canada 2018).

The ice-breaking ferry M/V *Williston Transporter*, which operates in British Columbia, Canada, is considered the best analog to the project ferry. The 360-foot-long vessel provides transportation for logging and mining operations around Williston Lake. The ferry has operated year-round since 1995 without “loss of cargo or release of pollution” (PLP 2018-RFI 052). See the Transportation Spill Scenario Probabilities Memo (AECOM 2019a) for statistical analysis on the probabilities of diesel spills from ferries.

4.27.4.3 Existing Response Capacity

PLP would maintain oil spill response and recovery equipment at the mine site, the ferry terminals, and the port site, including booms, sorbents, pumps and hoses, recovery and disposal containers, and personal protective equipment (PPE) for personnel. A skiff and personal flotation devices would also be maintained at the ferry landings and the port. Marine tugs, diesel haul trucks, and the ferry would also be equipped with spill response kits. Operators would be trained in spill reporting and procedures to minimize and contain low-volume spills (PLP-RFI 060).

Spill response supplies would be on hand at fuel and hazardous substances storage sites, and during any transfer or handling of fuel or hazardous substances. The quantity and type of supplies would be sufficient and appropriate to respond to the most probable spill volume. Spill response supplies at Amakdedori port would include kits for wildlife hazing, bird capture, otter captures, and otter pens. Containment booms would be available at the ferry terminals, Amakdedori port, and on vessels, consistent with 33 CFR Part 154.1045. Regular inventories and maintenance of spill equipment would be conducted at each location to ensure its response readiness (PLP-RFI 126).

ADEC establishes response procedures in its Alaska Responders manual (PLP 2018-RFI 060). Tactics include deployment of booms, berms, dikes, dams, use of sorbent, digging of pits and trenches, and pumping of spilled diesel. Recovery procedures cover on-land, marine, and shoreside environments.

In the event of a large spill that requires additional recovery efforts, PLP would contact Alaska Chadux, an OSRO that provides experienced response personnel and oil recovery/cleanup equipment such as pumps, absorbent pads, sweeps, booms, land bladders, towable bladders, tanks, skimmers, rope mops, drums, harbor and shore seal booms, and response vessels, as required. Chadux personnel and supplies would be mobilized from one or more of their hubs closest to the impacted area, including Nikiski, Homer, Kodiak, and/or Anchorage. Chadux may also maintain some response equipment at the project site (PLP 2018-RFI 060).

In addition, ADEC maintains pre-positioned equipment depots across the state, including a container of supplies in Iliamna that would be available at cost to responsible parties (ADEC 2018i).

See also the "Spill Preparedness, Prevention, and Response Measures" subsection.

4.27.4.4 Mitigation/Avoidance and Minimization

Design Features of ISO Diesel Storage and Transfer Tanks

- ISO tanks are the industry standard for transporting both hazardous and non-hazardous liquids in bulk, and are built to withstand extreme pressure and damage.
- The cylinder-shaped tanks are constructed of stainless-steel to resist corrosion, and are housed in a steel outer frame that provides strength and impact protection during transport.
- Tank valves would be fitted with a blanking plate during transport to prevent accidental opening (PLP 2018-RFI 060).
- Each tank is designed with three separate closures; all three closures would have to fail for the tanks to leak (PLP 2018-RFI 060).
- The outer frames of the ISO tanks would be equipped with corner castings that allow them to be loaded and locked into place on the haul truck trailers and the ferry deck like a standard shipping container.
- Secondary containment would be provided for all diesel storage (at tank farms, etc.) and transfer operations.
- Inspection and maintenance programs.
- Discharge detection systems would be employed for above-ground storage tanks and piping.
- Emergency response personnel would be required to participate in regular emergency response and spill drill exercises.

- Spill response supplies would be on hand at fuel and hazardous substances storage sites and during any transfer or handling of fuel or hazardous substances.
- Additional spill response equipment would be kept at storage hubs at the mine site, the north and south ferry terminals, and Amakdedori port (PLP 2019-RFI 126).

Design Features of Marine Tug-Barges

- Marine vessels used to deliver fuel to Amakdedori port would be Alaska Class ice-rated articulated tug-barges similar to the 483-foot, 100,000-barrel articulated tug-barges currently under construction for Crowley Marine.
- All tug-barges used to deliver fuel would be double-hulled, which are designed to reduce the likelihood of diesel spills from vessel collision or grounding.
- The barges would have at least 12 to 14 water-tight compartments, with an estimated capacity of approximately 300,000 gallons each (PLP 2018-RFI 060). If one or more compartments were to flood, the vessels are designed to maintain buoyancy and stability.
- Marine radar would be used to avoid other vessels and accurately approach the dock (Owl Ridge 2018b).

Design Features of Iliamna Lake Ferry

Incidents with the ferry could include collision, sinking, loss of power or steering capabilities, grounding, fires, and flooding of engine rooms or other compartments. Such vessel incidents are generally attributable to human error more often than mechanical failures or adverse weather conditions. PLP would employ experienced crews, and crews would receive ongoing training. The ferry would be designed with state–of-the-art navigation and propulsion systems, with four azimuthing thrusters, and have the ability to operate in 100-mile-per-hour (mph) winds, with safe station-keeping at winds up to 150 mph (PLP 2018-RFI 052). Additional vessel safety features that would mitigate the potential for incidents are as follows:

- One-inch-thick heavy steel shell (required for ice breaking) would result in very low potential for damage to the ferry from grounding or a collision.
- Fuel tanks would be located away from the shell of the vessel so that the tanks would not be impacted in the event of a collision.
- Multiple watertight compartments would reduce the chance of sinking. If any one of the compartments was to flood, the vessel is designed to remain afloat, stable, and operational.
- The ferry would have two fully independent engine rooms so that if one engine room was to flood or suffer damage, the ferry would lose half its power, but the remaining engine room would supply sufficient power to keep all four propellers fully functional.
- Fire detection and fire-fighting systems, including an automatic sprinkler system in the crew accommodation spaces.
- The engine control room would have a backup operating station (in the event that the wheelhouse is not operational).
- Remote monitoring and/or remote control capabilities would be available, as needed, from a remote operations center.
- Stowage plan would be designed to ensure no movement of cargo at a list (tilt) of 8 degrees (e.g., in the extreme case of loss of one of the engine rooms) (PLP 2018-RFI 052).

- Corner castings on the outer frames of the ISO tanks would enable the tanks to be loaded and locked into place on the ferry vessel deck like a standard shipping container (PLP 2018-RFI 060).
- The sides of the ferry would contain upset conditions (PLP 2018-RFI 065).
- ISO tanks would also be required to be stored in secondary containment on the ferry.
- The vessel would be designed specifically for operations in ice (PLP 2018-RFI 052). An icing prevention plan would be considered a standard best management practice (BMP) to be employed by the Applicant.
- Additional mitigation identified during the EIS process includes a coastal and ocean engineering analysis for both Iliamna Lake and the port, which would help ensure that project vessels are fit-for-purpose. Likelihood of implementation of this mitigation measure is considered probable.

See Chapter 5, Mitigation, for complete design/safety specifications.

4.27.4.5 Diesel Spill Scenarios

Diesel spills from a tanker truck rollover and a marine tug-barge allision were analyzed for potential impacts. Large diesel spills from the Iliamna Lake ferry and a tank farm were ruled out as not realistic probabilities of occurrence, so were not selected for impacts analysis, and are addressed briefly below.

Overfilling of tanks resulting in a release of diesel outside of secondary containment is a relatively high probability scenario that is not analyzed in this EIS. Potential impacts from such a scenario would likely be similar to, but on a smaller scale than, those described below for a diesel spill from a tanker truck rollover. Diesel spills from handy-size vessels would likely have smaller volume but higher probability than spills from marine tug-barges. Analysis of the larger-volume marine tug-barge spill was selected here to address a larger magnitude of potential impacts.

Scenario: Diesel Spill from Tanker Truck Rollover

This scenario addresses the probability and consequences of a release of 3,000 gallons of diesel into the environment due to a tanker truck rollover at a location along the mine and port access roads. No studies have been identified that analyze fuel spill rates on private, controlled-access industrial roads, such as the mine and port access roads (ARCADIS 2013). The probability of this scenario is therefore based on available historic spill data for diesel transport along the Dalton Highway (as discussed above); the most relevant fuel transport analog in Alaska. Note that diesel transport on the Dalton Highway is mostly hauled in double-trailer ISO-compliant tanks, not ISO tanks mounted on triple trailers, as intended by the Applicant. Triple-trailer setups may be at a higher risk of upset than single or double trailers. Spill risk may also vary between transport in ISO tanks versus tanker trucks. The spill volume of 3,000 gallons represents the largest diesel spill volume reported on the Dalton Highway between 1995 and 2017.

Based on interpretation of the available Dalton Highway data, the potential annual spill rate for a 3,000-gallon spill was calculated to be 2.0×10^{-7} spills per truck mile traveled, or 0.011 spill per year over 66 miles of road transport (55,433 truck miles traveled per year). (Note that miles of road transport varies by alternative from 53 to 82 miles [Table 4.27-1]. The original calculation used for the Alternative 1 road corridor was 66 miles.) This equates to a probability of a 3,000-gallon spill of 1 percent in any given year; 20 percent in 20 years; 55 percent in 78 years; or an average of one 3,000-gallon spill every 90 years (AECOM 2019a). Although these estimates are based on limited historical data, the calculated spill rate of 2.0×10^{-7} per truck mile is essentially identical to the $1.9x10^{-7}$ rate identified in a separate analysis by the EPA Watershed Assessment (EPA 2014).

As noted above and as outlined in AECOM 2019a, the probability of lower-volume spills is higher than the probability of higher volume spills. A 3,000-gallon spill from a tanker truck rollover represents the largest diesel spill volume reported on the Dalton Highway between 1995 and 2017, and therefore represents the range of higher-volume, lower-probability spills of this type. This scenario was selected to address a wider range of potential impacts than a smaller-volume spill. Smaller diesel spills from truck accidents may occur more frequently.

In this scenario, a tanker truck hauling three trailers, each loaded with a full 6,350-gallon ISO tank of diesel, is headed north when the truck veers off the road, resulting in a rollover. The vehicle would be equipped with a real-time GPS location device, which would allow rapid identification of the precise location of the incident (PLP 2019-RFI 126).

One of the ISO tank outer frames is crushed and punctures one of the ISO tanks, causing a steady release of diesel. Some released diesel would begin to evaporate immediately. Depending on the seasons/weather conditions, some of the diesel would begin to slowly percolate into the soil; some would pool up on the ground and bury low-lying vegetation; and some would flow downslope. Less than half the volume contained in the punctured tank is released in this scenario, for a total release of 3,000 gallons of ULSD.

There are numerous stream crossings along the road corridors for all alternatives. If this scenario were to occur at a stream crossing, diesel could directly enter surface water and be rapidly transported downstream. There is a variety of small ponds along the transportation corridor (especially the port access road) that would serve as natural containment, slowing the spread of diesel. Depending on the location of the spill, small amounts of diesel could reach Iliamna Lake and float on the surface as a sheen.

If the release were to occur in winter, the diesel would pool up on the frozen ground and would be less likely to permeate into the soil. Diesel could flow downgradient onto the surface of frozen waterbodies and would pool up, likely not being carried downstream where streams are frozen. In areas where ice is inconsistent, thin, or fractured, diesel could enter partially frozen waterbodies or flowing water. Diesel trapped under ice would complicate recovery efforts and could reduce/delay evaporation of volatile components of the diesel.

Spill Response

See the “Spill Preparedness, Prevention, and Response Measures” subsection for the actions that the Applicant has committed to. Alaska regulations 18 AAC 75.432(a)(1) and 18 AAC 75.432(2) outline the requirements for responding to a spill that enters open water, including containing or controlling the spill within 72 hours, and cleaning up the spill within the shortest possible time to minimize damage to the environment. Alaska State regulation 18 AAC 75.425 outlines requirements for an ODPCP.

PLP would have an ODPCP plan (or a more comprehensive plan that covers all requirements) in place that would detail the measures to prevent, respond, contain, report, and clean up diesel spills (PLP 2019-RFI 126). Drivers would be trained in spill reporting and procedures to minimize and contain low-volume spills, and the driver would be able to conduct an initial response and call for assistance immediately. Tanker trucks would be equipped with spill response kits, which the driver would be able to deploy to help contain and slow the spread of diesel. Adverse weather conditions could challenge early response procedures. Frozen conditions could challenge some aspects of the response.

Additional spill response supplies would be maintained at the mine site and both ferry terminals (PLP 2018-RFI 060). PLP employees would likely be able to respond to the spill site with additional supplies within 1 to 3 hours, depending on the location of the spill, weather conditions, etc. Relatively effective containment of the 3,000-gallon spill could likely be completed the same day. Spilled fuel would be recovered with sump and truck pump-out systems and/or sorbents, and the bulk of the spilled volume would be pumped into spill response containers. Soil with residual diesel contamination may need to be excavated and removed off site for remediation.

Response efforts could be focused on sensitive areas, such as wetlands or anadromous fish streams, as needed.

Alternatives Analysis

The potential for a diesel spill due to tanker truck rollover could vary slightly by alternative; road corridor lengths and road conditions, such as grade, would vary between alternatives. Alternative 1a would include 72 miles of road transport to haul diesel; Alternative 1 would include 65 miles of total road transport; Alternative 2—North Road and Ferry with Downstream Dams would include 53 miles of road transport; and Alternative 3 would include 82 miles of total road transport. The road corridors for Alternative 2 and Alternative 3 would be expected to have more road segments with higher grade, based on more steep topography in the southern and eastern portions of the road corridor, which could increase the potential for truck accidents and potential spills. Final road design, including grades, has not yet been determined. Alternative 3 would not involve any transport by ferry, so there would be no potential for diesel spills from the ferry into Iliamna Lake under Alternative 3.

Potential Impacts of a Diesel Spill from Tanker Truck Rollover

This section addresses potential impacts of a diesel spill from the tanker truck rollover scenario described above. Impacts are considered in terms of their magnitude, duration, geographic extent, and potential to occur. A diesel spill on the road corridor would not necessarily impact all the resources addressed in this EIS. The following resources were selected for analysis due to the higher potential significance of the impacts.

Soils

A spill of 3,000 gallons of diesel along the road corridor could have direct impacts on soil quality. Under non-frozen conditions, diesel may penetrate and be held within porous soils, so that soil would be contaminated with hydrocarbon levels that would exceed regulatory limits. During frozen conditions, diesel would pool up on the frozen ground, and could potentially permeate the soil to a limited depth.

The magnitude of soil contamination in this scenario would depend on the location of the spill, the permeability of the soils at the site, the season, and the speed and effectiveness of the spill response. The extent of the impacts would be limited to soils near the spill site that are directly in contact with spilled diesel.

Containment and recovery of spilled diesel would reduce the impact to soils. If diesel is recovered promptly and does not permeate the soil, impacts to soils could be negligible. Residual diesel that is not recovered from soil surfaces would likely evaporate or biodegrade from microbial activity.

Contaminated soils could be excavated and removed for off-site remediation if necessary. Potential soil erosion during excavation and remediation could be avoided by use of BMPs. Impacted areas could be recontoured and revegetated, which could take multiple seasons due to the climate. The duration of impacts could therefore last until soils have been fully recovered, likely within 2 to 4 years.

Water and Sediment Quality

Surface Water—A 3,000-gallon spill of diesel along the road corridor has the potential for a direct impact on surface water quality. All road alternatives have a high number of stream crossings, so that a truck rollover has a reasonable probability of occurring at or near a stream. Diesel spilled near a stream or other waterbody could flow downslope and enter surface water. Spilled diesel would float on the surface of the waterbody, and the high concentration of hydrocarbons would greatly exceed applicable water quality criteria (WQC) in the upper portions of the water column. Toxic components of diesel could also be entrained in turbulent water such as stream riffles and river rapids. Some toxic components of diesel could persist in the environment after most diesel has weathered or evaporated.

The magnitude of the contamination would depend on the location of the spill in terms of proximity to waterbodies, the topography at the site, the season, and the speed and effectiveness of the spill response. If the spill were to occur away from surface water, and cleanup and recovery are successful, there could be no impacts to surface water quality.

The extent of surface water contamination would vary depending on the type of waterbody impacted and the season. A spill that reaches an isolated waterbody such as a lake or pond would not be likely to spread farther, but the diesel could concentrate into a thicker sheen in these environments. This natural containment could facilitate recovery of spilled diesel. If diesel enters a flowing stream, however, the fuel could be carried tens of miles downstream before evaporating and dispersing. Stream volumes and velocities would also influence the spread of diesel. Diesel spilled into streams that feed Iliamna Lake could produce a floating sheen on the lake surface. During frozen conditions, spilled diesel would likely pool up on the surface of frozen waterbodies, and would be less likely to spread out, likely increasing the rate of recovery.

The duration of the contamination would last until hydrocarbon levels of impacted waters returned to below threshold levels specified by applicable WQC (15 micrograms per liter [µg/L]; ADEC 2018a). This time period would vary, depending on the waterbodies involved, the season, and the effectiveness of spill response. Evaporation would remove up to half of the spilled diesel from all types of waterbodies within a few days; and more quickly in summer. Dispersion and emulsification would be dominant weathering processes in streams, but not in lakes or ponds. Recovery of spilled diesel would likely be effective in lakes and ponds and on frozen surfaces, but not in flowing streams. The duration of impacts would likely be a few days to a few weeks.

Sediments—If the spill of diesel were to occur some distance from a waterbody, there would likely be no impacts to waterbody sediments.

If the spilled diesel were to reach a waterbody, sediments in the waterbody could be susceptible to hydrocarbon contamination from adsorption of diesel. Sediment that is contaminated would be diluted by surrounding clean sediment and may or may not exceed sediment quality guidelines (SQG). The extent of contamination would include any waterbodies impacted by diesel.

Diesel that becomes trapped within sedimentary particles would be biodegraded by naturally occurring microbes over a time period of months to years (NOAA 2018i). If a high volume of diesel is adsorbed onto sediment, the diesel trapped within sedimentary particles could persist for years. Diesel trapped in sediments could also re-contaminate overlying surface water at a later time, although the contamination may or may not exceed SQG because of dilution.

Groundwater—In this scenario, assuming the anticipated spill response, spilled diesel would likely be recovered prior to impacting groundwater resources.

Under non-frozen conditions, spilled diesel that is not recovered could penetrate through porous soils into shallow groundwater aquifers, directly impacting groundwater quality. The road corridors north of Iliamna Lake contain abundant shallow aquifers. Diesel that reaches shallow aquifers would float on the upper surface of the water table (the phreatic surface), so that the concentrations of diesel-range organics in groundwater could exceed the 1.5-milligram-per-liter (mg/L) groundwater cleanup level (ADEC at 18 AAC 75).

The magnitude of the contamination would depend on the volume of diesel that reaches the aquifers, which would be influenced by factors such as soil type, viscosity, and temperature of the diesel; and weather conditions.

Most aquifers in the project area are discrete and discontinuous, but some aquifers are more extensive. Diesel spills in most locales would be unlikely to spread long distances underground. Groundwater contamination would be localized to areas near the spill site, but some contamination could extend to a larger area.

During frozen conditions, diesel would be less likely to penetrate soils, and would likely pool up on the surface. However, some diesel could reach groundwater resources, even in the winter.

Noise

Noise could be generated from spill recovery operations, including increased vehicle traffic, and use of cleanup equipment. If the increased vehicular traffic would be less than double the amount of existing traffic, then the noise level increase would be less than a 3-decibel (dBA) increase over existing traffic noise levels (generally less than noticeable). Noise from cleanup equipment would depend on the type of equipment used. However, equipment such as pumps, tractors, heavy-haul trucks, and Vac-trucks would have a maximum noise level of approximately 85 dBA or less at 50 feet (Federal Highway Administration [FHWA] Roadway Construction Noise Model), and would be limited to the cleanup area for the duration of the cleanup and recovery effort.

Air Quality

Volatile organic compounds (VOCs), hazardous air pollutants (HAPs) and greenhouse gas (GHG) pollutants resulting from a spill would be high in the immediate vicinity of the spill area, but would decrease quickly due to the dispersion of the spill itself, and dispersion of pollutants by the winds, waves, and currents. Ambient concentrations eventually return to pre-spill conditions within a relatively short period of time (BOEM 2012).

In situ burning, a potential component of spill response strategy, would generate products of combustion (carbon monoxide, oxides of nitrogen, sulfur dioxide, particulate matter [PM], and black smoke). Ambient air quality would return to pre-burn conditions relatively quickly (BOEM 2012).

The magnitude and potential of the impacts would depend on the amount of diesel fuel that evaporates, disperses, or burns. With greater amounts of fuel that evaporates or burns, the impacts would be more likely and larger in magnitude. Concentrations of criteria pollutants could temporarily exceed the National Ambient Air Quality Standards (NAAQS) concentrations; but over time, the air quality would return to pre-spill conditions. The duration of air quality impacts would be temporary, and return to pre-activity levels at the completion of the activity. The extent of impacts would be limited to discrete portions in the project area where the spill took place.

Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

Across all alternatives, less than 10 percent of the road corridor passes through wetlands or waterbodies, while the remainder is uplands. This analysis describes the impacts if the spill were to occur in wetlands or waterbodies. A spill into a pond, lake, or stream would impact surface waters, as discussed above for Water and Sediment Quality. A spill of diesel into wetland soils could cause high plant mortality (NOAA 2019d). A spill into vegetated wetlands would primarily affect scrub-shrub and emergent vegetation, because these wetland types represent over 99 percent of the vegetated wetlands in the transportation corridor. Diesel has been shown to have high acute toxicity to marsh plants and associated communities (Michel and Rutherford 2013). Diesel can also impact other components of wetland ecosystems, such as aquatic and terrestrial invertebrates and soil microorganisms. Individual species can express greater or lesser sensitivity to exposure, but this information is not known for species in the project area. It is possible that evergreen trees and shrubs like Labrador tea would be less sensitive to diesel due to their waxy coatings.

The magnitude of impact is directly related to the extent of oiling of plant surfaces. Large spills resulting in heavy oiling of wetland vegetation and soils would likely cause extensive plant mortality through both direct physical damage to contacted tissues and translocation of toxic components to the root systems. In such cases, regeneration of wetland vegetation would depend on propagules from off site, and restoration of the wetland may take several years. Where oiling of vegetation is not complete or does not extend into root systems or soils, little plant mortality would be expected, and impacted vegetation may recover within one or two growing seasons.

In addition to the size of the spill, the hydrologic status of the wetland and the timing of the spill both influence the extent of wetland damage from diesel spills. Spills into inundated wetlands or saturated soils are less likely to result in complete vegetation mortality, because the diesel would remain on the surface and be dispersed or evaporated (Michel and Rutherford 2013). Biodegradation of diesel by soil microorganisms can deplete oxygen and micronutrient levels around plant roots, potentially resulting in plant mortality. Spills that occur when vegetation is dormant are also not as likely to result in vegetation mortality.

Terrestrial Wildlife

Potential impacts of the spill scenario on terrestrial wildlife would vary depending on the species, time of year, and location of the spill. It is important to note that most studies on impacts to wildlife from oil spills referenced in this section are related to spills of heavier oil (such as crude oil) and are not specific to lighter oils such as ULSD. Heavier oils and diesel both contain polycyclic aromatic hydrocarbons (PAHs), which are harmful to wildlife; are some of the last components of oil to degrade; and can persist in the environment for years (Burns et al. 2014). Some of the direct impacts of oil spills on wildlife may include temporary physical harm to wildlife, trauma such as skin irritation, altered immune system, reproductive or developmental damage, liver disease, chronic effects such as cancer, and direct mortality (Ober 2010). Wildlife come into contact with oil (including ULSD) through three primary pathways: ingestion (via swallowing of oil or consuming oiled prey items); absorption (direct skin contact); and inhalation (breathing in of volatile organics). Less-direct impacts may include relocation of home ranges as wildlife search for new food sources, increased time spent foraging, and disruption of natural lifecycles (Ober 2010). These impacts vary depending on the amount of time oil persists in the environment, location of the spill, natural dispersal activity (via wave action), photodegradation, weathering processes, including microbial activity, and effectiveness of cleanup efforts. Impacts on wildlife can be both acute (occur at the time of the spill), and chronic (occur later in time or over the long-term). Generally, acute impacts occur over a short duration (hours to days), while wildlife is directly exposed to ULSD through inhalation, ingestion, and adsorption of PAHs and other compounds in the ULSD prior to it degrading. Acute impacts generally affect wildlife that is in the immediate vicinity of the spill, or enters an area affected by a spill prior to it being cleaned up or naturally degraded. Chronic impacts are more likely to occur after the acute impacts have passed, and can make the duration of a spill last longer. Further discussion of acute versus chronic impacts on wildlife from oil spills is included under the marine tug-barge allision scenario.

Overall impacts from a diesel spill on terrestrial wildlife under the 3,000-gallon scenario are anticipated to be at a lower magnitude than a heavy oil spill, and have a short duration (several months to a few years), because diesel rapidly evaporates, disperses, and is broken down by soil microbes. Impacts are anticipated to be localized to the immediate area of the spill, but this would vary depending on the time of year (summer versus winter conditions), specific location of the spill (upland versus wetland habitat), and effectiveness of spill response and cleanup activities.

If a terrestrial spill occurs in upland vegetated environments, impacts are anticipated to be of low magnitude, short duration (several months to a few years), and small geographic extent limited to the area immediately around the spill. The spill is anticipated to be cleaned up quickly, with most of the diesel evaporating or seeping into the soil before being removed. Impacts to terrestrial wildlife would be limited, because most species would avoid the area during the spill and cleanup activities. Small mammal species (e.g., mice, voles, lemmings, shrews, ground squirrels) and wood frogs may not be able to immediately vacate the area during the spill, especially if they are underground at the time of the spill. There is the potential for acute toxicity over a brief time span before the diesel evaporates, dissipates, or is broken down by natural weathering processes. Acute toxicity is anticipated to occur only to small mammal species and wood frogs that live in the immediate vicinity of the spill, or come in direct contact with the diesel before it evaporates. Small mammals and wood frogs have a potential to become coated in diesel, and ingest vegetation coated in diesel. Impacts are anticipated to remain localized in the immediate area of the spill. Acute impacts would last a few days to months (depending on temperature and time of year) until the diesel has evaporated and been broken down by soil microbes. No long-term impacts are anticipated.

Larger terrestrial mammals such as bears (*Ursus* species), moose (*Alces alces*), and caribou (*Rangifer tarandus*) are unlikely to be impacted by a terrestrial diesel spill because it is unlikely they would be in the immediate vicinity during the spill, and are likely to vacate the area during active spill cleanup. Vegetation in the localized area of the spill may have the portion along the ground coated in diesel; but due to evaporation, little vegetation that may be consumed by large mammals would be impacted. Cleanup activities would involve removal of contaminated soils and vegetation. Soil microbes would further degrade any diesel in the soil, and rain or snow events would flush the diesel off vegetation. For terrestrial mammals that might be exposed, the number of individuals is expected to be small.

If a spill occurs adjacent to a lake, stream, marsh, or other waterbody during summer months, impacts are more likely to extend quickly beyond the immediate spill site as diesel disperses rapidly across water (or is carried downstream). Species such as moose, beaver (*Castor canadensis*), and river otters (*Lontra canadensis*), which forage in wetlands, are the most likely terrestrial mammals to be impacted. Both beavers and river otters may experience toxic impacts of ULSD coating their fur via ingestion during self-grooming. There is also the potential for hypothermia if their fur becomes oiled. Species in the immediate vicinity may experience acute toxicity, especially if freshwater vegetation becomes covered in diesel. This is likely in the immediate vicinity of the spill. Impacts are anticipated to be localized, and vary depending on time of year and the efficiency of spill response activities. Terrestrial wildlife other than river otters and beavers are anticipated to vacate the area during the spill and cleanup activities. In addition, spill response equipment would be kept at the mine site, both ferry terminals, and port to enable rapid response to a spill anywhere along the transportation corridor.

If a spill enters a waterbody occupied by wood frogs, depending on the time of year, there could be acute toxicity to eggs, tadpoles, and adults. If ULSD becomes entrained in vegetation and sediment, there could be repeated exposure to ULSD until it is either cleaned up or degraded to the point where it is no longer toxic. If wood frog eggs, tadpoles, or adults suffer mortality, there could be localized impacts to the population in the affected area. Wood frogs from adjacent unaffected areas are anticipated to recolonize waterbodies that are affected by a ULSD spill.

Spills that occur during winter months may be less likely to impact wildlife species, because frozen substrates may limit the spread of diesel and permit more efficient spill cleanup. During partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), diesel may be trapped beneath ice, potentially prolonging cleanup and duration of impacts. Impacts would be localized to the immediate vicinity of the spill. Spills that occur adjacent to frozen waterbodies are anticipated to have a low to negligible impact, because ULSD is easier to contain and clean up on frozen surfaces.

Because this spill scenario does not include transport on Iliamna Lake, no impacts to harbor seals that live in Iliamna Lake are anticipated, apart from impacts to foraging habitat in river mouths that empty into Iliamna Lake. If a diesel spill were to occur near a waterbody that empties into Iliamna Lake, there is a potential for harbor seals to be exposed to oily water and temporarily disturbed while cleanup activities occur; however, the seals are anticipated to avoid the area (or be hazed) while cleanup is occurring.

Birds

It is important to note that most studies on impacts to birds from oil spills are related to spills of heavier oil (such as crude oil) and are not specific to lighter oils such as ULSD. Although both oil types contain some of the same compounds, they react differently when spilled into the environment and have different persistence rates. A ULSD spill may affect a small number of birds in the immediate vicinity of the accident, and small areas of adjacent habitat. Sources of injury or mortality may include oiling of body feathers, inhalation of toxic volatile compounds (especially for birds with impaired mobility such as molting birds and nestlings), potential mortality from ingestion while preening, hypothermia from oiled feathers, and consumption of oiled food (vegetation, fish, insects, etc.). The intensity of a spill would vary depending on the time of year and habitat where it occurs. If a spill occurs during the spring and fall, migratory birds are more likely to be impacted. If the spill occurs during the summer, then resident breeding species (and their nests and young) have a potential to be impacted. A spill during the winter is likely to have the lowest impact, because most avian species have vacated the area, and only a few resident species remain year-round. In addition, a diesel spill in upland vegetation would have a lower geographic extent compared to a spill in a marsh or waterbody. If diesel disperses to a nearby stream, the effects could spread further and affect aquatic birds, such as spotted sandpiper (*Actitis macularius*), American dipper (*Cinclus mexicanus*), mergansers (*Mergus* species), and other waterbird species, if present. Response efforts, including increased human activity, could disturb birds, causing them to temporarily avoid the area. If birds are nesting in roadside vegetation that becomes oiled, nests and/or eggs and young may be impacted. Species known to occur in the area that nest close to or on the ground include spruce grouse (*Falcipennis canadensis*), ptarmigan species (*Lagopus* species), fox sparrow (*Passerella iliaca*), common redpoll (*Acanthis flammea*), and dark-eyed junco (*Junco hyemalis*), among others. Because the area affected would be small, the number of birds likely to ingest diesel or contaminated food would be small. A spill in or adjacent to marsh habitat may impact breeding birds such as species of yellowlegs (*Tringa* species), solitary sandpipers (*Tringa solitaria*), rusty blackbirds (*Euphagus carolinus*), swans (*Cygnus* species), ducks (*Anas* species), geese (*Branta* species), phalaropes (*Phalaropus* species), and species that feed on fish and freshwater invertebrates such as loons (*Gavia* species), grebes (*Podicpes* species), and belted kingfishers (*Megaceryle alcyon*).

The most severe impacts would occur to birds that are not able to leave the area immediately, such as juveniles from nearby nests and molting (temporarily flightless) birds. Birds that nest in marshy/freshwater habitats are more likely to be impacted than species that nest in upland habitats. Residual contamination that enters the food chain could affect raptors such as bald (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*), osprey (*Pandion haliaetus*), and northern harriers (*Circus hudsonius*) that may eat contaminated fish or small mammals. In summary, a diesel spill from a tanker truck rollover is anticipated to have a small, localized impact on a discrete geographic area (while it is cleaned up and dispersed), with a low magnitude and short duration (a few months to several years), depending on the amount of time to clean up and/or allow the diesel to fully decompose, and any vegetation/habitat to return to pre-impacted conditions.

Alternative 2 and Alternative 3—Diamond Point Port

Potential impacts to birds would be similar regardless of the specific port location under Alternatives 2 and 3. Therefore, impacts are discussed collectively herein. If a tanker truck rollover occurred along the Alternative 2 and Alternative 3 transportation corridor in the short segment along the shore with Iliamna Bay, there is a potential for marine birds to be oiled. Marine birds that could be impacted include black oystercatchers, harlequin ducks, goldeneyes, common mergansers, scoters, long-tailed ducks, and other species that feed along the rocky shoreline where the transportation corridor abuts Cook Inlet waters. Any birds in the immediate vicinity of the spill have a potential for inhalation and ingestion toxicity while preening. There is also a potential for secondary exposure by feeding on contaminated bivalves or other invertebrates. If a spill were to occur along the shoreline of Iliamna Bay, the impact would be localized, and cleaned up fairly quickly due to the close proximity of the port and spill response equipment. If the spill occurred at low tide, the spill may be able to be contained faster, limiting spread. However, if the spill occurred at higher tides, then some adjacent water may become oiled. Wave action and tidal fluctuation have a potential to expose birds to oil that is not cleaned up and entrained in porous substrates, such as unconsolidated material and sand or mud. Given the relatively low volume of spilled ULSD in the scenario, individual birds may suffer injury or mortality, but the overall magnitude would be low. The duration could range from several months to a few years, depending upon the number and type of species impacted.

Fish

As discussed above, floating diesel tends to evaporate over time from mixing with the stream currents, wind, and wave action; with no or very little visible sheen remaining within 3 days (NOAA 2006). Toxic components of diesel could also be entrained in turbulent water such as stream riffles and river rapids. Some toxic components of diesel could persist in the environment after most diesel has weathered or evaporated. The extent and duration of impacts to fish would be short-term, and expected to be limited to the waters in the vicinity of the spill, because the volume and concentration on the surface would attenuate downstream. Most adult and juvenile fish exposed to a diesel spill are mobile, and generally capable of limiting exposures until concentrations attenuate. Depending on the location, a spill occurring between mid-May and June could have impacts on out-migrating juvenile salmon species. These fish could experience acute toxicity, particularly in shallow water, stream margins, and off-channel habitats, where low stream currents could accumulate fuel. Impacts to these fish and invertebrates could include potential mortality, depending on the concentration and exposure time.

Threatened and Endangered Species

There are no federally listed TES that occur in the terrestrial portion of the project. Any spills that occur on land are anticipated to be dissipated, degraded, or contained prior to reaching the marine environment of Cook Inlet, where TES occur. The only instance where a terrestrial-based tanker truck rollover could impact the marine environment would be if a truck rolls over along the port access road for Alternative 2 and Alternative 3 at Diamond Point. The transportation corridor along the edge of Iliamna Bay is short, but immediately adjacent to marine waters. Therefore, a spill would have to occur along this road segment for it to enter the marine environment, which is highly unlikely given the short distance and slow speeds vehicles would be traveling as they leave the port. If a spill were to occur and not be contained prior to reaching the marine environment, some diesel may impact TES such as Cook Inlet beluga whale (rare in the area), northern sea otters (common in the area), Steller sea lions (occasional and uncommon in the area), and Steller's eiders (present from fall to spring). These species may experience inhalation and or ingestion toxicity (through preening for eiders or cleaning oiled fur for sea otters), or consume prey, such as bivalves that have consumed ULSD. Depending on the tidal stage and extent of the spill, various substrates may entrain oil resides. Mud flats and unconsolidated materials that are porous have a potential to trap oil; species may then become exposed again during high tides or storm events. Spills that occur in close proximity to the port have a higher potential to be contained and cleaned up relatively quickly due to the close proximity of spill response equipment. However, tides and wave action would likely disperse some of the diesel. Although there is a potential for a small amount of ULSD to reach the marine environment, impacts are likely to be short-term (several months to a few years) and restricted to the immediate vicinity of the spill. Any ULSD that spreads beyond Iliamna Bay would be highly dispersed, and would evaporate and degrade quickly. Additional details of impacts from ULSD in the marine environment are provided below under the marine tug-barge allision scenario.

Marine Mammals

A diesel spill that occurs on the Alternative 1a or Alternative 1 road corridor would not reach the marine environment of Cook Inlet and would have no impact on marine mammals in Cook Inlet. However, if a spill occurred in waters that flow into Iliamna Lake, there is a potential for harbor seals to be impacted. There is a potential for inhalation, ingestion, or dermal absorption of ULSD or consumption of contaminated prey. The magnitude would vary depending upon time of year, specific location in the lake and if harbor seals are present. If ULSD were to enter Iliamna Lake impacts are likely to be short-term (several months to a few years) and likely disperse downstream with continual flushing of the lake from stream inputs. In addition, the ULSD would continue to evaporate and degrade through natural weathering processes. The magnitude of potential impacts would likely be low due to the dispersed nature of the ULSD and may impact a few harbor seals if they are in the vicinity at the time of a spill.

Alternative 2 and Alternative 3—Diamond Point Port—If a diesel spill occurred along the Alternative 2 and Alternative 3 transportation corridor along the port access road at Diamond Point and some ULSD reached the marine waters of Cook Inlet in Iliamna Bay, some marine species may be impacted. Similar to impacts detailed above for TES, harbor seals, porpoises, whales, and other marine mammals that are in the immediate vicinity of the spill have the potential to be impacted by inhalation, ingestion, and consumption of oiled prey. Although there is the potential for a small amount of ULSD to reach the marine environment, impacts are likely to be short-term (several months to a few years), restricted to the immediate vicinity of the spill, and impact a few individuals present during the spill. Any ULSD that spreads beyond Iliamna Bay would be highly dispersed and would evaporate and degrade quickly. Additional details of impacts from ULSD in the marine environment are provided below under the marine tug-barge allision scenario.

Needs and Welfare of the People–Socioeconomics

It is unlikely that cleanup and remediation activities following a tanker truck release would result in increased employment opportunities in the region. Cleanup crews would be small, and likely consist of PLP personnel.

Commercial and Recreational Fishing

In the event of petroleum spills, Alaska Department of Fish & Game (ADF&G) has the power to close commercial fisheries through the Emergency Order process, as it did in July 2018 with the sinking of the Fishing Vessel Pacific Knight. The 3,000-gallon tanker spill scenario would not affect commercial fishing in the immediate term unless the spill occurred during the fishing season, and reached fishing grounds in visible concentrations. In the longer term, a spill could result in an extremely limited reduction in harvest value if the spill killed juvenile salmon or eggs that might have been future adult returners. Roughly 1 in 1,000 eggs turns into a returning adult salmon; and historically, the commercial fishery has harvested nearly 70 percent of returning adult sockeye. Therefore, roughly 1 in every 1,400 to 1,500 eggs is harvested as an adult by the commercial fishery; and over the last 20 years, the 10-year average ex-vessel value per harvested sockeye has ranged from $4.75 to $7.62 in 2019 US dollars.

Recreational fishing opportunities and effort could be affected in the near-term if the spill occurred during the open-water fishing season, and if anglers choose to avoid areas with visible ULSD concentrations. However, the stream receiving the spill would not likely comprise the majority of its watershed, and the clean portions of the watershed may continue to provide recreational fishing opportunities. Nearby unimpacted waterbodies may provide alternative recreational use sites. Large-scale mortality events are not expected, and the potential for longer-term impacts is extremely low.

Cultural Resources

Direct impacts to cultural resources from a potential spill resulting from a tanker truck rollover and release of 3,000 gallons of diesel to the surrounding environment would directly impact cultural resources or known or potential historic properties if such a release would occur within the bounds of a cultural resource area or historic property site. These impacts could include contamination of organic cultural materials and site sediments. Such an event would likely result in direct impacts through loss of integrity for eligibility to the National Register of Historic Places (National Register) from cleanup activities. These impacts would likely severely damage the site, and resources would not be anticipated to return to previous levels even after actions that caused the impacts were to cease. Indirect impacts could occur to the character or setting (visual, noise, and olfactory impacts) of cultural resources if the spill were to occur in the vicinity. These impacts are particularly acute where setting and feeling are crucial aspects of a cultural resource's importance. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Those impacts would be temporary and would cease when response efforts are completed.

Subsistence

A diesel spill resulting from a tanker truck rollover could have impacts on subsistence. Animals and subsistence users may temporarily avoid the area of the spill. The effects would be localized and temporary because fuel would evaporate, and be cleaned up. If soil excavation and/or site remediation are required, impacts to subsistence plants could last multiple seasons at the spill site. Quick response and cleanup of the spill, as well as clear and timely communication with nearby communities, would help ease concerns about contamination for subsistence users in nearby communities.

Health and Safety

A release of diesel could cause stress to community members in close proximity from real or perceived risks of contamination, and potentially impact human health. Spills create anxiety about the safety of subsistence foods and water quality. Quick response and containment of spills (particularly for spills in water), and a system of testing wild foods and drinking water for contaminants to give local people complete and understandable information in a timely manner, could help alleviate some anxiety and reduce potential impacts to human health. There would be potential adverse impacts to social determinants of health (Health Effects Criteria [HEC] 1), with psychosocial stress resulting from community anxiety over a tanker truck release. A tanker truck release may involve a surface transportation accident or injury, but would not likely create increased risks for transportation-related injury or accident (HEC 2). The duration of impacts would be short-term (1 to 12 months). There could be potential diesel or diesel fume exposure (HEC 3), and impacts to subsistence resources and food security (HEC 4).

Scenario: Diesel Spill from Marine Tug-Barge Allision

This scenario considers the probability and consequences of a 300,000-gallon spill of diesel from a marine tug-barge hauling diesel through Lower Cook Inlet into one of the potential ports in Kamishak Bay. The scenario addresses the diesel that would be transported by marine tug-barge each year for use at the mine site. Other oil products (e.g., bunker, lube oil, hydraulic fluid) are used in much smaller volumes by marine vessels and are not being analyzed here.

In this scenario, a barge allision with a rocky shoal results in a rupture of one of the fuel compartments, resulting in the release of 300,000 gallons of diesel into Lower Cook Inlet. There are a number of submarine rocky outcrops (shoals) in Kamishak Bay that pose a danger to passing ships. Ship captains would be aware of these shoals, and would operate vessels accordingly; but foul weather, strong currents, or a loss of power could cause ships to become grounded and damaged by the rocks. The outer hull of the double-hulled barges is designed to protect the fuel compartments from damage, so that the probability of a release from this scenario is very low.

The probability analysis herein is based on the most recent US data on marine oils spills from BOEM for OSRA (BOEM 2016), as well as a project-specific study on maritime oil spill risk assessment (Owl Ridge 2018c). Based on analysis of these data, a 300,000-gallon spill has a 1.5×10^{-4} annual probability of occurrence, or a 0.015 percent chance of occurring in any given year (BOEM 2016; Owl Ridge 2018c; AECOM 2019a). The estimated recurrence interval of such a spill is 6,600 years, with a probability of occurrence of 0.30 percent in 20 years, or 1.2 percent in 78 years (AECOM 2019a). Note that this spill risk is based on data from Cook Inlet, and is not specific to Kamishak Bay. See AECOM 2019a for details on the statistical analysis and review of relevant data.

As previously noted and as outlined in AECOM 2019a, lower-volume spills have a higher probability than higher-volume spills. A 300,000-gallon spill from a marine vessel has a low probability. The larger-volume spill scenario was selected to address a wider range of potential impacts that could occur compared to a smaller-volume spill.

On release of the diesel into Lower Cook Inlet, the diesel would rapidly spread out and float on the surface of the water in a thin film, while strong tides and currents would immediately begin to disperse it. Wave action could cause the diesel to emulsify, breaking it up into small droplets that float in the water column, and are then further dispersed by tides and currents. The spilled diesel would immediately begin to evaporate into the atmosphere. Within hours, the diesel would be widely dispersed over the water surface in the surrounding area. High wind and waves could increase the rate of dispersion. Photo oxidation would further break down the floating diesel over a period of days to weeks (NOAA 2018i). If no recovery efforts were made, the diesel would be expected to naturally evaporate and disperse within 10 to 20 days (AECOM 2019a). During winter conditions, an estimated 67 percent of the diesel would evaporate within 4 days (Owl Ridge 2018c). Evaporation rates would likely be higher during summer months.

A site-specific oil spill trajectory model predicts that the remaining floating diesel would be transported southward out of Kamishak Bay towards Shuyak and Afognak islands, north of Kodiak Island, and/or to Cape Douglas, depending on sea conditions. Much of the remaining diesel would likely evaporate and disperse before beaching on these shorelines. Depending on currents and proximity to the shoreline, remaining diesel could be washed ashore. The oil spill trajectory model predicts that most of the remaining diesel would be beached at Shuyak Island State Park and Kodiak National Wildlife Refuge (Owl Ridge 2018c).

Beached diesel could penetrate shoreline sediments, such as sandy beaches. Wave action would be expected to continue flushing the diesel back out to sea, while the diesel would continue to evaporate and disperse. Some diesel could penetrate into sandy surfaces and contaminate beach sand. Naturally occurring soil microbes would likely consume and decompose the diesel, although in a cold climate, it is unknown how long this process would take to fully consume the diesel. In the event of a near-shore diesel spill with heavy contamination of shoreline sediments, the contaminated sediments could be excavated and removed for off-site mitigation.

Spill Response

See the "Spill Preparedness, Prevention, and Response Measures" subsection for the actions that the Applicant has committed to. Alaska regulations 18 AAC 75.432(a)(1) and 18 AAC 75.432(2) outline the requirements for responding to a spill that enters open water, including containing or controlling the spill within 72 hours, and cleaning up the spill in the shortest possible time to minimize damage to the environment. Alaska State regulation 18 AAC 75.425 outlines requirements for an ODPCP. PLP would have an ODPCP plan (or a more comprehensive plan that covers all requirements) in place that would detail the measures to prevent, respond, contain, report, and clean up diesel spills (PLP 2019-RFI 126).

Diesel spill response would begin immediately with barge personnel. Barges would be equipped with oil spill response kits, and operators would be trained in spill reporting and procedures to minimize and contain low-volume spills. Due to the large size of this hypothetical spill, the operators would contact the Alaska Chadux oil spill response group for assistance. Chadux is able to respond to some spill sites around Alaska within 24 hours, but due to the remote location of Kamishak Bay, response times are unknown. Oil spill response efforts could also be delayed by adverse sea conditions, including storms and/or sea ice.

Response crews would likely deploy booms to contain the spill, pump diesel from the water's surface into secondary storage, and apply sorbents to collect residual fuel, etc. The longer the diesel remains in the water, the more difficult it would become to recover. Even assuming a rapid response within 24 hours, containment and recovery of light fuels such as diesel are extremely difficult, and only a portion of the diesel would likely be recovered. Much of the diesel would naturally evaporate and disperse within hours to days (NOAA 2018i; AECOM 2019a). Dispersants are typically not used for light oils such as diesel. Non-mechanical recovery (i.e., in situ burning off of diesel) could be used in extreme cases, such as to prevent diesel from entering a sensitive area. It may be necessary to clean up the shoreline through contaminated soil removal or other methods for areas with residual diesel.

Response efforts could also include helicopter overflights to observe the dispersal of the diesel, determine the extent of possible shoreline oiling, and determine if any marine mammals, birds, or other vulnerable species are present and at risk of oiling.

Alternatives Analysis

The potential for a marine tug-barge allision could vary somewhat by alternative. Alternative 1a and Alternative 1 would include the Amakdedori port location, while Alternatives 2 and 3 would use the Diamond Point port. Both Amakdedori and Diamond Point port have nearby rocky shoal outcrops (Section 3.15, Geohazards and Seismic Conditions). The Diamond Point port site generally has thicker sea ice in higher concentrations for longer periods than the Amakdedori port site (Section 3.16, Surface Water Hydrology). The variation in dock design between alternatives would not be anticipated to modify the potential for a marine tug-barge allision.

The protected nearshore waters around Diamond Point port have biological resources that are generally more abundant and concentrated compared to the Amakdedori port location, including several nearby seabird colonies. See the "Alternative 2 and Alternative 3—Diamond Point Port" subsection for impacts analyses specific to the Diamond Point port under wildlife, marine mammals, birds, fish, and threatened and endangered species.

Potential Impacts of a Diesel Spill from Marine Tug-Barge Allision

This section addresses potential impacts of a diesel spill from the marine tug-barge allision scenario described above. Impacts are considered in terms of their magnitude, duration, geographic extent, and potential to occur. A marine diesel spill would not impact all the resources addressed in this EIS. The following resources were selected for analysis due to the higher potential significance of the impacts.

Soils

Shoreline sediment contamination could occur where diesel washes onshore, but the contamination would likely be short-term. Any diesel washed onshore would be continually flushed by wave action, and unlikely to accumulate on soils (NOAA 2018i). If, however, a large volume of the spilled diesel were to be washed onshore, there is a potential for direct hydrocarbon contamination of soils. Impacts would be similar to those addressed above for the tanker truck scenario, with a greater or lesser magnitude, depending on how much diesel reaches land. The extent and duration of impacts would also vary, depending on the volume of diesel that comes in contact with soils.

Water and Sediment Quality

Marine Environment—A 300,000-gallon spill of diesel into Lower Cook Inlet would cause high-magnitude direct impacts to marine water quality from hydrocarbon contamination. The high concentration of hydrocarbons from the floating diesel would greatly exceed applicable WQC in the upper portions of the water column. Toxic components of diesel could also be entrained in turbulent water such as tidal areas. Some toxic components of diesel could persist in the environment after most diesel has weathered or evaporated. The extent of impacts would include the upper portions of the water column for potentially miles of open ocean, because the floating diesel would spread out immediately on release, and be distributed farther by currents, waves, and tides. Under the Fuel Oil Spill Trajectory Modeling Report for the Pebble Project (SLR 2018), a 300,000-gallon spill in Kamishak Bay directly south of Augustine Island would spread to the south, and reach the northern shores of Shuyak and Afognak islands and/or Cape Douglas, depending on sea conditions, within 4 to 5 days. Emulsification of the diesel could allow droplets of diesel to spread down through the water column, impacting water quality somewhat deeper beneath the surface. Cleanup efforts could reduce the geographic extent of the contamination by containing and recovering some of the spilled diesel.

The duration of the contamination would last until hydrocarbon levels of impacted waters returned to below threshold levels specified by applicable WQC (15 µg/L; ADEC 2018a). The persistence of the diesel would vary with weather and sea conditions. The ULSD would naturally evaporate and disperse after approximately 10 to 20 days (AECOM 2019a; SL Ross et al. 2003). Cleanup efforts would likely reduce the duration of the contamination by containing and recovering some of the spilled diesel. The duration of impacts would probably be on the order of 2 to 3 weeks or less before spill recovery efforts and natural weathering processes removed the spilled diesel.

Due to the presence of suspended sediment in Cook Inlet, a small volume of diesel could adsorb onto suspended sediment (mostly silt), and could eventually settle onto the seafloor. Although the extent could cover multiple square miles of seafloor and the duration could last for years, the magnitude of seafloor sediment contamination would likely not exceed SQGs due to dilution.

On-Shore Environment—A marine spill of diesel is unlikely to cause exceedance of water quality criteria for onshore surface water or groundwater. Diesel that is able to wash onshore would be continually flushed by wave action and diluted by uncontaminated seawater (NOAA 2018i). Variations in beach substrate would alter the ability of waves to flush diesel from the shoreline. If, however, a large portion of the spilled diesel were to be washed onshore, there is a potential to contaminate coastal waterbodies and shallow aquifers with elevated hydrocarbon levels. Some diesel could be trapped in shoreline sediments, including locally abundant tidal mudflats, possibly facilitated by burrows of various benthic invertebrates. Diesel trapped in shoreline sediments may be re-entrained in seawater before it fully degrades.

Diesel could potentially be washed onshore into a coastal pond, and stranded. Diesel emulsions and dissolved hydrocarbons could potentially infiltrate permeable beach deposits into shallow, unconfined aquifers and impact groundwater quality (Kuan et al. 2012). Impacts would be similar to those addressed above for the tanker truck rollover scenario.

Noise

Noise could be generated from spill recovery operations, including increased vehicle and/or helicopter traffic, and use of recovery equipment (such as pumps). However, the time over which additional noise would be generated would be limited to the time required for the recovery effort (limited duration); localized in the area of recovery operations; and with low increase in sound levels.

Air Quality

VOCs, HAPs, and GHG pollutants resulting from a spill would be high in the immediate vicinity of the spill, but would decrease quickly due to the dispersion of the spill itself, and dispersion of pollutants by the winds, waves, and currents. Ambient concentrations eventually return to pre-spill conditions in a relatively short period of time (BOEM 2012).

In situ burning, a potential component of spill response strategy, would generate products of combustion (carbon monoxide, oxides of nitrogen, sulfur dioxide, PM, and black smoke). Ambient air quality would return to pre-burn conditions relatively quickly (BOEM 2012).

The magnitude and potential of the impacts would depend on the amount of diesel fuel that evaporates, disperses, or burns. With greater amounts of fuel that evaporates or burns, the impacts would be more likely, and larger in magnitude. Concentrations of criteria pollutants could temporarily exceed the NAAQS concentrations; however, over time, the air quality would return to pre-spill conditions. The duration of air quality impacts would be temporary, and return to pre-activity levels at the completion of the activity. The extent of impacts would mostly be limited to near the spill location in Kamishak Bay.

Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

A marine spill of diesel is unlikely to have impacts on wetlands and special aquatic sites that would require remedial action. Any diesel washed onshore would be continually flushed by wave action, and would be unlikely to accumulate on shoreline vegetation (NOAA 2018i). If, however, a large volume of the spilled diesel were to accumulate, there is a potential for direct oiling of vegetation and contamination of sediments. This would most likely affect estuarine waters and mudflats in nearby protected bays. Effects on sediments are described above for Water and Sediment Quality. A large amount of diesel that penetrates wetland soils could cause high plant mortality (NOAA 2019d). Vegetated tidal wetlands, such as salt marshes, are very scarce in the project vicinity. Impacts to these wetlands would be similar to those addressed above for the tanker truck scenario, with a greater or lesser magnitude, depending on how much diesel reaches shore.

Terrestrial Wildlife

Impacts from a 300,000-gallon spill of diesel into Lower Cook Inlet are anticipated to have minor impacts on terrestrial wildlife. Most terrestrial species do not use the marine-terrestrial interface extensively, although some large mammals, such as brown bears (*Ursus arctos*) and other mammal species (such as river otters), may occasionally forage along exposed tidal flats in Kamishak Bay. In Kamishak Bay, there is a small area of razor clam (*Siliqua* species) beds at the mouth of Amakdedori Creek (GeoEngineers 2018), but the rest of Kamishak Bay does not support extensive razor clam beds (NOAA 2002), and therefore it is not a major clamming area for bears. There are exposed tidal flats in Kamishak Bay around Amakdedori port that may be impacted by a diesel spill. The closer to shore that the spill occurs, the more ULSD would end up along the shoreline; however, the further away from Amakdedori port that the spill occurs, the diesel is more likely to drift south in the Douglas River Shoals area, and beyond. The magnitude of the spill remains the same regardless of where the spill occurs; however, the geographic extent of the diesel spill increases the further from shore that the spill occurs. Under the Fuel Oil Spill Trajectory Modeling Report for the Pebble Project (SLR 2018), a 300,000-gallon spill in Kamishak Bay directly south of Augustine Island would spread south; and within 4 to 5 days, mass around the northern shore of Shuyak and Afognak islands. The scenario is similar if it occurs during November to December and March; therefore, the diesel ends up in the same location regardless of the time of year. There is a potential for marine bivalves and other invertebrate filter feeders to ingest diesel that washes onto tidal flats exposed during lower tides. They may experience mortality, depending on the concentration of diesel they ingest. Diesel trapped in shoreline sediments may be re-entrained in seawater before it fully degrades. Invertebrates and other terrestrial wildlife prey species may be consumed by terrestrial mammals foraging along the shore, which may lead to trophic-level transfer of ULSD contaminants. It is assumed that some diesel that comes in contact with the shore would be cleaned up during spill response efforts (although some diesel would likely soak into the ground and be lost), and the length of time required for cleanup would vary depending on the exact location and ability for cleanup crews to reach the affected area.

Overall impacts on terrestrial wildlife are anticipated to be localized, and the duration would vary (several months to a few years) depending on the amount of acute versus chronic impacts. During the chronic phase of the *Exxon Valdez* oil spill (which is not specifically comparable to an ULSD spill, but provides context for acute versus chronic impacts), much of the bioavailable oil was found in intertidal habitats, so wildlife that use those habitats were more likely to be exposed to oil and suffer chronic effects of exposure (Esler et al. 2018). Chronic effects of oil spills on wildlife can occur in several ways, including direct (i.e., lingering oil that has not broken down and occurs in sediments of beaches and other locations that sequester oil), and delayed toxic effects (i.e., immunity suppression, genetic material and organ system damage, and oxidative stress), demographic lags (i.e., delay in population recovery due to reduced reproductive potential, rates of dispersal, population structure), and indirect effects (impacts to prey and food web disruption)(Esler et al. 2018).

Individual terrestrial mammals may also be affected by wildlife protection measures, including hazing and pre-emptive capture and relocation activities designed to prevent animals from encountering the spill area. Capture and handling of wildlife can increase exposure to infectious diseases, and animals exposed to contaminants may have suppressed immune function (USFWS 2015b). Typical spill response actions are expected to be relatively small in scale, with impacts limited to the vicinity of the spill site and would therefore affect a limited number of terrestrial mammals. Impacts could extend until remnant diesel is cleaned up or broken down.

Research on brown bears along the Katmai coast was conducted following the *Exxon Valdez* oil spill to determine if there were population-level impacts (Sellers et al. 1999). Biologists observed brown bears in Katmai National Park feeding on oiled bird carcasses and intertidal invertebrates on oiled beaches (Lewis 1993). One yearling brown bear was found dead, with high concentrations of naphthalene and phenanthrene, and it is believed to have died from ingestion of crude oil (Sellers et al. 1999). Several other bears showed exposure to crude oil. To understand potential population-level effects, the survival and reproductive rates between radio-collared adult female brown bears whose movements indicated possible use of oiled shorelines were compared with bear locations at a different site (at Black Lake further south along the Alaska Peninsula), where there were no oiled beaches. Sellers et al. (1999) did not detected a significant difference in survival or reproductive rates from 1989 to 1991, compared to 1992-1995 (when toxicity and availability of oil from the spill was considered negligible). It was therefore concluded that the *Exxon Valdez* oil spill did not result in measurable impacts on the Katmai brown bear population.

Other species, such as river otters, were also affected, with fewer otters in oiled areas; and they appeared to be less healthy. Some river otters died directly from oil coating or toxic crude oil fumes (Lewis 1993). Based on Esler et al. 2018, river otter populations were impacted by the *Exxon Valdez* oil spill because they spend time in coastal environments feeding on nearshore marine fishes, which placed them in proximity to spilled oil and chronically lingering oil in intertidal beach sediments. River otters from oiled areas showed compromised health during the years immediately after the spill, and their population was considered recovered by 1997 (Esler et al. 2018). Therefore, terrestrial wildlife has a potential to be impacted both directly (through inhalation and coating in ULSD) and indirectly (through consuming oiled prey) with varied impacts depending on the species impacted. As detailed previously, multiple spill response measures would be implemented to the extent feasible if a spill were to occur. A large portion of the ULSD would evaporate, degrade, and dissipate, with impacts on species directly in the footprint of the ULSD spill. Overall impacts on terrestrial wildlife are anticipated to be localized and short-term (several months to a few years), but could extend longer depending on the resuspension of oil from semi-porous substrates such as unconsolidated materials, clay fines, and sands. The geographic extent of impacts would be influenced by tidal flow, and the exact location of the spill and direction it is carried in the current. It is assumed that some diesel that comes in contact with the shore would be cleaned up during spill response efforts (although some diesel would likely soak into the ground and be lost), and the length of time required for cleanup would vary depending on the exact location, and the ability for cleanup crews to reach the affected area.

Alternative 2 and Alternative 3—Diamond Point Port—If this spill were to occur near the Diamond Point port, ULSD could end up in several locations, depending on the time of year, currents, wind patterns, tidal stage, etc. If the spill occurred near the entrance to Iliamna and Iniskin bays, species in the bays and nearshore environments would likely be impacted. If the spill occurred further offshore, the ULSD would likely rapidly dissipate, with some of it adhering to the nearshore environment around Augustine Island. In either case, both marine mammals and marine birds, which are discussed below, would be impacted to a greater degree than terrestrial wildlife. Impacts to terrestrial wildlife (which are detailed above) may occur if species are foraging along the shore or consume oiled prey. In particular, bear surveys around the eastern part of Iliamna Lake to Diamond Point and Iliamna and Iniskin bays between 2004 and 2007 documented high densities of brown bears; particularly along the Iniskin River and the end of Iniskin Bay (ABR 2011c). Large numbers of brown bears were observed in the sedge meadows and mudflats at the heads of Iniskin and Chinitna bays during spring and summer each year, with the highest numbers in June (ABR 2011c). Therefore, there is a potential for bears (and other wildlife) that feed along the shoreline to be exposed to ULSD, depending on the time of year, location of the spill, tidal/wave action, and extent of spill containment and cleanup. Overall impacts are anticipated to be of low magnitude, and may impact a few individuals, with a duration lasting from several months to a few years, depending on how much ULSD is cleaned up and how quickly it is broken down by microbes.

Birds

The assessment of oil spill impacts to migratory birds is based on not only oil type (e.g., lighter diesel versus heavier crude), but a combination of risk factors, such as probability of a spill, spill size, spill duration, weather conditions, and effectiveness of oil spill response (Stehn and Platte 2000). Based on the Cook Inlet Maritime Risk Assessment: Spill Baseline and Accident Casualty Study (Glosten 2012), diesel is not as adhesive to substrates; evaporates more readily; and is considered relatively non-persistent in the environment compared to heavier crude oils. The anticipated persistence time in the environment for diesel can range from 1 month up to 1 year, depending on the concentration and location of the spill. Diesel also may show greater acute toxicity due to evaporation of volatile components, which can be inhaled. The following description of the short- and long-term effects of oil spills on birds is summarized from the US Fish and Wildlife Service (USFWS 2004b), EPA (1999b), and the National Oceanic and Atmospheric Administration ([NOAA] 2020).

Many studies on impacts to birds from large oil spills are related to heavier oil (such as crude oil) spills and are not specific to lighter oils such as ULSD. Although both oil types contain many of the same compounds, they react differently when spilled into the environment and have different persistence rates. Although many of the impact assessments are based on heavy oils, the severity of oil spills to birds relies more heavily on whether birds are present in the spill area and are likely to come in contact with the spilled oil, rather than the oil type.

Diesel can foul bird feathers as severely and readily as crude oil, destroying the insulation and/or buoyancy that feathers provide. Light oils, such as diesel, can also leave a film on intertidal resources, and have the potential to cause long-term contamination (through re-entrainment during storm surges and high tide events). Birds that use the intertidal zone to rest or forage can be exposed to these diesel residues (USFWS 2004b). The presence of diesel in the environment may be of shorter duration than heavy oils, but while diesel remains in the environment, the risk to birds (from physical fouling, acute toxicity, and sublethal toxicity) is probably very similar to that of heavy oil, given the presence of toxic PAHs in both.

Spilled oil (including diesel and heavier crudes) can adversely affect birds from both internal and external exposure (NOAA 2020). Oil harms birds through physical contact, toxicity through ingestion or inhalation, destruction of food sources or habitat, and through long-term reproductive impairment. Physical contact with oil destroys the insulation value of feathers, causing mortality from hypothermia or loss of buoyancy. Heavily oiled birds can lose their ability to fly and their buoyancy; causing drowning. In an effort to clean themselves (preen), birds ingest and inhale oil. Ingestion can kill animals immediately, but more often results in lung, liver, and kidney damage and subsequent death. Birds constantly preening to remove oil, or unable to fly due to the oil, would be more vulnerable to predators. In the long-term, oil ingestion has been shown to suppress the immune system, and cause organ damage, skin irritation and ulceration, damage to the adrenal system, and behavioral changes. Oil can also affect animals in non-lethal ways, such as impairing growth and reproduction, and from the loss of important habitat.

Diesel is considered to be one of the most acutely toxic oil types, and can affect marine birds by direct contact, but remains on the water surface for only a brief time and is rapidly diluted (NOAA 2018i). Several hundred small diesel spills from fishing vessels in Alaska over the past decade have resulted in few birds being directly affected. However, a small diesel spill occurring adjacent to a large nesting colony, or in a high bird concentration area, could cause more serious impacts (NOAA 2018i).

During most large oil spills (which are generally heavier oils compared with diesel), seabirds are harmed and killed in greater numbers than other kinds of creatures (NOAA 2020). The types of birds most affected by an oil spill at sea are those that spend a majority of their time on the surface of the water, such as gulls, geese, ducks, auks, grebes, terns, and loons. If the oil reaches shore, shorebirds and songbirds may be affected, as well as any birds that use these contaminated habitats. Migratory birds may be affected if critical migration staging, foraging, or resting areas are contaminated, especially if the spill occurs during a season of high migratory bird use (such as during spring migration). Shorebirds that feed on clams, mussels, worms, and other invertebrates in the intertidal zone may consume prey that has been exposed to oil along the shoreline (Ober 2010). There are several shorebird concentration areas where large numbers of shorebirds congregate, primarily during spring migration in Iliamna and Iniskin bays. Shorebird concentration areas are often situated where dense populations of *Macoma* clams are found (Glosten 2012). Bivalves, such as clams, are unable to metabolize PAHs, which are toxic components of oil. Therefore, this could lead to a reduction in prey source for migrating birds. Shorebird species such as least sandpipers (*Calidris minutilla*), western sandpipers (*Calidris mauri*), and semipalmated plovers (*Charadrius semipalmatus*) that stop-over during migration may be impacted. Migratory stop-over locations are critical staging and foraging areas for migrating shorebirds, because they rapidly feed for a few days before moving on.

If a spill occurs in winter, the only shorebird species present in Cook Inlet would be the rock sandpiper (*Calidris ptilocnemis*). However, in some winters, almost the entire population of the nominate race of rock sandpiper (*Calidris ptilocnemis ptilocnemis*), a species of high conservation concern, winters in Upper Cook Inlet (Ruthrauff et al. 2013). The species forages primarily on the bivalve (*Macoma balthica*) in areas where foraging substrates (intertidal mudflats) are accessible, even during periods of extreme cold (Ruthrauff et al. 2013). A spill during the winter could impact a primary rock sandpiper foraging area. Rock sandpiper distribution during the winter does not heavily overlap with Kamishak Bay or Iliamna or Iniskin bays (refer to Section 3.23, Wildlife Values, for numbers of shorebirds); therefore, a spill that impacts these areas along western Cook Inlet may impact several hundred foraging rock sandpipers.

If a ULSD spill occurred during the summer breeding season, impacts to birds would be especially intense due to large numbers of breeding seabirds in lower Cook Inlet. If birds came into contact with spilled diesel, individuals could be killed, sickened, lose food and habitat, or experience reproductive problems. If the spill spreads to shore, nesting birds may be affected. Later in the summer, any birds that may be molting in the vicinity of the spill would be vulnerable to adverse impacts due to their temporary inability to fly. The Douglas River Shoals area, which forms the southern boundary of Kamishak Bay, provides important molting and wintering areas for a variety of waterbirds in a complex matrix of tidal mudflats and marshes. This area is also important staging and breeding habitat for a variety of waterfowl species (NOAA 2002). Oil in this area has a potential to adhere to substrates and become re-entrained during high tides and storm events.

Numerous foraging areas of regional or global importance for sea ducks, seabirds, and breeding seabird colonies, as well as areas important for migratory shorebirds, are in lower Cook Inlet, as detailed in Section 3.23, Wildlife Values. Although there are no seabird colonies at Amakdedori port, there are several to the north and south; and multiple nesting areas are at the mouths of Iliamna and Iniskin bays. In addition, there are many seabird colonies around Cape Douglas at the mouth of Cook Inlet and Shuyak and Afognak islands, which may be impacted if spilled diesel spreads that far south (NOAA 1997). Seabird colonies that are south of Kamishak Bay that may be impacted by ULSD drifting on currents that head south out of Cook Inlet include colonies around Cape Douglas. Seabirds that breed in the area include pelagic and red-faced cormorants, black-legged kittiwakes, glaucous-winged gulls, tufted and horned puffins, pigeon guillemots, and black oystercatchers (NOAA 2002; Griffin 2018).

During the summer, seabird colonies on the northern sides of Shuyak and Afognak islands include many of the same species observed at Cape Douglas, and include glaucous-winged gull, mew gull, pelagic cormorant, tufted and horned puffins, parakeet auklet, pigeon guillemot, arctic tern, black oystercatcher, and common eider (NOAA 1997). These birds are generally present in and around their nesting colonies or in the general vicinity from April through October. During the winter, there are large concentrations of waterfowl off the coast on the northern side of Shuyak and Afognak islands. There are also bald eagles nesting in many locations around these islands. Oil has a potential to impact nesting seabirds and bald eagles that are foraging in nearshore waters through contamination of eggs and young from oiled feathers on adult birds, and potential for colony disturbances from cleanup activities. Waterbirds are particularly vulnerable to oil spills and response activities during the molting period from late June through mid-August, and during the wintertime (NOAA 1997).

Many bird populations can recover following a one-time mortality event (e.g., a localized oil spill) if the fraction of the total population killed remains small. However, as the fraction killed becomes larger, the severity of population impact can increase above that expected by a simple proportional change (Stehn and Platte 2000). Disruption of social behavior, loss of mates, competition with other species, or increased predation may prevent or extend the time before population recovery. Declining populations or populations with a limited capacity for growth would be at greater risk. All loons, eiders, and other sea ducks have a relatively low capacity for population growth (Stehn and Platte 2000).

The March 1989 *Exxon Valdez* oil spill has been heavily studied to understand the impacts on avian populations in Prince William Sound and the Gulf of Alaska. Although the *Exxon Valdez* oil spill (in which over 11 million gallons of crude were released into the environment) is not a suitable analogy for the 300,000-gallon ULSD spill considered in this scenario, it provides some insight into population-level impacts to birds in the area from oil spills. Various bird populations responded differently; and while some recovered quickly, some have yet to recover. Bald eagles were exposed to acute impacts of oil through depredating or scavenging on marine animals (including carcasses) nearshore and on oiled beaches (Esler et al. 2018). Bald eagle populations in the area affected by the spill experienced 5 percent acute mortality but had recovered by 1995 to pre-spill numbers. Other species such as harlequin ducks, pigeon guillemots, and marbled murrelets did not fare as well. Harlequin ducks, which have high site fidelity, relatively small home ranges, feed heavily in the intertidal habitat where oil persisted, consume benthic invertebrates, and have delayed maturity and limited annual productivity, were not considered recovered until 2014 (Esler et al. 2018). Both pigeon guillemots and marbled murrelets have undergone long-term declines, and have not recovered following the spill. The spill occurred at a time when many piscivorous seabirds declined in abundance in Prince William Sound, potentially due to a change in the pelagic food web (Esler et al. 2018). Therefore, the recovery of both species has been confounded by ecological changes in the marine environment that have reduced preferred prey availability. Both species have not fully recovered to pre-spill population estimates. Therefore, the impacts of a spill in the marine environment could potentially have vastly differing impacts on species, depending on their foraging habitats, locations, and prey. The *Exxon Valdez* oil spill illustrated that birds that consume benthic invertebrates were more likely to be exposed to oil, and subject to chronic direct effects compared with species that consumed fish. Invertebrate prey, particularly filter feeders, may accumulate hydrocarbons, which can lead to detrimental impacts on species consuming them, compared with fish, which possess mechanisms capable of metabolizing and eliminating hydrocarbons (Esler et al. 2018).

This spill scenario magnitude of impact on birds would vary depending on the location and timing of the spill, species impacted, and duration before cleanup activities and natural weathering processes degrade the diesel. The duration would also vary, depending on what proportion of bird populations are affected. Some bird species, such as bald eagles, may recover quickly or suffer minor mortality; other species, such as harlequin ducks and other seabirds, may have longer recovery times. If a spill occurred during the molting or breeding season, it could impact birds at particularly vulnerable time periods and could have colony-level impacts, depending on the precise location and timing of the spill. Spill response activities, including countermeasures such as deflection and containment, and hazing, may affect birds through disturbance and exposure to toxic substances. Individuals may also be affected by wildlife protection measures, including hazing activities designed to prevent birds from encountering the contaminated area. Capture and handling can increase exposure to infectious diseases, and animals exposed to contaminants may have suppressed immune function (USFWS 2015b). Spill response actions could impact birds near the spill site, as well as some distance away, because the diesel could readily travel more than 50 miles within 3 or 4 days (Owl Ridge 2018c).

Alternative 2 and Alternative 3—Diamond Point Port—There are many seabird colonies around Iliamna and Iniskin bays, and on Augustine Island. A review of the Cook Inlet and Kenai Peninsula Environmentally Sensitive Areas (ESA) maps for summer, fall, winter, and spring (NOAA 2002) identify a wide variety of sensitive biological resources at all times of the year. Based on the spring ESA map (and confirmed by surveys for the Environmental Baseline Data; see Section 4.23, Wildlife Values) there are waterfowl concentrations in Iliamna Bay (birds that are staging to head north for breeding) and many seabird colonies.

Based on surveys conducted by ABR in summer 2004 and spring 2005, the most commonly detected waterbird species (over 1,000 birds detected), in decreasing order of abundance across all surveys, were: glaucous-winged gull, harlequin duck, greater scaup, long-tailed duck, Barrow's goldeneye, and green-winged teal (ABR 2011d). Boat-based offshore surveys from summer 2004 to spring 2006 documented fewer birds; when all surveys were totaled, white-winged scoters, glaucous-winged gulls, and long-tailed ducks were the most abundant. Large numbers of waterbirds were detected in both spring and fall 2005, primarily in Iniskin Bay, with estimates of several thousand birds. In spring 2005, higher densities of waterbirds were located near the mouth and middle of Iniskin Bay; in fall 2005, higher densities were further back in Iniskin Bay. Historically, in the mid-1970s, the largest wintering concentration of seaducks in all of lower Cook Inlet occurred in Iniskin Bay; During summer, Iliamna and Iniskin bays contained a large concentration of scoters. Gulls, dabblers, and scaup concentrated in Iniskin and Chinitna bays in the summer (Erikson 1977). Agler et al. (1995) also documented large concentrations of birds on the western side of lower Cook Inlet in summer, and the number of wintering birds (primarily waterfowl) in Iliamna and Iniskin bays was the highest in western Cook Inlet.

The nearshore marine waters of Iliamna, Cottonwood, and Iniskin bays are important year-round habitat for a variety of shorebird species, primarily during spring migration. Surveys conducted by ABR from 2006 to 2012 documented a wide variety of species in Iliamna and Iniskin bays, with the highest numbers of shorebirds moving through the area in early May on their northern spring migration (ABR 2011c). On May 3, 2005, more than 5,000 shorebirds were recorded in Iliamna and Iniskin bays (ABR 2011c). Common shorebirds were western sandpipers and dunlin (ABR 2011c). These birds fed on the mudflats at the back end of Iniskin Bay. Low numbers of rock sandpipers (generally less than 200 birds) also used the bays during fall, winter, and spring from late October through late April; however, they were most abundant in November (ABR 2015c). The largest flocks of rock sandpipers were found foraging on the soft-sediment substrates of inner Iliamna and Iniskin bays.

Many rocky islands, islands, and cliff areas support colonies of breeding waterbirds during summer months at the mouths of Iliamna and Iniskin bays and around Augustine Island. The North Pacific Seabird Data Portal (an online database of seabird colony population numbers from various surveys[1]) includes several seabird colonies in this area. These are South Head, White Gull Island, North Head, Knoll Head, Toadstools, Entrance Rock, Vert Island, Scott Island, Mushroom Islets, Iniskin Island, Twin Rocks, Pomeroy Island, and Oil Reef (USFWS 2012b). Several of these islands (White Gull Island, Vert Island, Iniskin Island, and Pomeroy Island) had greater than 500 breeding birds in the late 1970s (Erikson 1977; ABR 2011a). The main nesting species include black-legged kittiwake, black oystercatcher, common eider, glaucous-winged gull, pelagic cormorant, double-crested cormorant, tufted puffin, horned puffin, and pigeon guillemot, among others. The exact numbers of nesting birds for each species varies depending on the year; however, additional details are provided in Section 3.23, Wildlife Values, regarding species abundance and trends for Iliamna and Iniskin bays. Birds may be impacted through direct oiling of feathers while resting, preening, and foraging on waters coated in ULSD. As the ULSD disperses, evaporates, and degrades, the impact would be reduced; however, ULSD may adhere to the nearshore environment. Species, such as black oystercatchers, that feed along the tide line may be exposed to ULSD. Although the exact fate of the spilled ULSD is unknown, there is a potential for a variety of waterbirds to be exposed. During fall and winter, the nesting waterbirds begin to migrate south, and wintering waterfowl arrive. Protected bays such as Iliamna and Iniskin provide important sheltered overwintering habitat for several species, including scoter species. Therefore, a ULSD spill at any time of year has the potential to impact a large number of birds from a variety of avian species.

A spill of this magnitude could potentially impact several nesting colonies, and result in oiled birds and decreased fitness for overwintering birds. The severity would depend on the timing of the spill in relation to avian activity (e.g., nesting, migrating, staging, molting), precise location, and ability for spill response measures to be implemented. Capturing and handling oiled birds can be difficult, and result in additional stress to handled birds.

Fish

As discussed above, floating diesel tends to weather and evaporate over time from mixing with the stream currents, wind, and wave action (NOAA 2006). Toxic components of diesel could also be entrained in turbulent water such as tidal areas. Some toxic components of diesel could persist in the environment after most diesel has weathered or evaporated. Several direct effects to fish or benthic invertebrates could occur in the spill footprint in littoral or intertidal zones, including:

[1] Analyses and conclusions contained in this document are based wholly or in part on information obtained from the North Pacific Pelagic Seabird Database. The author(s) have complied with published guidelines for the ethical use of data.

- Toxicological effects as fuel fractions are absorbed or consumed by organisms in the affected area.
- Habitat alteration as diesel fuel accumulates onto sediment habitats with the intertidal zone, causing toxicity to algae and marine macrovegetation, epibenthic, and benthic communities, and avoidance by more mobile macroinvertebrates and fish.
- Local disruption of the food web if algae, macrovegetation, and invertebrate communities important to fish are affected by the spill.

The magnitude of impacts would depend on the size of the spill in the nearshore intertidal zone and the character of the shoreline. Although the duration of the effects of diesel spills in open waters is relatively brief, areas that are physically protected have lower flushing rates and smaller tidal movements; therefore, the duration of the effects in those areas may be longer.

Shellfish in protected or shallow water would be at higher risk than finfish, because they are less mobile; unable to avoid exposure; and are indiscriminate filter feeders. Shellfish also lack the enzymes to process and break down ingested contaminants. Finfish are generally more mobile and selective of ingested food, and have enzymes to detoxify exposure to many oil contaminants. Larval life phases of finfish are less mobile, however, and would have a greater exposure to diesel spills than juveniles or adults (NOAA 2019a).

Intensity of the impacts would vary based on the location of the spill, and the species and life stage present. Impacts are not likely to last longer than 30 days in open water, but could be of longer duration in areas physically sheltered from wind, wave, and tidal influences. In these protected areas, there is a potential of mortality to larval fish such as herring and invertebrates, depending on the concentration and persistence of the contamination.

Alternative 2 and Alternative 3—Diamond Point Port—Fish resources of Diamond Point port are described in Section 3.24, Fish Values. Data indicate that juvenile Pacific herring and salmon use habitats in Diamond Point port for rearing. Surveys suggest that the Iliamna and Iniskin Estuaries represent a minor contribution to the Pacific Herring spawning in Cook Inlet (Owl Ridge et al. 2019). Mortality to juvenile fish could occur as described above; however, the soluble fraction compounds have relatively short residence times in water and sediments (Hayes et al. 1992) and can be reduced to below detection levels in a few days or weeks, depending on site-specific conditions.

Threatened and Endangered Species

North Pacific Right Whale, Sperm Whale, and Gray Whale (Western North Pacific DPS)—Under the Fuel Oil Spill Trajectory Modeling Report for the Pebble Project (SLR 2018), a 300,000-gallon spill in Kamishak Bay would spread south; and within 4 to 5 days, mass around the northern shore of Shuyak, Afognak, and adjacent islands. These three whale species have a potential to migrate through and feed in the upper portion of the Gulf of Alaska (through Shelikof Strait and across Stevenson Entrance) and encounter ULSD from the spill scenario as it is carried by ocean currents south through lower Cook Inlet and amasses around the northern shore of Shuyak and Afognak Islands. The period of exposure would likely be limited to a few days if the spill occurred when whales were migrating or present in the area. There is a known gray whale migration corridor in the spring (April to May) and during winter (November to March) along the northern side of these islands (NOAA 1997). The impacts to these species are anticipated to be similar to those detailed below for other whale species, which includes the potential for inhalation (particularly if they surface in an area of floating ULSD), ingestion (particularly if surface feeding), and skin/dermal irritation. The magnitude of potential impacts would depend on the time of year, if whales were present at the time when ULSD is traveling across Shelikof Strait and Stevenson Entrance to the northern shore of Shuyak and Afognak islands, and other environmental factors.

A ULSD spill could impact individuals in listed populations, and would have a greater impact if several whales were affected. If whales were feeding or surfaced in an area of ULSD, they could experience acute impacts. Chronic impacts are less likely to occur because these whale species would be transitioning through the area, and are more likely to occur further south in the Gulf of Alaska away from the modeled spill area. The extent would include the mouth of lower Cook Inlet and the waters on the northern side of Shuyak and Afognak islands. The duration of acute exposure would likely be a few days while ULSD is moved by ocean currents to the northern shore of these islands. The duration of chronic exposure could last longer, depending on impacts to prey species and potential for re-exposure, which in turn would depend on the extent of cleanup activities and natural weathering processes.

Cook Inlet Beluga Whale— The magnitude of potential impacts from the diesel scenario on the Cook Inlet beluga whale (*Delphinapterus leucas*) is high, because the stock and its critical habitat are only found in Cook Inlet (NMFS 2016b). Catastrophic events such as high-volume petroleum-based spills are infrequent, but may have effects on Cook Inlet beluga whale prey, whether through changes to spawning or migration patterns, direct mortality, or potential long-term sub-lethal impacts (Murphy et al. 1998). On contacting spilled oil, Cook Inlet beluga whales may experience inhalation, ingestion, and skin and conjunctive tissue irritation. Injury and mortality due to physical contact, inhalation, and ingestion is possible to beluga whales, especially calves of the year and juveniles (NMFS 2016b). The extent of a diesel spill depends on the location, weather conditions, and timing of the spill. Cook Inlet beluga whales are typically distributed in Upper Cook Inlet in summer and fall, and are more likely in the analysis area during winter and spring. Under the Fuel Oil Spill Trajectory Modeling Report for the Pebble Project (SLR 2018), a 300,000-gallon spill in Kamishak Bay directly south of Augustine Island would spread south; and within 4 to 5 days, mass around the northern shore of Shuyak, Afognak, and adjacent islands. This includes a variety of marine mammal habitat, including Cook Inlet beluga whale critical habitat (in Kamishak Bay). Localized effects from spills are generally limited to the direct damage to habitat in the immediate area of the spill; and the amount of critical habitat potentially impacted by a diesel spill is low in comparison to the total amount of critical habitat in Cook Inlet. The duration of acute impacts would be short because diesel rapidly evaporates, disperses, and is broken down. However, the duration of chronic impacts could be much longer (up to several years) depending on the extent of impacts to individual whales and their prey. Although much of the refined oil spilled is expected to either evaporate or naturally disperse into the water columns within a few days, the rate of weathering is dependent on temperature, light, and other environmental conditions.

Humpback Whale— On contacting spilled diesel, humpback whales may experience inhalation, ingestion, and skin and conjunctive tissue irritation similar to other whales, but may also experience baleen fouling. Repeated surfacing in a large diesel spill with high levels of volatile toxic hydrocarbon fractions present could potentially lead to organ damage and/or mortality of humpbacks. Spill modeling in SLR (2018) indicates that a potential diesel spill may travel as far south as Shuyak, Afognak, and surrounding islands adjacent to Kodiak Island, where there are biologically important feeding areas for the humpback whale (Ferguson et al. 2015). The extent of impacts from a diesel spill on humpback whales depends on the location, time, and weather conditions. Humpback whales are not present in the analysis area in the winter months; instead, depending on the stock, the whales travel south to breed. Therefore, humpback whales are projected to be at the highest risk from impacts to oil spills during the summer and fall in high-density feeding areas surrounding Kodiak Island (Ferguson et al. 2015). Humpback whales prey on schools of forage fish (capelin [*Mallotus villosus*], sand lance [*Ammodytidae* family], Pacific herring [*Clupea pallasii*]) species, as well as copepods and euphausids in the water column near the water's surface, where diesel may be present. The duration of acute impacts would be short-term, because diesel rapidly evaporates, disperses, and is broken down. However, the duration of chronic impacts could be much longer (up to several years), depending on the extent of impacts to individual whales and their prey.

Fin Whale—The magnitude of impacts from a diesel spill on fin whales would likely be low, because fin whale sightings in the analysis area are low, and whales are typically sighted in the Aleutian area, Bering Sea, and around Kodiak Island. The highest densities of fin whales in this area occur from June through August, although they may be observed in this area year-round by aerial and acoustic surveys (see Section 3.25, Threatened and Endangered Species). Fin whales would potentially be impacted by the diesel spill, because spilled diesel is modeled to contact waters surrounding Kodiak Island and Shelikof Strait, which are deemed Biologically Important Feeding area for fin whales (Ferguson et al. 2015). However, by the time the spilled oil reaches these areas, it would largely have dissipated. The duration of acute impacts would be short-term, because diesel rapidly evaporates, disperses, and is broken down, lessening the time available for fin whales to come into direct contact with the spilled diesel. However, should fin whale prey become contaminated, the duration of impacts could last for several years through the reduction or mortality of local prey, creating periods whereby summer prey would not be available for an undetermined time period depending on prey recovery rates. The likelihood of impacts from a diesel spill on fin whales is also low, because fin whales may, on contacting spilled oil, experience similar inhalation, ingestion, skin, and conjunctive tissue irritation, as discussed for other whales; but because they are also baleen whales, they may also experience baleen fouling.

Northern Sea Otter—The magnitude of potential impacts from a diesel spill on the southwestern stock of the Northern sea otter is high. The 2013 Southwest Stock of the Northern Sea Otter Recovery Plan lists oil spills and oiling as a threat and impediment to recovery. Sea otters are particularly vulnerable to contamination by oil (Williams and Randall 1995). Five characteristics of sea otter biology help explain their extreme vulnerability to oil contamination (USFWS 2013).

1. Sea otters depend on their fur and the air trapped within it for thermal insulation. Oil destroys the water-repellent nature of the fur, and it eliminates the air layer, thereby reducing the insulative value by 70 percent (Williams et al. 1988). The direct result is acute hypothermia.
2. Once the fur is fouled, sea otters ingest oil as they groom themselves. Ingested oil damages internal organs, resulting in acute and chronic effects on animal health and survival. Based on a mink model, oral exposure to low doses of oil can lead to changes in hematology, immune function, and reproductive success (Mazet et al. 2001; Schwartz et al. 2004).
3. Benthic invertebrates accumulate and store toxic hydrocarbons. Sea otters therefore ingest hydrocarbons when they feed on these organisms during and after an oil spill. Bivalves are unable to metabolize PAHs, which are toxic components of oil; therefore, otters can be exposed to these components while feeding even after oil has dispersed from the water's surface. Additional oil can become re-entrained in the water when sediment is disturbed during foraging.
4. Sea otters are nearshore animals that exhibit strong site fidelity, often remaining in or returning to oiled areas after release. In addition, they often rest in kelp beds, which collect and retain spilled oil.
5. Sea otters are often found in single-sex aggregations, which can include hundreds of individuals. Therefore, large numbers of sea otters (representing a portion of the reproductive potential of a population) can become fouled by oil simultaneously.

In addition, sea otters spend the majority of their time on the water's surface, increasing exposure and direct contact with a diesel spill. Oil-based product contamination can have both immediate and long-term effects on sea otters and on population recovery (Peterson et al. 2003). Potential impacts of oil spills on sea otters could range from negligible to severe, depending on the location, extent, and type of oil that is spilled. Direct, acute effects to sea otters from a large spill include mortality, and lung, liver, and kidney damage (Lipscomb et al. 1994). Chronic effects to sea otters from exposure to oil have been shown to affect mortality patterns, abundance, and survival rates in the years following the *Exxon Valdez* oil spill (Peterson et al. 2003) (Note: the oil spilled in the *Exxon Valdez* oil spill was crude, and not ULSD). Indirect, chronic effects to sea otters from a large oil spill may be caused by 1) sub-lethal initial exposure to oil, causing pathological damage to the otters; 2) continued exposure to hydrocarbons persisting in the environment, either directly or through ingestion of contaminated prey; and 3) altered availability of sea otter prey as a result of the spill (Ballachey et al. 1994). The *Exxon Valdez* oil spill had catastrophic impacts on sea otters, and it took 20 to 25 years after the spill for direct chronic or delayed toxic effects to no long cause sea otter mortality (Esler et al. 2018). In 2014, 25 years after the spill, sea otters were declared recovered. Although potential chronic impacts from a ULSD spill are not comparable with the recovery times for otters from the *Exxon Valdez* oil spill, they highlight the potential for longer-term impacts.

The extent of impacts from a diesel spill on sea otters depends on the location and size of the spill, and the weather conditions at the time of the spill. A large spill can cover a vast area, because sea otters prey on a wide variety of benthic marine invertebrates and forage in shallow coastal waters (Riedman and Estes 1990), which vary widely in exposure to the open ocean, substrate type, and community composition. In addition, sea otter density throughout Kamishak Bay is high (Klein, pers. comm., 2018; ABR 2019a, b, c, f), and a potential spill could cause displacement of sea otters from their habitat, which was observed after the *Exxon Valdez* oil spill (Burn 1994).

There are large numbers of sea otters along the Katmai National Park coastline from Douglas River Shoals, around Cape Douglas and south along the Alaska Peninsula. Based on aerial surveys conducted by the National Park Service from 2012 through 2015, the northern sea otter abundance in Katmai National Park appears to have stabilized, following more than a decade of growth (Coletti et al. 2018). The waters along the coastlines are shallow, with abundant mixed-sediment habitats that support high densities of clams, which are a preferred prey for sea otters (Coletti et al. 2018). There are also large concentrations of sea otters on the northern sides of Shuyak and Afognak islands (NOAA 1997). Therefore, a spill scenario that extends south of Cook Inlet has a potential to impact a large number of sea otters in the nearshore habitats of the Katmai coastline and Shuyak and Afognak islands.

Sea otters have high metabolic demands relative to other marine mammals and can consume 20 to 25 percent of their body weight per day in invertebrate prey (Costa and Kooyman 1984). The level of contamination in prey may depend on where prey is found (e.g., subtidal versus intertidal), and the effects of prey contamination on sea otters may depend on age class preferences for different prey types (e.g., juvenile sea otters preferring to forage in intertidal zones, which would be more contaminated than the subtidal zones in which adult sea otters prefer to forage). Although diesel rapidly evaporates, disperses, and is broken down, if sea otters come into direct contact with spilled diesel, the duration of impacts may potentially cause long-term, chronic effects to some individuals. A 300,000-gallon ULSD spill in an area with high sea otters use (such as Kamishak Bay, Douglas River Shoals, the coastline around Katmai National Park, and Shuyak and Afognak islands) could result in mortality of sea otters, and this acute loss in the local population could be felt for several years due to the demographic lag hindering recovery (Esler et al. 2018). This was the case in the *Exxon Valdez* oil spill; it took 25 years for the sea otter population to fully recover.

Steller Sea Lion— Although the density of Steller sea lions in Cook Inlet is low, a spill under this scenario has a greater chance of reaching Steller sea lion critical habitat features such as rookeries, major haulouts (and their surrounding aquatic zones), and foraging areas (i.e., Shaw and the Barren islands, described in further detail in Section 3.25, Threatened and Endangered Species). Steller sea lions also use North Douglas Point, and up to 50 individuals were documented on the island during a June 30, 2018 National Park Service aerial survey (Griffin 2018). Sea lions use the waters around the mouth of Cook Inlet, and may experience direct acute impacts of ULSD if they forage, surface, and swim through ULSD moving south through the mouth of Cook Inlet. The spill trajectory indicates that the ULSD would reach the northern shores of Shuyak and Afognak islands in several days. There are several Steller sea lion haulouts along the northern shore of these islands that have a potential to be impacted (NOAA 1997). Steller sea lions may contact ULSD as they enter and exit the water at these haulouts. Sea lions that contact diesel may become contaminated with hydrocarbons internally through inhalation, contact, and absorption through the skin; or ingestion, either directly or by consuming contaminated prey (Engelhardt 1987). The extent of impacts from a diesel spill on Steller sea lions is modeled to intersect with Steller sea lion critical habitat in Shelikof Strait, and could have negative impacts on the habitat, as well as the animals themselves, if they were to come into direct contact with the spilled diesel. However, after the *Exxon Valdez* Oil Spill, oil was not found to persist on the rookeries and haulout sites, probably due to their steep slopes and high surf activity (Calkins et al. 1994). The duration of acute impacts would be short-term, because diesel rapidly evaporates, disperses, and is broken down; however, if animals were to come into direct contact with the diesel, there could be longer-term, chronic impacts to the exposed animals resulting from toxicity affects.

Steller's Eiders—In the event of a diesel spill during fall, winter, or spring, the federally threatened Alaska population of Steller's eider (*Polysticta stelleri*) may be impacted. As detailed in Section 3.25, Threatened and Endangered Species, most Steller's eiders do not arrive in Kamishak Bay until late November, and tend to move north into more protected bays as winter progresses. By mid- to late-April, Steller's eiders have left the area to migrate to their breeding grounds along the northern slope of Alaska. Generally, spills in the summer would have no impact on Steller's eiders, because the diesel would evaporate, dissipate, photodegrade, and be cleaned up prior to the arrival of wintering Steller's eiders. However, some eiders molt in late summer and early fall at Douglas River Shoals, which may be impacted under the scenario. ULSD would be rapidly carried by currents south of the spill point and mass along the shoreline and rocky terrain at Douglas River Shoals (SLR 2018). Although a large portion of the ULSD would evaporate, a large spill of 300,000 gallons would cause acute oiling on birds that contact the oiled water. Fuels and oils can be toxic to Steller's eiders (Fox et al. 1997) and their prey; therefore, impacts from a diesel spill that reach Douglas River Shoals may have a high-intensity impact on Steller's eiders. In particular, because bivalves cannot metabolize PAHs, Steller's eiders may be exposed to toxic components even after oil has been removed from the water's surface. Bivalves, such as mussels and clams, form a large portion of the Steller's eider high-calorie diet necessary for molting and wintering in Cook Inlet. They would be especially vulnerable during their molting season (July to September), when they are temporarily unable to fly, making it more difficult for them to avoid an oil spill. Steller's eiders are gregarious, and often large numbers are closely grouped together; therefore, a single spill may result in a large number of birds being affected simultaneously. Steller's eiders maintain high site fidelity for molting locations, and throughout the winter. Therefore, they are at increased risk of chronic petroleum exposure if cleanup activities are not successful.

Of the Steller's eiders that winter and molt in Cook Inlet, the USFWS assumes that less than 1 percent are from the listed Alaska-based breeding population (USFWS 2008b). If diesel ends up at Douglas River Shoals, several thousand Steller's eiders may be impacted. During aerial transect surveys in 2005, approximately 2,000 molting Steller's eiders were observed in the Douglas River Shoals in late August and September. During winter surveys in 2005, 3,921 Steller's eiders were recorded in southern Kamishak Bay (Larned 2006). Therefore, depending on the location of a spill and time of year (if eiders are present), a diesel spill may impact between 20 and 39 Steller's eiders from the federally listed Alaska population (currently estimated at 577 individuals [USFWS 2017])). Alaska Chadux's wildlife response team would be deployed to assist in cleaning up and providing transportation to rehabilitation facilities for oiled birds, with the ability to capture, transport, clean, and rehabilitate affected birds depending on a variety of environmental factors. It is difficult searching for live oiled birds, safely capturing them, and then transporting them to rehabilitation facilities. Furthermore, if a large spill occurred, there would likely be other sea ducks and waterbirds that would require safe capture and transport to facilities for cleaning and rehabilitation. However, previous cleanup events have resulted in rehabilitated birds that lived for several decades after being oiled (International Bird Rescue 2019). King eiders (*Somateria spectabilis*) were oiled in February 1996 from the M/V Citrus Oil Spill in the Pribilof Islands. One hundred eighty-six birds, mainly eiders, were rescued, rehabilitated, and released. Of those birds, at least four king eiders have been reported to the Bird Banding Lab with the latest return in 2019. These data underscore the success that rescue, rehabilitation, and release can have on a long-lived species.

It is thought the Steller's eiders exist near the limits of their energetic thresholds; therefore, environmental perturbations that reduce prey availability or increase their energetic needs may harm the species (USFWS 2007). During winter, Esler et al. (2002) found that harlequin duck (*Histrionicus histrionicus*) survival was 5.4 percent lower in oiled areas of Prince William Sound compared to unoiled areas more than 6 years after the *Exxon Valdez* oil spill (Note: the oil spilled in the *Exxon Valdez* oil spill was crude, and not ULSD). This was attributed to lower survival during midwinter, when effects of oiling are exacerbated by environmental stressors. Harlequin ducks are similar in size to Steller's eiders, and occupy similar habitat during the winter; therefore, they are a reasonable surrogate species for impacts to Steller's eiders. Periodic releases of hydrocarbons from oiled beaches in Prince William Sound would be similar to periodic releases of hydrocarbons from oiled areas of Douglas River Shoals if not adequately cleaned up. If diesel remains in areas that are used during molt and throughout winter by Steller's eiders, there is a potential for chronic exposure, which may reduce survivorship. Petroleum products that are released into the marine environment can continue to cause adverse impacts that last up to several years, and include changes in prey abundance, distribution, diversity, and ingestion of chronic toxic levels of petroleum (USFWS 2007). In a study analyzing levels of PAHs (a harmful component of oil) in Steller's eiders, harlequin ducks, and blue mussels (*Mytilus trossilus*, a prey source) at seaports such as Dutch Harbor, it was determined that blue mussels can contain high concentrations of PAHs (Miles et al. 2007). Therefore, prey items are one pathway that harmful components of oil can be consumed by Steller's eiders. It was found that at higher doses, Steller's eiders may be more susceptible to harm from PAHs or other stressors (Miles et al. 2007). In addition, the severity of a diesel spill would increase if it resulted in decreased ability for Steller's eiders to recover through decreased reproductive potential, as documented for harlequin ducks by Esler et al. (2002). The extent and duration of the diesel spill would be directly related to ocean currents, time of year, and effectiveness of diesel cleanup.

In summary, although the probability of a 300,000-gallon ULSD spill is low, Steller's eiders may experience high-intensity impacts if the geographic extent of a spill reaches molting and wintering areas at Douglas River Shoals while eiders are present. Cleanup efforts could reduce the geographic extent of the contamination by containing and recovering some of the spilled diesel. Most direct impacts from exposure to ULSD are anticipated to be short-term, because ULSD rapidly evaporates, disperses, and is broken down. However, if cleanup activities are only partially successful, there is the potential for chronic toxicity for Steller's eiders and their prey. Cleanup and containment activities would be used to limit the spread of the spill, and Alaska Chadux's wildlife response team would be deployed to assist in cleaning up any oiled birds. Furthermore, if a large number of birds were impacted, there is a potential for long-term population effects because Steller's eiders are long-lived birds that breed only during optimal periods. If a spill impacted Douglas River Shoals while several thousand Steller's eiders were present, depending on the success of capture, rehabilitation, and release, the impact on the Alaska-based breeding population could extend for multiple years while bird numbers recover. However, there are examples where previously oiled eiders have been rehabilitated, released, and lived for many years afterwards.

Alternative 2 and Alternative 3—Diamond Point Port—If this spill occurred near the Diamond Point port, impacts to TES would be similar to those previously described, but impacts would occur further north around Iliamna and Iniskin bays, with ULSD likely extending to Augustine Island and then spreading further south. This area has the same TES as further south in Kamishak Bay, with similar impacts anticipated. There would be no difference in potential impacts to whale species that migrate past the mouth of lower Cook Inlet, except that ULSD may be more dispersed and weathered by the time it is carried out of Cook Inlet by currents. There would be differences in the numbers of marine mammals potentially impacted. Several beluga whales have been historically documented in Iliamna and Iniskin bays, and there are high densities of northern sea otters around Augustine Island (especially on the western side). Steller sea lions also occasionally occur near the mouths of Iliamna and Iniskin bays and around Augustine Island. No fin or humpback whales have been detected in either bay, but several humpback whales were detected on the western side of Augustine Island by ABR during surveys in summer 2018. There are several groups of Steller's eiders that winter in Iliamna and Iniskin bays, but in lower numbers compared to Douglas River Shoals. Impacts are anticipated to be similar to those detailed above. The magnitude of impacts to TES would be similar to that described previously for each species, with a similar duration, but the extent would be concentrated in the northern part of Kamishak Bay and nearby bays.

Marine Mammals

It is important to note that many studies on impacts to marine mammals from large oil spills are related to spills of heavier oil (such as crude oil) and are not specific to lighter oils such as ULSD. Although both oil types contain some of the same compounds, they react differently when spilled into the environment, and have different persistence rates. Many of the impacts from oil on marine mammals are based on data from heavy oil spills (such as the *Exxon Valdez* spill), and the text may describe a worst-case scenario. Impacts from a spill of ULSD would have a reduced magnitude compared to a spill of heavy oil, such as crude oil. Many of the impacts detailed previously for TES would also apply to non-TES described below.

Oil-based substances, such as diesel, can impact marine mammals in the following ways: 1) acute toxicity caused by an event such as an oil spill can result in acute mortality or injured animals with neurological, digestive, and reproductive problems; and/or 2) can cause detrimental effects through complex biochemical pathways that suppress the immune system or disrupt the endocrine system of the body, causing poor growth, development, reproduction, and reduced fitness (NMFS 2008a).

Although much of the ULSD spilled is expected to either evaporate or naturally disperse into the water column within a few days, the rate of weathering is dependent on temperature, light, and other environmental conditions. Once dispersed into the water column, or settled into substrates, petroleum compounds can remain bioavailable in lower concentrations, and pose a risk to marine organisms that come in contact with these compounds at a later time.

Chronic exposure to diesel spills and latent contamination in the sediments for nearshore species also pose risks to many marine organisms (NMFS 2005b). Prey species of marine mammals could also become contaminated, experience mortality, or otherwise be adversely affected by spilled oil and through indirect impacts (i.e., species fitness and distribution). Fish-eating marine mammals, such as killer whales (*Orcinus orca*), and Dall's (*Phocoenoides dalli*) and harbor porpoise (*Phocoena phocoeana*), could experience reduction in abundance, distribution, and diversity of prey species from contact with diesel spills, and experience injury from consuming contaminated food items or from direct contact with diesel fractions. Marine mammals could be excluded or redistributed from their habitat if their forage fish prey base is reduced for even a short period of time.

Killer whales suffered acute impacts from the *Exxon Valdez* oil spill, including mortality to both a major resident pod (AB pod) and a unique transient population (AT1 population) that occur in Prince William Sound (Esler et al. 2018). Neither group has recovered, despite a lack of chronic direct effects, and the AT1 population may never recover. Both groups have been constrained by demographic factors related to life history characteristics and small population size. In particular, the AT1 population, which suffered a loss of females, and has not produced a viable calf since 1984, may be headed for eventual extinction (Esler et al. 2018).

Harbor seals are common in Cook Inlet and may experience acute and chronic impacts of an ULSD spill. Harbor seals use Shaw Island, and more than 400 individuals were documented on the island during a June 30, 2018 National Park Service aerial survey (Griffin 2018). Harbor seals have been documented along the shoreline in Kamishak Bay, near the mouth of Cook Inlet and along the shores of Shuyak and Afognak Islands. Therefore, they have a potential to be exposed to ULSD in several locations, depending on the extent of the spill.

Baleen whales may, on contacting spilled oil, experience inhalation, ingestion, skin and conjunctive tissue irritation, and baleen fouling. Whales may not be able to detect oil or may not avoid it if they can detect it, thereby increasing their risk of exposure to oil. Effects to pinnipeds from exposure to oil (such as seen from the *Exxon Valdez* oil spill) can include mortality, brain and liver lesions, skin irritation and conjunctivitis, increased PAH concentrations in blubber, increased petroleum-related aromatic compounds in bile, and abnormal behavior, including lethargy, disorientation, and unusual tameness (Frost et al. 2005). If individual, small, or large groups of marine mammals were exposed to large amounts of fresh diesel from a spill, especially through inhalation of highly toxic aromatic fractions, they might be seriously injured or die from such exposure. The duration of potential impacts is expected to be temporary (until the diesel has evaporated and broken down by microbes). The extent of potential impacts would be localized to the immediate area of the spill, and generally represents a small portion of the available habitat in Cook Inlet.

Alternative 2 and Alternative 3—Diamond Point Port—Based on the ESA index maps (NOAA 2002) and data provided in Section 3.23, Wildlife Values, and Section 3.25, Threatened and Endangered Species, there are many harbor seal haulouts around the mouths of Iliamna and Iniskin bays and around Augustine Island. The magnitude and duration of impacts to harbor seals and other marine mammals would be similar to those described above, but the geographic extent of impacts is likely around Iliamna and Iniskin bays, and Augustine Island.

Needs and Welfare of the People—Socioeconomics

It is unlikely that a diesel spill in lower Cook Inlet would result in increased employment or income opportunities in the Bristol Bay region. Manpower requirements would be low.

The impacts on employment, income, and sales would be negative if commercial and recreational fishing and/or tourism were to suffer due to the real or perceived impacts of a spill. Although these negative employment, income, and sales effects would be brief, their intensity would vary, and could result in changes in socioeconomic indicators well outside normal variation and trends if a major spill occurs with shoreline contact and/or contamination of fish. Duration of impacts would likely be short-term, affecting socioeconomic resources during the spill and subsequent cleanup efforts. Disruptions of commercial or recreational fishing would likely affect communities in Southcentral Alaska.

Commercial and Recreational Fishing

Depending on the timing of the spill, it could affect commercial salmon fisheries in Kamishak Bay, the health and viability of Weathervane scallop resources in the Bay, and the health and viability of the Pacific herring resource, which spawns in the Bay. Shuyak and Afognak islands are in ADF&G's Kodiak Management Area, which hosts seasonal commercial and recreational fisheries. The harvest size of the Afognak District commercial fishery is quite limited, particularly compared to the rest of the Kodiak Management Area or the Bristol Bay fishery; but a spill in July or August could result in commercial fishing restrictions in the area. Coho salmon and halibut are the primary targets of the area's recreational fishery; anglers would likely avoid any areas with visible petroleum sheens on the water. Economic impacts from a marine diesel spill based on the perception of the quality and the value of seafood produced in this region are not likely, but are possible depending on the public awareness and perception of the spill.

Cultural Resources

A release into the waters of Lower Cook Inlet would have little or no impact on marine archeological sites, because the substance and response efforts would be on the surface. Depending on the location of the spill and prevailing weather conditions at the time of the spill, impacts to cultural resources potentially located along shorelines would vary. Impacts would range in intensity from undetectable changes in integrity, to measurable changes in integrity, but not sufficient to affect National Register eligibility. If ground-disturbing cleanup activities were to occur within the bounds of cultural resource areas, direct impacts would be of higher intensity, and resources would not be anticipated to return to previous levels even after actions that caused the impacts were to cease. Any cleanup that could impact cultural resources would likely require a mitigation plan to limit those impacts. Indirect impacts could occur to the setting (visual, noise, and olfactory impacts) of cultural resources if the spill were to occur in the vicinity. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Those impacts would be temporary, and would cease when response efforts are complete.

Subsistence

The impact to subsistence resources from a diesel spill in lower Cook Inlet would vary depending on the timing of the spill, the duration before cleanup activities, and the rate of natural weathering processes that would degrade the diesel. A diesel spill in lower Cook Inlet could lead to mortality and temporary displacement of marine and anadromous subsistence resources, including marine invertebrates, marine mammals, marine fish, and salmon. The release would impact subsistence resources in lower Cook Inlet; based on the analysis of impacts on biological resources, impacts to subsistence would be short-term. The spill could result in concerns regarding contamination for lower Cook Inlet subsistence users and could cause changes to harvest patterns as users avoid the area. Quick response times and cleanup of the spill, as well as clear and timely communication with nearby communities, would help ease concerns about contamination for subsistence users in nearby communities.

Health and Safety

There are potential adverse impacts to social determinants of health (HEC 1), with psychosocial stress resulting from community anxiety over a marine tug-barge rupture at sea. A rupture release may involve a vessel accident or injury, and monitoring overflights could increase the risk of injury or accident related to air transportation (HEC 2). There could be potential diesel or diesel fume exposure (HEC 3) and impacts to near-shore subsistence and food security (HEC 4). Human health impacts would be short-term (i.e., 1 to 12 months), and limited to the vicinity of the spill area. Impacts would result in risks of illness or injury patterns if little to no diesel reached the shoreline, but would increase in intensity as the volume of diesel spilled and the amount reaching the shoreline increased.

Iliamna Lake Ferry Release

Incidents with the ferry could include collision, sinking, loss of power or steering capabilities, grounding, fires, and flooding of engine rooms or other compartments. Such vessel incidents, however, are generally attributable to human error more often than mechanical failures or adverse weather conditions. PLP would employ experienced crews, and crews would receive ongoing training. There are historically low rates of spills of any type from ferries. The statistical rates of incidence for spills from ferries are lower than those of marine barges addressed above. The operation of the ferry would be more secure and regulated than that of marine barges. A large-volume release of diesel from the Iliamna Lake ferry was considered to be so improbable as to have negligible risk, and was therefore eliminated as a scenario for impacts analysis in the EIS.

The ferry would be custom-built specifically for Iliamna Lake conditions, and for hauling diesel, concentrate, and other mine materials. Fuel tanks would be stored in secondary containment on the ferry. A 1-inch-thick heavy steel shell (required for ice-breaking) would result in very low potential for damage to the ferry from grounding or a collision. Fuel tanks would be located away from the shell of the vessel, so that the tanks would not be impacted in the event of a collision.

The ferry would be designed with state-of-the-art navigation and propulsion systems, with four azimuthing thrusters, and have the ability to operate in 100-mile-per-hour winds, with safe station-keeping at winds up to 150 mph (PLP 2018-RFI 052). Although subject to potentially extreme weather conditions, the operational environment in the lake is expected to be generally less harsh than the marine environment affecting marine barges (see Section 3.16, Surface Water Hydrology).

Based on historic data, and these design and operational features, the probability of a large spill of transported diesel from the lake ferry was judged to be significantly less than the historic spill probability for marine barges. The estimated annual probability of occurrence of $1.5x10^{-4}$ 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, spill response would begin immediately with ferry personnel. Ferries would be equipped with oil spill response kits, and operators would be trained in spill reporting and procedures to minimize and contain low-volume spills.

Depending on the size of the spill, the Chadux oil response group could be mobilized for spill response, as discussed above for a release from a marine tug-barge. Chadux is able to respond to some spill sites around Alaska within 24 hours; however, due to the remote location of Iliamna Lake, response times are unknown. Chadux would coordinate with the Applicant at a later phase in the project to determine what oil spill response equipment they could potentially maintain on Iliamna Lake. The Applicant would also maintain spill response equipment at both ferry terminals (including booms, sorbents, pumps and hoses, recovery and disposal containers, and PPE, a skiff, and personal flotation devices) that could be used by Chadux or other spill response personnel.

Response crews would likely deploy booms to contain the spill, pump diesel from the water's surface into secondary storage, and apply sorbents to collect residual fuel, etc. The longer the diesel remains in the water, the more difficult it would become to recover. Even assuming a rapid response within 24 hours, containment and recovery of light fuels such as diesel are extremely difficult, and only a portion of the diesel would likely be recovered. Much of the diesel would naturally evaporate and disperse within hours to days (NOAA 2018i; AECOM 2019a).

Spill response efforts could also be delayed by adverse weather or lake conditions, including storms and/or ice cover. The presence of ice cover and/or "rotten ice" on the lake could make recovery of spilled diesel more difficult.

Diesel Tank Farm Spill

Diesel fuel to be used primarily for operation of mining vehicles and the ferry would be stored at fuel storage facilities (tank farms) at the mine site truck shop, Amakdedori port, and the ferry terminals. Diesel would be stored in a variety of tanks ranging in volume from about 10,000 to 1.25 million gallons (PLP 2018d; Owl Ridge 2018b). Diesel would be stored in bermed and dual-lined secondary containment areas (SCAs) designed to contain spilled fuel. Per federal regulations (40 CFR Part 112), SCAs must contain 110 percent of the largest tank volume. Alaska State regulations (18 AAC 75.057) also require SCAs to have extra capacity to allow for accumulation of precipitation.

Tank farm spills are usually small-volume, and are generally contained in the SCAs. Potential causes of a spill at the tank farms could include scenarios such as: 1) a leaking valve seal, resulting in a small release (less than 10 gallons) that would be detected during daily inspections; 2) human error, resulting in the overfilling of a vehicle; or 3) tank rupture, resulting in release of the entire tank contents into the SCA. In all of these scenarios, spills would be fully contained in the SCAs, and fuel recovery would be 100 percent, minus any losses to evaporation. Potential spills would therefore have a low-intensity impact to air quality, and no impact to soil or water quality. Any spilled fuel would be removed from the secondary containment with sump and truck pump-out systems and/or sorbents.

Due to the low probability of a tank farm release of diesel outside of secondary containment, this scenario was eliminated for impacts analysis in the EIS.

4.27.5 Natural Gas Releases from Pipeline

Natural gas is primarily composed of methane, which is a colorless, odorless, tasteless gas. Other components of natural gas vary by source, and can include ethane, propane, butane, pentane, nitrogen, and carbon dioxide. Natural gas releases can be hazardous to human health when gas accumulates in a confined space, wherein high concentrations of gas can be an asphyxiant; or to human health and the environment if exposed to an ignition source, which can lead to fire or explosion. The pipeline would be on the seafloor, lakebed, and buried in a shallow trench in the soil; and would not pass through any confined spaces, such as buildings, where gas could accumulate. The pipeline would be largely in remote areas where ignition sources would not be present, and where human presence would be limited.

The pipeline would be designed, constructed, and operated per federal pipeline safety and environmental regulations, including USDOT, Bureau of Safety and Environmental Enforcement (BSEE), and Pipeline and Hazardous Materials Safety Administration (PHMSA), 49 CFR Part

192.179). USDOT regulations would cover appropriate corrosion protection, pressure monitoring, and shutdown devices to allow for rapid response to any leaks. Regular inspections, including visual inspections and pigging, would be conducted as required by USDOT codes and regulations (PLP 2019-RFI 126).During pipeline operations, there could be minimal disruption to current activities in Cook Inlet or Iliamna Lake due to pipeline maintenance and repairs (PLP 2019-RFI BSEE 2). The gas transmission pipeline would transport only pipeline-quality gas (PLP 2019-RFI 126). See Chapter 2, Alternatives, for pipeline design and safety features.

4.27.5.1 Pipeline Hazards

Common causes of pipeline leaks and releases include damage to pipe from excavation, damage to pipe from a motor vehicle, and material failure of the pipe or weld (PHMSA 2018). Due to the remote location of the pipeline and restricted access of the corridor, erroneous excavation would be unlikely, and motor vehicle damage would not occur, because the pipe would be buried in the over-land segments. Anchor damage could be a potential hazard to the pipeline in segments where pipeline is laid on the lakebed or seafloor and not buried, particularly in areas of high vessel traffic.

In Alaska, earthquakes and volcanic activity are potential sources of pipeline damage. No known active surface faults intersect the pipeline corridor (Figure 3.15-1); therefore, damage to the pipeline from surface fault displacement would not be expected. Seismic activity associated with nearby Augustine volcano is rarely of high magnitude, even during eruptive activity, and would not be expected to impact the pipeline. In the event of a major earthquake, liquefaction of wet soils or sediments in the pipeline corridor could potentially lead to pipeline displacement, flotation, and/or rupture, which could result in a release of gas. Pipeline design and engineering would account for potential liquefaction, thereby reducing the risk of pipeline rupture. See Section 4.15, Geohazards and Seismic Conditions, for a complete discussion of seismic hazards.

The pipeline would traverse the floor of Cook Inlet south of the active Augustine volcano. Lava flows from Augustine rarely reach the shoreline, and are not capable of traveling very far through water. Periodic debris avalanches—chaotic mixtures of volcanic rock, ash, and debris—do flow from Augustine into Cook Inlet on average once every 150 to 200 years (Beget and Kienle 1992). Due to the infrequency of such events, and the distance between the volcano and the pipeline, such volcanic flows would be unlikely to impact the pipeline during the life of the project. See Section 4.15, Geohazards and Seismic Conditions, for a complete discussion of volcanic hazards.

4.27.5.2 Fate and Behavior of Released Gas

Potential gas leaks from the pipeline would be released into the surrounding soil or water column, rise buoyantly up to the surface, and dissipate readily into the air. Potential natural gas releases from the pipeline would have a low-intensity impact on air quality by introducing dominantly methane, a GHG, into the air.

Due to its buoyancy, natural gas generally does not accumulate in water, and would not have an impact on water quality. Ongoing releases of natural gas that extend for weeks to months, however, can allow small bubbles of natural gas to accumulate and remain temporarily suspended in the water column in the immediate area. This can lead to locally high levels of methane and oxygen-depleted zones in the water column, which may impact aquatic life. Large-scale releases from offshore natural gas wells have impacted marine fish (Patin 2001).

Methane can sometimes accumulate in deeper soils beneath structures, under certain conditions. Accumulation of natural gas in the shallow soil beneath the narrow buried pipeline is not likely, and impacts on soil exceeding soil quality criteria would not be expected.

Natural gas pipeline releases would not be expected to cause contamination of water or soil; therefore, detailed impact assessment of leak scenarios is not included in this section.

4.27.5.3 Spill Response

PLP would have a spill response plan in place that would cover potential leaks/releases of natural gas. Federal code regulates natural gas facility safety features.

Mainline sectionalizing valves would be installed with a spacing of no more than 20 miles for the onshore sections of the pipeline (PLP 2020d). Offshore segments would not be equipped with valves, as allowed by 49 CFR Part 192.179. In the event of a gas release, valves would be shut off to limit the gas release.

The natural gas pipeline would be constructed of new pipe specifically designed for natural gas transmission in a cold climate through diverse terrain, including marine and lake water. The pipeline would be equipped with a leak detection system. In the event of a release, shut-off valves would be closed to limit the extent of the natural gas release. On the eastern side of Cook Inlet, near the compressor station, an automatic shut-off system would be installed. On the western side of Cook Inlet, at the port site, either an automatic or manual shut-off valve would be installed. Port personnel would always be on site and able to respond with manual shut-off if needed (see Chapter 5, Mitigation).

In the event of a natural gas release from the pipeline and/or pipeline repair, there could be minor disruption to current activities in Cook Inlet and Iliamna Lake.

<u>Alternatives Analysis</u>

The potential for a natural gas release from the pipeline could vary by alternative based on pipeline lengths and routes. The pipeline total lengths would vary slightly by alternative, including 193 miles for Alternative 1a; 187 miles for Alternative 1; 164 miles for Alternative 2; and 165 miles for Alternative 3. The pipeline routes for Alternative 1a and Alternative 1 would including a crossing of Iliamna Lake, while the pipeline route for Alternative 2 and Alternative 3 would follow the northern transportation corridor to the mine site, with no segments crossing Iliamna Lake. Therefore, under Alternatives 2 and Alternative 3, there would be no potential for a gas release into Iliamna Lake.

4.27.6 Concentrate Spills

Ore concentrate is composed of finely ground rock and mineral particles that have been processed from raw ore to concentrate the economic metallic minerals. For the project, raw ore from the open pit would be crushed and milled until it reaches the consistency of very fine sand, and then go through multi-phase processing to separate the metallic minerals from the waste rock, including flotation with chemical reagents, thickening, and filtration. The resulting concentrate would be dewatered and shipped off site for smelting (PLP 2018d). Copper-gold and molybdenum concentrates would contain sulfide minerals and other heavy metals, and would be considered potentially acid-generating (PAG), and capable of metals leaching (ML). Concentrates may also contain residues of chemical reagents, including sodium ethyl xanthate and sodium hydrogen sulfide, both of which can be toxic to fish in low concentrations. See discussion of chemical reagents below under Reagent Spills.

4.27.6.1 Copper-Gold Concentrate

Approximately 97.5 percent of the ore concentrate produced by the project would be copper-gold concentrate. A daily amount of 2,400 wet tons of copper-gold concentrate would be transported from the mine site to the port, for a total of 876,000 wet tons per year (PLP 2018-RFI 065).

The method of copper-gold concentrate transport would vary by alternative. For alternatives 1, 1a, and 2, concentrate would be transported by truck and ferry from the mine site to one of the port sites. For the Alternative 3 base case, truck/trailer combinations would haul concentrate from the mine site to the Diamond Point port along the north access road. The Alternative 3 base case does not include a ferry crossing on Iliamna Lake. The Alternative 3 concentrate pipeline variant would include transport of concentrate by pipeline from the mine site to Diamond Point port, and would also not include ferry transport. Potential impacts of concentrate spills from both truck and pipeline are addressed below.

For Alternative 1a, Alternative 1, Alternative 2, and the Alternative 3 base case (i.e., without the concentrate pipeline variant), copper-gold concentrate would be loaded into specialized heavy-steel bulk shipping containers with locking lids at the mine site (Figure 4.27-1). Containers would be 20 feet long, 7 feet tall, and 8 feet wide, and would hold a maximum of 724 cubic feet (ft^3) of material. Each container would hold 76,000 pounds (38 tons) of concentrate. Containers would have ISO container twist-lock systems on the corners, like a standard shipping container, for securing the container onto a tractor trailer (PLP 2018-RFI 045).

Each truck would pull three trailers, with one container per trailer, for a total of 228,000 pounds (114 tons) of concentrate per truck trip. For Alternative 1a, Alternative 1, and Alternative 2, truck/trailer combinations would haul concentrate to the north ferry terminal, where the containers would be loaded onto the ferry and secured with pins to prevent shifting during transit across Iliamna Lake. A second layer of containers would be stacked on top using the same twist-lock system on the corners (PLP 2018-RFI 045). Containers would be unloaded at the south ferry terminal, loaded onto haul truck/trailers, and transported to the marine port.

Once the concentrate containers are delivered to the marine port, containers would be transferred from truck trailers onto lightering vessels (barge/tug combination) and secured on the barge decks with pins. Three to four lightering vessels would transport the copper-gold concentrate containers out to waiting bulk carrier vessels, and load the concentrate for transport to off-site smelters for further processing. See Chapter 2, Alternatives, for lightering locations.

The primary lightering locations for Alternative1a and Alternative 1 have been identified as having high wave potential. Operational limits for the vessels loading concentrate would be a function of their seaworthiness in various sea states. The vessel operators would be responsible for loading concentrate in accordance with those operational limits.

To minimize the potential for over-water spills of concentrate or release of fugitive dust, the containers would be equipped with locking lids, and the containers would be lowered deep within the hold of the bulk vessel before being overturned, and the lids released. The hold would be filled with concentrate to only approximately 50 percent of the maximum capacity of the hold, due to the density of the material. Therefore, there would be adequate space to maneuver the containers in the hold above the cargo and below the hatch. The highest discharge elevation of concentrate would be 20 feet below the hatch (PLP 2018-RFI 009). See the "Mitigation" subsection for more details. Loading operations would be interrupted when warranted by sea and weather conditions (PLP 2018-RFI 032; PLP 2018-RFI 045). A total of 10 trips by lightering vessel would be required to load each bulk carrier, which would remain at anchor for 4 to 5 days. The peak production rate of copper-gold concentrate would require transporting a total of approximately 22,800 specialized bulk shipping containers of concentrate by truck, ferry, and barge each year (PLP 2018-RFI 065).

Annually, there would be an estimated 27 bulk marine vessel cargo shipments of copper-gold concentrate exported out of the port, with vessels anchored at the lightering locations, for a total of 108 to 135 days (Owl Ridge 2018c).

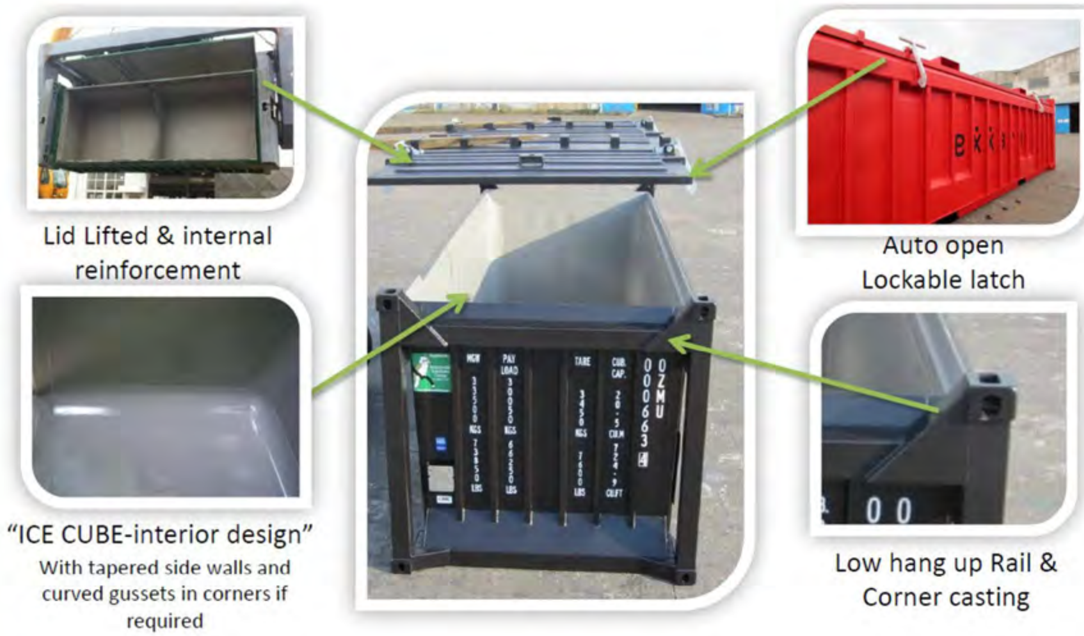
For the Alternative 3 Concentrate Pipeline Variant, copper-gold concentrate would be transferred from the mine site to the Diamond Point port as a concentrate slurry by pipeline. The concentrate pipeline is described in Chapter 2, Alternatives. The concentrate pipeline would be mostly buried, except where attached to bridge infrastructure at major stream crossings. The slurry would be dewatered at the port site, and stored in a bulk cargo pile in a dedicated concentrate storage building between bulk carrier sailings (PLP 2020d; PLP 2019-RFI 066a).

For barge loading, the concentrate would be reclaimed from the storage building and transferred to the barge loading area by fully enclosed conveyors with a tubular structure to contain dust and shed snow. At the barge loading dock, the barge loader would employ an enclosed conveyor boom and telescoping spout to distribute the cargo onto the barge deck with mechanical dust collection. The barge loader would load lightering barges with approximately 6,000 tons of concentrate per barge to transport to the bulk carrier ships. The lightering barges would have a dust-cover system to prevent fugitive dust and protect the cargo from rain/snow (PLP 2020d; PLP 2019-RFI 066a).

Once loaded, the barges would be transported to and secured against Handysize vessels at the mooring location in Iniskin Bay. The barges would be equipped with an internal reclaim system and conveyors (PLP 2019-RFI 066a) or use wheel loaders (PLP 2020d) to feed a self-discharging boom conveyor (ship loader) that would transfer the concentrate to the bulk carrier. The barge location would be adjusted along the ship during the loading process. The boom conveyor/loading trunk would be fully enclosed and equipped with a telescoping spout and mechanical dust collection to prevent spillage and fugitive dust. The loading trunk would extend down into the hold of the ship to minimize the potential for generation of fugitive dust, and mist sprays would be used to further control dust (PLP 2020d; PLP 2019-RFI 066a).

Due to the high density of the concentrate, the holds would not be loaded to the top, further reducing any potential for concentrate dust to escape the hold. Approximately five to six trips by the lightering barges would be required to load a bulk carrier, which would be anchored for 3 to 4 days at the lightering location. The bulk carrier ships would transport the concentrate to out-of-state smelters. Up to 27 Handysize ships would be required annually to transport concentrate.

Under the Alternative 1 Summer-Only Ferry Operations Variant, additional storage of concentrate containers would be needed at the mine site and the port site.



Sources: PLP 2018-RFI 045

US Army Corps of Engineers

COPPER-GOLD CONCENTRATE SHIPPING CONTAINER

PEBBLE PROJECT EIS

FIGURE 4.27-1

4.27.6.2 Molybdenum Concentrate

Molybdenum concentrate production would comprise approximately 2.5 percent of the project's total concentrate production (PLP 2018-RFI 066). Molybdenum concentrates produced at the mine site would be loaded into flexible intermediate bulk container (FIBC) bulk bags, then into standard 20-foot-long sea shipping containers. Each day, about 107 wet tons of molybdenum concentrate would be transported from the mine site by truck and/or ferry to the port, for a total of 39,300 wet tons each year (PLP 2018-RFI 065). Molybdenum concentrate would be transported by truck and/or ferry for all alternatives; Alternative 3 Concentrate Pipeline Variant would not include a molybdenum concentrate pipeline because the volume of the concentrate is much lower than the copper-gold concentrate. Molybdenum concentrate containers would be unloaded from the trucks and loaded directly onto barges for transport to off-site smelters; no lightering to marine bulk vessels would be required (PLP 2018-RFI 065).

See the "Mitigation" subsection for a summary of avoidance and minimization/design features to reduce the likelihood of concentrate spills.

4.27.6.3 Fate and Behavior of Spilled Concentrate

This section describes the general fate and behavior of spilled concentrate for a wide range of hypothetical releases. Specific impacts from the selected release scenarios are presented below.

Ore concentrates are composed of finely ground naturally occurring rock and mineral material, and their physical characteristics would be like those of very fine sediment (clay- and silt-sized). If spilled into the environment, the immediate physical fate and behavior would be similar to those of other naturally occurring sediments. However, the chemical characteristics of concentrates are both PAG and capable of ML due to the presence of sulfides and other metallic minerals. In the long-term, over years to decades depending on conditions, spilled concentrates would have the potential to produce acid, and leach metals into the environment.

Concentrate Solids versus Concentrate Slurry

If released on land, concentrate solids would behave like typical fine, clay to silty material. Some of the fine particles of dried concentrate could be distributed by wind as fugitive dust. Recovery of spilled concentrate solids from dry land would involve the use of heavy equipment to collect and recover the material and place it back into the containers.

Concentrate solids spilled into flowing water would be dispersed downstream to some degree, depending on the flow conditions. Concentrate spilled into high-energy streams may be difficult to impossible to recover, because concentrate would likely be rapidly flushed downstream. Concentrate spilled into low-energy water such as ponds or very low-volume streams could be recovered relatively easily, requiring in-water recovery efforts such as dredging/excavating).

Under the Alternative 3 Concentrate Pipeline Variant, concentrate would be transported from the mine site to Diamond Point port through a 6.25-inch-diameter steel concentrate slurry pipeline. At the mine site, contact water would be added to the fine-grained concentrate solids to create a slurry (a thick fluid) with a water content of 45 percent, enabling the slurry to flow in the pipeline (PLP 2018-RFI 066). The fate of released concentrate slurry would be the same as that of the fine-grained concentrate solids, but the behavior of the slurry in the short-term would be different than truck-hauled concentrate because of its high water content and fluid nature.

If the slurry pipeline were to rupture where buried, pressure in the pipe could force the slurry into the surrounding material and possibly to the surface. If concentrate is released to a relatively flat land surface, the concentrate slurry could be recovered relatively easily with heavy machinery. If the concentrate slurry were released onto a slope, the slurry could slowly spread out from the release site and flow downhill; potentially into a waterbody or wetland. Concentrate slurry would not likely permeate very deep into subsurface soils due to its viscous properties.

Trucks would haul concentrate solids over water crossings along road corridors. A concentrate pipeline would be attached to bridge infrastructure at major stream crossings. Therefore, there is a possibility that spilled concentrate could reach a waterbody. If either concentrate solids (truck) or slurry (pipeline) were released into a waterbody, both types of concentrate would initially sink to the bottom. Many of the fine particles would subsequently be entrained in the water, especially where current is present, leading to downstream sedimentation and an increase in total suspended solids (TSS).

Chemically, the concentrate solids and the concentrate particles in the slurry would behave the same way, in that they are both PAG and capable of ML over time, depending on conditions. Both concentrate solids and slurry could have residual amounts of chemical reagents. In addition, concentrate slurry would contain 45 percent untreated contact water, which would have elevated concentrations of metals, including copper. Unlike the metals in the concentrate solids, the metals in the aqueous phase of the slurry would be dissolved and bioavailable, to the extent that the slurry could be acutely toxic in a release.

Sedimentation and TSS

Concentrate particles would mostly be clay- and silt-sized, with a very small fraction of fine sand (Knight Piésold 2018p). A spill of these fine particles into a waterbody could cause both sedimentation and an increase in TSS in the water. The amount of material that remains suspended as TSS versus deposited as sediment depends mostly on particle size and the energy of the water/velocity of the current.

Most of the fine clay and silt particles would be entrained in the water and transported downstream by currents. This would create a downstream "plume" of cloudy, turbid water high in TSS. In high-energy/high-velocity streams, even sand particles can remain suspended for a time, contributing to the TSS level. The increased TSS and turbidity would continue until all the upstream concentrate has been recovered, settled, or naturally flushed downstream.

Sand particles are heavier, and would be more likely to remain on the streambed as "bedload." High-energy streams would continue to transport some of the bedload downstream. In lower-energy streams, deposited sediment could remain as stream bedload, especially in areas of weak current such as oxbows. An increase in sedimentation could bury existing substrate, and fill in voids in larger particles of substrate, such as between clasts of gravel, modifying the streambed habitat. Similar impacts could result from a spill of concentrate into a marine environment.

Fugitive Dust Generation

Spilled concentrate that is not recovered could dry out and produce dust. The copper-gold and molybdenum concentrates transported by truck or ferry would have 8 and 5 percent moisture, respectively (PLP 2018d), which would initially cause the particles to flocculate, or stick together. The copper-gold slurry would be wet, with 45 percent moisture; but on drying, could also generate dust. Concentrate dust would be PAG, and have potential for ML over time. Wind-blown fugitive dust could spread the PAG and ML material across a wider area, potentially impacting soils, waterbodies, vegetation, and air quality.

Factors Influencing Acid Generation and Metals Leaching

The following discussion of acid generation and metals leaching is relevant to spills of both concentrate and tailings. Background information on these chemical processes is provided in Section 3.18 and Section 4.18, Water and Sediment Quality, and is addressed in this section as relevant.

Solid particles of concentrate and tailings released into waterbodies can cause initially elevated levels of metals in their *total form*, while the fine particles remain suspended in the water column. Once particles have flushed from the waterbody or settled in the waterbody substrate, total metals levels in the water column decrease. Metals are generally not bioavailable in their total form, and do not become bioavailable until they are dissolved through the process of ML.

A variety of chemical and physical factors determine the potential for acid generation and ML from rock and rock particles/tailings. Major factors are summarized here and include:

- Chemical composition of the material (the amount of sulfur that could generate acid and the amount of leachable metals in the material): The copper-gold concentrate, for example, would contain approximately 27 percent sulfur (as sulfide minerals) and 26 percent copper. In comparison, the pyritic tailings would contain 15 percent sulfur and 0.26 percent copper (PLP 2018-RFI 045).
- Climate/temperature: Acid generation and metals leaching are generally faster chemical reactions at higher temperatures, and slower reactions at lower temperatures. These rates would be lower in the cold climate of the project, where freezing conditions for most of the year slow these chemical processes.
- pH: The leaching of most metals happens more readily at a lower (more acidic) pH; some metals and metalloids, however, leach readily at neutral or higher (more basic) pH. pH is variable in waters across the analysis area.
- Particle size: Smaller particles, such as the ground rock particles that make up concentrate and tailings, have a higher surface area per volume than larger rocks, so that acid generation and metals leaching can occur more readily from small particles. Laboratory testing generally tests very fine silt-sized particles to obtain a conservative estimate of acid generation and leaching rates, while field-based testing uses larger rock samples. Laboratory testing occurs at controlled temperatures, while field testing is subject to local climate conditions. Variation in these data is to be expected. The Applicant provided both field and laboratory data, which are summarized in this section and further addressed in Section 3.18 and Section 4.18, Water and Sediment Quality.
- Buffering capacity: Buffering capacity is the ability of water to resist a change in pH from addition of an acid or a base. Buffering capacity is variable in waters across the analysis area. Alkalinity is generally low in surface waters in the analysis area.
- Dissolved oxygen (DO) content: Water limits the diffusion of oxygen. Still/stagnant water contains essentially no DO, while flowing water (such as in streams) or circulating water (such as in overturning lakes or shoreline areas) can contain variable amounts of DO. The oxidation of sulfides, which can form acid, can potentially occur in flowing or circulating waters, although at a much slower rate than that from air exposure.

This EIS recognizes that potential rates of acid generation and metals leaching would vary in spill scenarios, and has adopted a conservative estimate of "years to decades" to address the potential timing of these processes. It is also recognized that these processes, once initiated, would be ongoing for centuries to millennia, as is constantly occurring in natural rock formations, depending on conditions.

Acid Generation

The copper-gold and molybdenum concentrates would contain approximately 27 and 35 percent sulfur, respectfully, as sulfide minerals (PLP 2018-RFI 045). When exposed to the oxygen gas present in air or oxygenated water, sulfide minerals can oxidize over time, and generate sulfuric acid in the presence of water. Both types of concentrate are PAG (see Section 3.18, Water and Sediment Quality, for discussion of PAG geochemistry). When sulfide minerals are stored sub-aqueously under still or stagnant water, dissolved oxygen is largely absent, so that the minerals cannot be oxidized, and sulfuric acid cannot be formed. Flowing water such as streams contains some dissolved oxygen, so that sulfide minerals in flowing water can be oxidized to generate acid, although at a much slower rate than when exposed to air. Lake water that experiences high circulation/turnover can become well oxygenated, as can shallow intertidal waters. In these environments, sulfide minerals can also be oxidized to generate acid, although at a much slower rate than when exposed to air.

Concentrate that remains on land could oxidize, and later produce sulfuric acid when exposed to water (e.g., rain), which could impact surrounding resources, and potentially be transported into waterbodies, affecting water quality and/or aquatic biota. However, acid generation from sulfide minerals requires years to decades; and during this slow process, any generated acid would be continually diluted by the region's precipitation and surface water recharge.

Metals Leaching

The copper-gold concentrate would contain about 26 percent copper and 1.6 percent molybdenum, and the molybdenum concentrate would contain 50 percent molybdenum and 1.5 percent copper (PLP 2018-RFI 045). Although naturally occurring, metals such as copper can potentially cause long-term impacts when introduced into the environment in elevated concentrations (compared to background levels). Metallic minerals in the concentrate solids would not be immediately soluble in water, and the leaching of metals into the environment would likely require years to decades. Metals present in the aqueous phase of the concentrate slurry would be dissolved and bioavailable, and could cause exceedances of water quality criteria if released in a spill.

As described above for acid generation, particle size is also a factor in potential metals leaching, because metals leaching can happen more quickly from small particles, such as concentrate and tailings. Laboratory testing generally tests very fine silt-sized particles to get the most conservative estimate of metals leaching rates, while field-based testing often uses larger rock samples to determine leaching rates. The Applicant provided both field and laboratory data on leaching rates, so variation in these data is to be expected. This EIS has adopted a conservative estimate of years to decades to address the potential timing for the onset of metals leaching.

4.27.6.4 Historical Data on Concentrate Spills/Spill Frequency and Volume

Operators of various mines across Alaska have reported spills of ore concentrates. Most reported spills are less than 100,000 pounds, and records indicate that most of the spilled material is recovered (ADEC 2018h).

Trucking

The Red Dog zinc and lead mine in northwestern Alaska is an appropriate data analog for the Pebble mine, based on similar transport of ore concentrate from the mine site by truck/trailer to a port. Red Dog concentrate spills data are therefore used in determining spill probabilities for the project. Zinc and lead concentrates are trucked from the Red Dog mine site on a 52-mile-long haul road (DeLong Mountain Transportation System) to shallow water port facilities on the

Chukchi Sea near Kivalina. As of 2005, haul trucks at Red Dog mine hauled 85 tons of concentrate in two side-dump trailers (AECOM 2019a). Note that the Applicant would haul 114 tons of concentrate in three trailers. The risk of a trucking accident from hauling three trailers may be higher than for hauling two trailers. Red Dog operations hauls less concentrate per truck trip, but each trailer at Red Dog would haul more concentrate (approximately 42.5 tons per trailer) than each trailer that would be hauled by the Applicant (approximately 38 tons).

The ADEC Spills Database lists 18 trucking-related reported concentrate spills along the Red Dog haul road between July 1995 and August 2018 (ADEC 2018h). A media report notes the mine operator as having reported approximately 30 trucking-related concentrate spills since the mine opened in 1989 (Alaska Journal 2002). Trucking-related concentrate spills recorded in the database range in size from 10 to 145,000 pounds (from a truck rollover); however, most spills are in the range of 20,000 to 80,000 pounds, with an average of 43,000 pounds. Recovery of spilled concentrate on land is straightforward, simply requiring collection of the material with heavy equipment. Most spills on the Red Dog haul road have been recorded as impacting land only, and report full recovery/recycling of spilled material. Spills into surface water, however, especially into flowing water, can be difficult to impossible to recover. A truck rollover on the Red Dog haul road in 2015 resulted in a spill of 145,000 pounds of concentrate that impacted a freshwater resource. No recovery information is provided for this spill, and the case is not listed as closed.

Generation of fugitive dust from zinc and lead concentrate was a concern at Red Dog Mine after mining operations began in 1989. Concentrate was originally trucked along the road from the mine to the port in trailers covered only by tarps, allowing concentrate dust to escape and be deposited along the roadbed, resulting in adverse impacts. In 2002, Red Dog converted their operations to include hard-covered trailers with lids, and dust generation was subsequently reduced. (Details on the locking capabilities of the concentrate containers currently used at Red Dog are not available.) Areas surrounding the haul road are being monitored as part of the state's contaminated sites cleanup process (ADEC 2018d). Note that the Applicant would haul concentrate in specialized containers with locking lids, so that fugitive dust generation as observed at Red Dog Mine would not be anticipated.

Concentrate Pipelines

Very few concentrate pipelines are in operation, and no published failure rates are available. Most of the available pipeline failure data come from oil and gas pipelines.

Historically, most pipeline failures are due to external corrosion and mechanical damage by excavating equipment or other vehicles (PHMSA 2018). The likelihood of external corrosion (rusting) increases over time. Data specific to corrosion rates of concentrate pipelines are not readily available, but in general for gas transmission, gas gathering, and hazardous liquid pipelines, corrosion accounted for approximately 17 percent of reported pipeline incidents in recent years, based on PHMSA data between 2013-2017 (PHMSA 2018b). The rate of external corrosion of pipelines would depend on climate, and would increase over time. Based on a 20-year operational lifetime of this pipeline, external corrosion leading to failure would be very unlikely. Rates of external corrosion would be expected to increase over time (see the "Cumulative Effects" subsection).

EPA (2014) points out that the potentially corrosive nature of the concentrate slurry could increase pipeline failure rates above historic failure rates due to internal corrosion. As described in the "Mitigation" subsection, the concentrate pipeline would have a full internal liner that would protect against internal corrosion.

Mechanical damage to the pipeline by vehicles would also not be likely during the project due to the remote nature of the project area, the controlled access of the road corridor, and no anticipated excavation equipment activity near the pipeline.

Marine Vessel

US Coast Guard (USCG) and PHMSA databases contain no records of ore concentrate spills from marine vessels (USCG 2018; PHMSA 2018). The ADEC database has no records specific to concentrate spills from marine vessels in Alaska (ADEC 2018h). Spill rates of hazardous materials from marine vessels are extremely low (USCG 2018).

Historically, at ports serving mines around the world, there have been concerns with spills and escape of fugitive dust during overwater transfer of concentrate from containers into bulk cargo vessels. Transfer operations technology has dramatically improved in recent years. At the Red Dog Mine, for example, concentrate is loaded from land-based storage into lightering barges, and then into the holds of deepwater vessels—entirely through a system of enclosed conveyor belts—greatly reducing the potential for spills and/or fugitive dust generation. There are no records of concentrate spills from marine vessels or during overwater operations at Red Dog Mine (ADEC 2018h).

PLP's method of overwater transfer of concentrate into bulk carrier vessels, as described in the "Mitigation" subsection, would also greatly reduce the potential for spills and/or fugitive dust generation. The method would involve opening concentrate containers only once they are deep within the ship's hold, and allowing concentrate to fall no more than 10 feet, so that there would be very limited turbulent rise of concentrate dust.

Iliamna Lake Ferry

There are no historical data available on ore concentrate spills from ferries. Historical data show that spill rates from marine vessels are generally very low (USCG 2018). Spill rates from the ferry would be expected to be comparable to those of marine vessels or even lower, due to the specialized design and operation of the ferry.

4.27.6.5 Existing Response Capacity

There are currently no organizations in Alaska that specialize in response to spills of ore concentrates. PLP would have a spill response plan in place that would address spills of ore concentrate and other hazardous materials.

4.27.6.6 Mitigation

PLP would have a spill response plan in place that would address spills of ore concentrate and other hazardous materials (see mitigation measures in Chapter 5, Mitigation, and additional mitigation discussion in Appendix M1.0, Mitigation Assessment).

Spill-Prevention Measures: Copper-Gold Concentrate

Summary of mitigation measures presented in PLP 2018-RFI 045:

- Bulk cargo containers are designed specifically for transporting ore concentrates from mine sites to marine vessels for the global mining industry.
- Containers are certified in accordance with the International Maritime Dangerous Goods code for transport of dangerous cargo.

- Containers are constructed of heavy steel with removable locking lids. Lids would be locked after loading at the mine site and would not be opened until the container is within the hold of the marine bulk carriers.
- Lids are designed to seal to prevent rainwater entry or release of fugitive dust.
- Containers would be secured to truck trailers by standard ISO container twist-lock system on the corners.
- On the barge and ferry, containers would be positioned on pins to prevent sliding on the deck from vessel motion. A second layer of containers would be stacked up using the same ISO container twist-lock system on the corners.
- Accidental upset of the containers would be contained by the sides of the ferry or the deck of the barges.
- Containers are designed to keep their lids intact in the event of a rollover. Containers have been tested and have demonstrated minimal spillage of product when overturned. If a container were to overturn on land, a forklift or crane would be used to lift and reposition it. Any spilled material would be picked up using a shovel, loader, or vacuum truck as appropriate.
- In the event of a container falling overboard, its recovery would be dependent on water depth and lake/sea conditions.

Fugitive Dust Control Measures: Copper-Gold Concentrate

For Alternative 1a, Alternative 1, Alternative 2, and Alternative 3 base case, copper-gold concentrate containers would be lightered out to moored bulk carriers at one of the lightering locations and emptied into the open hold of the vessel. For Alternative 3 Concentrate Pipeline Variant, concentrate would be transferred by conveyor, lightered out on the decks of barges, scooped up from the decks by wheeled loaders into ship loaders, then loaded into the open hold of the bulk carrier.

These processes have the potential to generate fugitive dust. This potential would be minimized with the following measures:

- For Alternative 1a, Alternative 1, Alternative 2, and Alternative 3 base case:
    - A barge-mounted crane with a specialty spreader unit would lower containers deep into the open hold of the vessel; it is only at that point that the system would unlock the lid and turn the container upside down to release the concentrate into the ship's hold.
    - The crane operator would be responsible for lowering the container deep enough into the hold so that the concentrate falls less than 10 feet, and the discharge elevation is 20 feet or more below the hatch (PLP 2018-RFI 045; PLP 2018c). This prevents falling concentrate from causing turbulent disturbance of concentrate and eliminates any cross-winds from blowing the concentrate out of the ship's hold.
    - The hold would be filled with concentrate to only approximately 50 percent of the maximum capacity of the hold. (The hold could not be filled completely due to the density/weight of the concentrate.) A typical bulk carrier hold is 60 feet in depth. Therefore, the highest discharge elevation of concentrate would be 20 feet below the hatch (PLP 2018-RFI 009c).
    - Copper-gold concentrate is moist (8 percent moisture), which helps to reduce dust generation.

  - If necessary, a water fog system could be installed around the perimeter of the hatch to further moisten the concentrate and capture potential dust.
  - Loading operations would be interrupted when warranted by sea and weather conditions (PLP 2018-RFI 045, RFI 032).
  - After containers have been emptied, lids would be re-installed to avoid any residual material from escaping, and they would be returned to the barge and taken to shore. Each container would then have its exterior cleaned with a vacuum or spray system at the port site prior to being returned to the mine for refilling.
  - Container lids would remain in place until arrival at the mine (PLP 2018-RFI 045).
- For Alternative 3 Concentrate Pipeline Variant:
  - Concentrate would be transferred from the storage building to the barge-loading area by fully enclosed conveyors to contain dust (PLP 2019-RFI 066a).
  - The barge loader would employ an enclosed conveyor boom and telescoping spout to distribute the cargo onto the barge deck with mechanical dust collection (PLP 2019-RFI 066a).
  - The lightering barges would have dust covers to control dust emissions (PLP 2020d).
  - The loading trunk of the ship loader would extend down into the hold of the ship to minimize the potential for generation of fugitive dust, and mist sprays would be used to further control dust (PLP 2020d).
  - The holds of the bulk carriers would not be loaded to the top, further reducing any potential for concentrate dust to escape the hold (PLP 2020d).

Fugitive Dust Control Measures: Molybdenum Concentrate

Molybdenum concentrates would be loaded into FIBC bulk bags and then into standard 20-foot sea containers. The doors at the end of the containers would be sealed for transport, and the bags would not be unloaded until they reached their destination at an off-site smelter (PLP 2018-RFI 045).

Avoidance and Minimization/Design Features of Concentrate Pipeline

The following is a summary of mitigation measures presented in PLP 2018-RFI 066:

- The 6.25-inch steel pipeline would contain an internal high-density polyethylene liner to prevent internal corrosion.
- Cathodic protection system (zinc ribbon or similar) would be used to prevent external corrosion.
- A pressure-based leak detection system would monitor pipeline for leaks.
- Rupture discs and pressure monitoring would protect the pipeline from overpressure events.
- The pipeline would be protected from freezing and buried with approximately 36 inches of cover, or deeper in areas where needed to prevent freezing (Chapter 2, Alternatives). At major stream crossings, the pipeline would be attached to the vehicle bridges and protected from freezing.
- Aboveground sections and pipeline bridge crossings would employ heavy wall pipe or casing for additional protection.
- Manual isolation and drain valves would be located at intervals no greater than 20 miles apart.

- Major river crossings would have isolation valves and pressure and temperature monitoring instrumentation installed.
- Decisions on the appropriate methodology for individual stream crossings would be made in consultation with the ADF&G Habitat Division.

4.27.6.7 Concentrate Spill Scenarios

These scenarios address the probability and consequences of spills of copper-gold concentrate. Molybdenum concentrate is not considered herein, because it would make up only 2.5 percent of the total concentrate produced and would therefore be subject to much lower spill potential. In addition, only copper-gold concentrate has been considered for transport by slurry pipeline as part of the Alternative 3 Concentrate Pipeline Variant.

Concentrate spills from a truck rollover and a concentrate slurry pipeline rupture were analyzed for potential impacts. Spills of copper-gold concentrate from over-water transfer, a marine vessel, and the Iliamna Lake ferry are addressed below, but were ruled out as unrealistic probabilities of occurrence, and not selected for impacts analysis.

Scenario: Concentrate Spill from a Truck Rollover

This scenario addresses the probability and consequences of a spill of 80,000 pounds of copper-gold concentrate into the environment due to a truck rollover along one of the access roads. An 80,000-pound spill was selected for this scenario because it represents the upper range of the average spill size from the Red Dog Mine analog data, presented above. The upper range size was selected to address a broader range of potential impacts.

In this scenario, a truck hauling three trailers, each with a full container of 76,000 pounds of concentrate, rolls over onto the side of the road corridor. The lid-locking mechanisms on two of the containers are damaged, allowing the lids to open, and about half of the concentrate from each container spills out. A total of 80,000 pounds of concentrate is released onto the roadside area. In this scenario, even if the spill were to occur on a bridge over a stream, most of the spilled concentrate would not be likely to end up in the stream. Concentrate would be composed of relatively dense, moist particles. In the event that a container of concentrate overturned, some concentrate would spill out onto the roadway, while some of the material would likely remain in the overturned container. Due to the density and solid nature of the material, the concentrate would not readily mobilize from the roadway into adjacent waterways. The impacts assessment therefore assumes that only a small portion (perhaps 10 percent) of spilled concentrate may spill into a stream. This would equate to approximately 800 pounds of concentrate, or 72 ft^3.

No studies have been identified that analyze trucking-related spill rates on private, controlled-access industrial roads, such as the project access roads (ARCADIS 2013). The probability of this scenario is therefore based on available historic spill data from transport of ore concentrate along the 52-mile haul road used by Red Dog Mine (as discussed above), the most relevant concentrate transport analog in Alaska. Based on the ADEC record of spills at Red Dog Mine, the estimated spill rate per mile for a trucking-related concentrate spill in the project was calculated to be 0.78×10^{-6}, which equates to an average of 0.4 trucking-related concentrate spills per year for 66 miles of road transport. Note that miles of road transport vary by alternative from 53 to 82 miles (Table 4.27-1). Sixty-six miles was used in the original calculation for the Alternative 1 road corridor. This equates to a 33 percent probability of such a spill in any given year, and a 100 percent probability in 10 years or more (i.e., 100 percent probability during the proposed 20-year project); or an average of one spill every 2.5 years (AECOM 2019a). (Note that in the expanded mine scenario, concentrate would be transported by pipeline, not by truck.) As noted above, as of 2005, haul trucks at Red Dog Mine hauled 85 tons (170,000 pounds) of concentrate in two side-dump trailers (AECOM 2019a). Note that the Applicant would haul 114 tons (228,000 pounds) of concentrate in three trailers. Red Dog Mine operations hauls less concentrate per truck trip, but each trailer at Red Dog would haul slightly more concentrate (approximately 42.5 tons/85,000 pounds per trailer) than each trailer that would be hauled by the Applicant (approximately 38 tons/76,000 pounds). The spill size of 80,000 pounds is representative of the range of typical concentrate spills from Red Dog Mine between 1995 and 2017; however, 80,000 pounds are slightly less than would be hauled by one Red Dog trailer, and slightly more than would be hauled by one of the Applicant's trailers.

If the concentrate were to spill into a stream, the bulk of the material would sink to the bottom, while the finer particles of concentrate would become suspended and transported downstream by the current. The remaining fine particles at the spill site would continually become entrained in the current and flushed downstream, and the downstream water would become turbid with elevated levels of TSS. Some of the material would be deposited along the streambed, especially in side-channels or other areas where the current is weak. Some material could be flushed downstream into Iliamna Lake or Iliamna Bay, where some of the particles may eventually settle out as deltaic deposits. There are numerous stream crossings along the road corridors for all alternatives, so there is a reasonable probability of this scenario occurring at a stream crossing.

Spill Response

PLP would have a spill plan in place that would detail the measures to prevent, respond, contain, report, and cleanup spills of concentrate and other potentially hazardous materials. See the "Spill Preparedness, Prevention, and Response Measures" subsection. Drivers would be trained in spill reporting and procedures to minimize and contain low-volume spills, and the driver would be able to conduct an initial response and call for assistance immediately.

If the spill were to occur on dry land, the concentrate would simply accumulate on the roadside. Recovery efforts would be straightforward, with any spilled concentrate recovered back into the containers by heavy equipment. The process would require very thorough cleanup to avoid residual spilled material that could generate fugitive dust.

If the concentrate were to spill into one of the small ponds present along the road corridors, it would sink to the bottom, and create short-lived clouds of turbidity/elevated TSS that would then settle out. Spilled material could be excavated or dredged from the pond, and recovery efforts would likely be effective. Residual amounts of concentrate could remain in the waterbody after cleanup.

The recovery of concentrate spilled into a stream would range from difficult to impossible, depending largely on the strength of the current, which would vary with each stream, and would also vary seasonally. In low-energy streams, much of the spilled concentrate may remain at the spill site for days before being flushed downstream, allowing crews time to dredge/excavate the material from the streambed. Some volume of the concentrate would be transported downstream and deposited along the streambed.

High-energy streams could likely transport most or all of the spilled concentrate downstream of the spill site within 24 hours. By the time crews could mobilize for a response, much of the material would likely be dispersed downstream, making recovery impossible/impractical. Concentrate would become widely dispersed along the streambed, and some of it would remain suspended in the water as long as the current remained strong. Concentrate would settle on the streambed in some areas of lower water velocity, but then would be remobilized by the current during periods of higher stream flow. Depending on the volume that enters the stream, much of the spilled concentrate could naturally flush out of the drainage within weeks to months, while some of the material that settles in low-energy reaches could remain for years to decades. Remaining concentrate would slowly be flushed downstream over ensuing decades, where the material would collect in deltaic deposits at the shoreline of Iliamna Lake or Iliamna Bay.

If the spill occurred during frozen conditions, concentrate would likely collect on top of frozen soil or the surface of frozen waterbodies, facilitating recovery. In some situations, spilled concentrate may penetrate ice on a frozen waterbody, allowing concentrate to spill into the waterbody below. In areas where ice is inconsistent, thin, or fractured, concentrate could enter incompletely frozen waterbodies or flowing water, complicating recovery efforts. Adverse environmental conditions such as heavy rain or snow could also complicate recovery, and strong winds could spread fugitive dust from the spilled concentrate prior to recovery.

Alternatives Analysis

The potential for a concentrate haul truck rollover could vary somewhat by alternative; road corridor lengths and road conditions, such as grade, would vary between alternatives. Alternative 1a would include 72 miles of road transport; Alternative 1 would include 65 miles of road transport; Alternative 2 would include 53 miles; and Alternative 3 would include 82 miles of total road transport. The road corridor for Alternative 3 would be expected to have more road segments with higher grade, based on more steep topography in the southern and eastern portions of the road corridor. Final road design, including grades, has not yet been determined.

Alternative 3 would not involve concentrate transport by ferry, so there would be no potential for concentrate spills from the ferry into Iliamna Lake. The Alternative 3 Concentrate Pipeline Variant is addressed with a spill scenario from the concentrate pipeline, below.

Potential Impacts of a Concentrate Spill from Truck Rollover

This section addresses potential impacts of a copper-gold concentrate spill from the truck rollover scenario described above. Impacts were analyzed in terms of their magnitude, duration, geographic extent, and potential to occur. A concentrate spill would not impact all the resources addressed in this EIS. The following resources were selected for analysis based on their higher potential for impacts.

Soils

Concentrate spilled onto soils would be recovered so that there would be no impact. Historical data from Red Dog Mine show that most concentrate spills that impact land only and do not enter surface water have a nearly 100 percent recovery (ADEC 2018h). Assuming the spill response as described in this scenario, residual concentrate or fugitive dust produced would not be likely to have impacts on soil quality exceeding soil quality criteria.

Water and Sediment Quality

If spilled concentrate does not enter surface water drainages, and recovery of spilled concentrate is prompt and thorough, there would be no anticipated impacts to surface water quality. If concentrate does enter surface waterbodies, depending on the location of the spill and the effectiveness of recovery efforts, the impacts discussed below could occur.

TSS and Turbidity—Fine particles of concentrate (silt and clay-sized) spilled into flowing water would become suspended in the water, creating a large plume of turbid water that would travel downstream. The plume could cause all downstream water in the channel to become turbid, with elevated TSS, until dispersing/settling out in a larger waterbody. The extent of the elevated TSS could be tens of miles downstream, especially where currents are strong. If spilled concentrate is recovered promptly, the duration of the TSS and turbidity would likely last for a few days. If the concentrate is not recovered, the duration of impacts could be weeks to months. If concentrate were to spill into a dry or very low-volume stream, most of the material would likely be recovered. If concentrate spilled into a low-volume stream and was not recovered, the material could be remobilized during periods of higher water levels. This could cause elevated TSS and turbidity to extend for additional months to years.

Sedimentation—If concentrate is released into flowing water, some of the particles would be deposited as sediment downstream, especially in areas where the current slows. Concentrate could bury existing stream-bottom sediments and fill in interstitial spaces between gravel clasts, modifying benthic habitat.

Acid Generation—For a discussion of factors that impact the ability of concentrate particles to generate acid, see "Factors Influencing Acid Generation and Metals Leaching" in the "Concentrate Spills" subsection.

Sulfide minerals in unrecovered concentrate, which would be deposited in limited areas, would slowly dissolve over years to decades. To produce acid, the sulfur needs to be oxidized. A small amount of oxygen can be dissolved in flowing water, and almost no oxygen would be present in still or stagnant water. Circulating water such as in Iliamna Lake can be periodically enriched in oxygen. Mean concentrations of oxygen in project area streams ranged from 10.2 to 10.5 mg/L, and 12.3 mg/L is the theoretical saturation limit for local conditions (Section 3.18, Water and Sediment Quality). The oxygen concentration in flowing water is capable of generating a small amount of acid from spilled concentrate; however, the process of acid generation would be slow, and any acid generated would be constantly diluted by the flowing water. As long as concentrates remain under water, acidic conditions would not be likely to occur. If concentrate were to spill into ponds or non-flowing water, it could be recovered. Any residual concentrate remaining on dry land for multiple years could potentially generate acid. In low-water conditions, or in deltaic environments, additional spilled concentrate could be exposed to air, increasing the potential for acid generation. In addition, concentrate that has settled on streambeds could be resuspended during flooding/storm events and could be further oxidized. The acid could be flushed into surface water, potentially reducing the pH of waterbodies. The rate of acid production is slow, however, and surface water so abundant, that any acid produced would be rapidly diluted, so that in this scenario, no measurable reduction in surface water pH that would exceed WQC would be likely to occur. (Note that "no measurable" change in pH means that any changes would be indistinguishable from natural background variation).

Metals Leaching—For a discussion of factors that impact the ability of concentrate particles to leach metals, see "Factors Influencing Acid Generation and Metals Leaching" in the "Concentrate Spills" subsection.

Downstream waters would be elevated in metals in their *total form,* while concentrate particles remain suspended in the water column. The metallic minerals in the concentrates are not readily soluble in water, so spilled concentrate would not immediately introduce metals in a bioavailable form. If spilled concentrate is promptly removed from the impacted waterbody, there would be no measurable leaching of metals. (Note that "no measurable" leaching means that any changes in metals levels would be indistinguishable from natural background variation.) If concentrate is not recovered, however, some of the metallic minerals would slowly dissolve over years to decades, potentially leaching metals into the water.

If the spill enters flowing water, some of the concentrate would be dispersed downstream. Even after a prompt and thorough spill response, some of this concentrate would not be recovered. However, due to the limited amount of concentrate that could remain in the streams, and the dilution of the slowly leached metals from stream water, the ML would likely not be a measurable impact.

If concentrate were to spill into ponds or non-flowing water, it could be recovered. Concentrate that is not recovered from isolated waterbodies, such as ponds, could leach metals that would not be diluted/flushed out. Water quality in these isolated waterbodies could be impacted by elevated metals levels.

The concentrates may also contain residues of chemical reagents. See the "Reagent Spills" section for a discussion of reagent fate and behavior in the environment.

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

No impacts to groundwater quality would be expected from this scenario.

If spill recovery involves dredging, BMPs would help to lessen the potential for erosion of streambed and shoreline sediments.

Residual Toxins—Concentrate may also contain residues of chemical reagents, including sodium ethyl xanthate and sodium hydrogen sulfide, both of which can be toxic to fish in low concentrations. See discussion of chemical reagents below under Reagent Spills. The amount of these reagents introduced into the environment in this scenario would be very minor.

Noise

Noise could be generated from spill recovery operations, including increased vehicle traffic, and use of cleanup equipment. If the increase vehicular traffic would be less than double the amount of existing traffic, then the noise level increase would be less than a 3-dBA increase over existing traffic noise levels (generally less than noticeable). Noise from cleanup equipment would depend on the type of equipment used. However, equipment such as pumps, tractors, heavy-haul trucks, and Vac-trucks would have a maximum noise level of approximately 85 dBA or less at 50 feet (FHWA Roadway Construction Noise Model) and would be limited to the cleanup area for the duration of the cleanup and recovery effort.

Air Quality

Concentrate deposited on land that is able to dry out has the potential to become airborne fugitive dust in the form of particulate matter and particulate hazardous pollutants. In the case of a concentrate spill on dry land, recovery of the concentrate would be straightforward, with most of the concentrate likely recovered. Only residual concentrate would likely remain at the spill site, which could dry and out produce potential fugitive dust. Assuming the spill response as included in the scenario, any fugitive dust produced could have localized and temporary impacts on air quality. If spill response was delayed, concentrate could dry out and spread more readily as fugitive dust.

The magnitude and potential of the impacts would depend on the amount of concentrate that deposited on land and meteorological conditions at the time of the spill. A larger spill with strong winds would likely increase the air quality impacts. Concentrations of particulate matter could temporarily exceed the NAAQS concentrations; but over time, the air quality would return to pre-spill conditions. The duration of air quality impacts would be temporary and would return to pre-activity levels at the completion of the activity. The extent of impacts would be limited to discrete portions in the project area, where the spill took place.

Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

Across all alternatives, less than 10 percent of the road corridor passes through wetlands or waterbodies, while the remainder is uplands. This analysis describes the impacts if the spill were to occur in wetlands or waterbodies. A spill into a pond, lake, or stream would impact surface waters as discussed above for Water and Sediment Quality. A spill into vegetated wetlands would primarily affect scrub-shrub and emergent vegetation, because these wetland types represent more than 99 percent of the vegetated wetlands in the transportation corridor.

The magnitude of impact is directly related to the location and timing of the spill. If it occurs during the winter while the waters and wetlands are frozen, then cleanup activities are likely to be more effective, and with a lower magnitude of impact compared to a spill during open-water season, when the spill would be more difficult to clean up, and therefore, more of it would enter waters or wetlands. Vegetation and any wetlands or special aquatic sites that are buried by the concentrate would experience high impacts. Vegetation may also be impacted during cleanup activities.

Concentrate solids would not be expected to affect wetlands through acid generation or ML in the short-term. Over years to decades, any unrecovered concentrate solids in the wetland area could produce acid or metals.

Wetlands and waters could be affected by sedimentation from concentrate solids. Concentrate could bury wetland plants and alter the substrate of exposed waterbodies. As described in the "Water and Sediment Quality" subsection, concentrate released into flowing waters would result in some of the particles being deposited as sediment downstream, especially in areas where the current slows. Adjacent riparian vegetation, including any wetlands or special aquatic sites present, could be covered.

The extent of the area impacted depends on the timing and location of the spill and the effectiveness of the spill response. Spills that occur into flowing water and those that occur in the open-water season are likely to affect a larger area than those that occur during the winter, because concentrate could become entrained in water and be transported. During partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), concentrate may be trapped beneath ice and spread out in flowing water. During frozen conditions with complete ice cover, concentrate is more likely to spill onto frozen surfaces and not spread out as much, and may be easier to clean up.

The duration of impacts is also related to the timing of the spill and the speed of cleanup. Spills that occur during the open-water season may require more time to clean up, and more time for wetlands to recover: possibly several growing seasons. Spills that occur during the winter would be more likely to spill onto frozen surfaces and not spread out as much; therefore, recovery may be faster. During partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), concentrate may be trapped beneath ice, potentially prolonging cleanup and duration of impacts.

Terrestrial Wildlife

Potential impacts from a concentrate spill in upland vegetation communities along the transportation corridor are anticipated to have low-magnitude, localized impacts of temporary duration (from days to weeks depending on cleanup activities) on terrestrial wildlife. Depending on the terrain where the spill occurs, the concentrate may flow downhill until it is stopped by natural topography, vegetation, and gravity. Some dust may be blown into adjacent vegetation; however, most of the concentrate would be removed, thereby reducing impacts on wildlife. It is unlikely that wildlife species would consume the concentrate, because wildlife are anticipated to avoid (and may be hazed from) the area during cleanup activities. There is a low potential that a few small mammals (such as voles, shrews, and lemmings) may be covered by concentrate at the time of the spill.

Historical data from Red Dog Mine show that most concentrate spills that impact land only and do not enter surface water have a nearly 100 percent recovery (ADEC 2018h). Spill duration would last until cleanup activities had removed most of the concentrate, which is anticipated to last a short time (perhaps up to a month); and rain is expected to wash off any remaining concentrate dust from the surrounding vegetation. Under the spill scenario, residual concentrate or minor fugitive dust produced may occur at low levels in a small, localized area around where the spill had occurred.

If a concentrate spill occurs and enters flowing water, concentrate would be carried rapidly downstream and dispersed. Increased TSS/turbidity and sedimentation in a waterbody from a concentrate spill have a potential to smother salmonid eggs in the immediate area of the spill. The smothering of eggs is likely only in the immediate area of the spill (under low-flow conditions or in a small stream), and would only impact eggs in the immediate footprint of the spill.

Leaching of metals from concentrate would likely require years to decades (see the "Fate and Behavior of Spilled Concrete" subsection). Moreover, copper does not bioaccumulate in fish, and therefore does not pose a consumption risk to bears (*Ursus* species), gray wolves (*Canis lupus*), or other terrestrial wildlife that consume salmon (EPA 2014).

Spills that occur during winter months are less likely to impact wildlife species, because many species are hibernating, or have reduced levels of activity and movement. Frozen substrates may allow for more efficient spill response and clean up, and limit the spread of concentrate, although incomplete or broken ice may allow concentrate to spread beneath the ice. Winter spills would be anticipated to have a low impact.

If a spill occurs in a pond, or other stagnant water location, impacts may extend longer, depending on the level of cleanup. If wood frogs occur in the pond, they could be impacted by cleanup activities; and over years to decades, any unrecovered concentrate solids in the wetland area could produce acid or metals.

In summary, a concentrate spill is anticipated to have a small localized impact on a discrete geographic area (while it is cleaned up), with a low magnitude and temporary duration lasting from days to weeks, depending on the amount of time to clean up the spill.

Finally, residual amounts of reagents would be released into the environment with the concentrate in this scenario. The small amount of reagents released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts from these toxins would be localized and of low magnitude.

Birds

Bird species in the immediate vicinity of a spill are likely to initially vacate the area, reducing potential impacts to birds. A spill during spring, summer, and fall may have the greatest magnitude, because migrating and breeding, and young-of-the-year birds are present. Spills that occur during winter months are less likely to impact birds, because most species have migrated south, and frozen substrates permit more efficient spill response and cleanup. For a spill during the summer, there is a low potential for bird species that nest on the ground to be impacted if a spill flows or covers up their nest or young. Species known to occur in the area that nest close to or on the ground include spruce grouse (*Falcipennis canadensis*), ptarmigan species (*Lagopus* species), fox sparrow (*Passerella iliaca*), common redpoll (*Acanthis flammea*), and dark-eyed junco (*Junco hyemalis*), among others. Because the area affected would be small, the number of birds likely to be impacted would be small. In upland terrestrial habitats, the concentrate would be cleaned up, and any fugitive dust or remaining concentrate on vegetation would be washed off during rain events.

If the concentrate spill occurs in a marsh, pond, or other non-flowing waterbody, the concentrate would be cleaned up, and is not expected to result in ML or copper toxicity to fish or invertebrates; and some waterbirds (such as ducks, geese, waterfowl, loons, grebes, mergansers, and others) and shorebird species may temporarily be displaced during cleanup activities. If cleanup activities occur during the summer breeding season near nests, some species may abandon their nests, which may result in breeding failure or loss of clutches. Therefore, impacts are anticipated to have a low magnitude in a localized area with a temporary duration.

Residual amounts of reagents that have not biodegraded would be released into the environment with the concentrate in this scenario. The small amount of the reagents released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts from these toxins would be localized and of low magnitude.

Fish

If released into an enclosed waterbody like a pond or a lake (including in a wetland), the concentrates would sink to the bottom and contribute to sedimentation. The fine particles would bury the natural substrate and could smother benthic organisms or eliminate benthic habitat. Recovery efforts could remove spilled concentrate from pond or lake bottoms where practicable, although the impact to benthic habitat would likely occur prior to recovery efforts. In addition, dredging to remove spilled concentrate could cause further disruption of the aquatic habitat.

A spill of concentrate would introduce fine sediment into the stream that would cause sedimentation and elevated TSS/turbidity downstream, into surface water that has naturally low TSS and turbidity. On large rivers such as the Newhalen, continual flushing and periodic high-flow events (spring break-up and fall floods) would transport the concentrate downstream to Iliamna Lake. The extent of the spill impact would be from the location of the spill downstream to where the concentrate settles out and is eventually incorporated into the streambed substrate as a fraction of the bedload. Some of the concentrate would cover and modify the benthic habitat.

Potential impacts of the spill to fish include decreased success of incubating salmon eggs; reduced food sources for rearing juvenile salmon; modified habitat; and in extreme cases, mortality to eggs and rearing fish. The scope of the potential effects to salmon life stages would depend on the timing and magnitude of the spill. The extent of the impact would depend on the downstream dispersal of a small amount (72 ft^3 in this scenario) of concentrate. Mortality to eggs through smothering would be spatially limited. Future return of an age class could be reduced. However, this impact would likely be very localized and may not be measurable above natural background variation. The duration of impacts would be short-term, or until the concentrate is dispersed and diluted downstream and/or incorporated into the bedload. Suspended solids from turbidity and TSS can injure juvenile salmon and reduce their ability to sight-feed on surface and near-surface invertebrates at higher concentrations of turbidity (USACE 2008b). At lower turbidity, juvenile salmon may use turbid waters as cover to hide from predators. Salmonids can encounter naturally turbid conditions in estuaries and glacial streams, but this does not necessarily mean that salmonids in general can tolerate increases of suspended sediments over time (Bash et al. 2001). Relatively low levels of anthropogenic turbidity may negatively affect salmonid populations that are not naturally exposed to relatively high levels of natural turbidity (Gregory and Levings 1996). The feeding efficiency of juvenile salmonids has been shown to be impaired by turbidity levels exceeding 70 nephelometric turbidity units (NTUs), well below typical; and well below typical and persistent levels in fresh waters of the analysis area (Pentec 2005). Therefore, impacts are anticipated to have a low magnitude in a localized area with a temporary duration.

Residual concentrate particles would be flushed downstream and deposited in low-energy areas, although a fraction of the spilled concentrate may ultimately reach deltaic deposits in Iliamna Lake or Iliamna Bay. Acid generation and metals leaching from these sporadic deposits would occur slowly over years to decades. Any acid produced and metals released would be rapidly and sufficiently diluted by fresh water, so that reduction in stream water pH and increases in metals concentrations relative to the baseline conditions are not likely. Therefore, impacts via metals toxicity to fish would not occur under the concentrate spill scenario being evaluated.

Small amounts of concentrate may be entrained in streambed sediment, and may leach metals slowly over years to decades. This could cause low-magnitude, localized impacts to benthic organisms that are preyed on by fish.

Finally, residual amounts of chemical reagents including xanthate would be released into the environment with the concentrate in this scenario. However, as discussed in EPA 2014, the small amount of xanthate released, coupled with the dilution that would occur in the downstream environment would suggest that impacts from these toxins would be localized and of low magnitude (Xu et al. 1988).

Threatened and Endangered Species

In the analysis area, TES are only found in the marine environment of Cook Inlet (and are described in Section 3.25, Threatened and Endangered Species). There are two creeks that flow east into Cook Inlet that are crossed by the alternative transportation corridors. For Alternative 1a and Alternative 1, one small creek is a tributary to Amakdedori Creek, which is crossed by the port access road just west of Amakdedori port. The potential for a spill to occur directly over this small creek, and then for concentrate to get carried downstream into Cook Inlet, is extremely low. The creek has low flow rates, and even if concentrate reaches Cook Inlet, it takes years to decades for copper to become bioavailable. The majority of the concentrate would be removed from the creek, but small amounts may get carried downstream into Amakdedori Creek. Any copper carried downstream is anticipated to settle down in the various backwater pools and low-flow locations of the creek as it slowly winds towards Cook Inlet. A trace amount may eventually be carried into Cook Inlet; however, continual flushing due to freshwater influx and wave action would disperse any concentrate, and it would have no discernable impact on TES.

There is another small creek (Williams Creek) that flows into Iliamna Bay that is crossed by the Alternative 2 and Alternative 3 transportation corridors. The potential for a spill to occur directly over this creek and the concentrate to be carried downstream into Cook Inlet is extremely low. This creek has low flow rates; therefore, concentrate spilled into Williams Creek would not be rapidly transported into Iliamna Bay, and the majority could be cleaned up before it reaches the marine environment. If a small amount of concentrate were to reach Iliamna Bay, it would be exposed to dilution by fresh water from Williams Creek and wave action.

Exposure to natural substances released into the marine environment is a potential health threat for Cook Inlet beluga whales and their prey; however, Cook Inlet beluga whales generally have lower contaminant loads than do beluga whales from other populations (NMFS 2016b). The Cook Inlet Beluga Whale Recovery Plan concludes that the magnitude of the pollution threat to Cook Inlet beluga whales and the relative concern of known and tested contaminants to Cook Inlet beluga whales are most likely low (NMFS 2016b). Similar to beluga whales, other marine mammal TES could potentially be affected by a concentrate spill, potentially through reduced prey resources. Any loss of prey would be difficult to quantify, given environmental variability in annual salmon numbers.

The potential for a spill along the Alternative 2 and Alternative 3 transportation corridor between Iliamna Bay and Diamond Point port is also low. The majority is likely to spill along the roadway and a small amount may enter the marine environment. Due to wave action, any concentrate that spills into Iliamna Bay is likely to be dispersed throughout the bay and settle out with the other deltaic sediments. In addition, there is a large reduction in copper toxicity that results from copper bonding with dissolved organic matter (EPA 2014). Therefore, there is a low potential that a concentrate spill would impact TES, and the magnitude would be of low intensity, with a temporary duration.

Marine Mammals

Similar to TES, marine mammals that occur in Cook Inlet (detailed in Section 3.23, Wildlife Values) would have a low potential to be impacted by a concentrate spill along the transportation corridor. The potential for impacts to reach Cook Inlet are low. Given the amount of time for copper in the concentrate to dissolve and become bioavailable, continual flushing by wave action, and further reduction in bioavailability due to dissolved organic matter, any concentrate that reaches Cook Inlet is unlikely to produce a noticeable difference in the prey base for marine mammals. Therefore, any impacts are anticipated to not be discernable.

If the concentrate spill were to occur over a stream or river that flows into Iliamna Lake, harbor seals in Iliamna Lake (hereafter Iliamna Lake seal) may be impacted. The extent of impacts that enters a river flowing into Iliamna Lake could reach foraging areas for Iliamna Lake seals. As discussed in Section 3.23, Wildlife Values, Iliamna Lake seals are regularly observed on the eastern side of the lake, in proximity to the Alternative 2 and Alternative 3 transportation corridors. As mentioned above, if the concentrate were to spill into a stream, the bulk of the material would sink to the bottom, while some of the concentrate would immediately be transported downstream by the current. The duration of impacts would be short-term (1 to 12 months), because the remaining fine particles at the spill site would continually become entrained in the current and flushed downstream; and the downstream water would become turbid, with high levels of TSS. Some material could be flushed downstream into Iliamna Lake, where the particles would mostly settle out as deltaic deposits. Increased turbidity of the water entering the eastern portion of the lake may result in temporary impacts to Iliamna Lake seals foraging in the area, and there is a potential for Iliamna Lake seals to be temporarily disturbed while cleanup activities occur. Iliamna Lake seals are anticipated to avoid the area (or be hazed) while cleanup is occurring, and overall impacts are anticipated to be low.

Needs and Welfare—Socioeconomics

It is unlikely that cleanup and remediation activities following a truck release of concentrate would result in increased employment opportunities in the region. Cleanup crews would be small, and likely consist of only PLP employees and specialized contractors. Such a spill would be unlikely to have negative impacts on employment, income, and sales in the region.

Recreation

In the event of a concentrate release from a truck, the spill and response effort would have a temporary effect on recreational resources. The movement of cleanup equipment may be noticeable to recreationists on Iliamna Lake and (seasonally dependent) snowmachine or all-terrain vehicle (ATV) users. The cleanup activities may displace sport fishing or hunting, depending on the area of the spill; however, there are comparable areas available throughout the region for recreation. There would be relatively few recreationists that would be impacted.

Commercial and Recreational Fishing

A truck rollover has an extremely low potential for affecting commercial fishing and the number of returning adult salmon. In any event, the rollover would not affect current-year harvests, because the event would occur upstream of commercial harvest opportunities. Depending on the timing and magnitude of a rollover and spill event, the event could result in the smothering of salmon eggs and reduced feeding success within a limited geographic area. Because salmon impacts are anticipated to be of low magnitude, in a localized area, and short-term, similarly limited effects on commercial salmon harvest values would be expected.

Recreational fishing on the region's rivers and streams is highly seasonal and focused on harvesting returning salmon, and angling for non-salmon salmonids feeding on deposited eggs and salmon carcasses. A rollover event could displace recreational angling efforts if the event or cleanup occurred during the open-water fishing season. The region provides enough angling opportunities for anglers to adjust their fishing locations. However, an event near specific angling locations could affect specific guide companies or angler sub-groups. These effects would be limited in duration and are not expected to extend beyond a single fishing season.

Cultural Resources

Direct impacts to cultural resources from a potential concentrate spill would be similar to the diesel spill scenario discussed above. It would directly impact cultural resources if such a release would occur within the bounds of a cultural resource area or known or potential historic property site. These impacts could include contamination of organic cultural materials and site sediments. Such an event would likely result in direct impacts through loss of integrity for eligibility to the National Register from cleanup activities. These impacts would likely severely damage the site, and resources would not be anticipated to return to previous levels even after actions that caused the impacts were to cease. Indirect impacts could occur to the setting (visual, noise, and olfactory impacts) of cultural resources if the spill were to happen in the vicinity. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Those impacts would be temporary and would cease when response efforts are complete.

Subsistence

A release of concentrate could have localized impacts to subsistence resources and could cause mortality and displacement of fish and wildlife before and during cleanup activities. The concentrate release would likely cause concerns over contamination for local subsistence users that could cause users to avoid the area and alter their harvest patterns. Quick response and cleanup of spills (particularly for spills in water), a system of testing wild foods, and clear and timely communication with nearby communities would help ease concerns about contamination for subsistence users in nearby communities.

Health and Safety

A release of concentrate could cause stress to community members in close proximity from real or perceived risks of contamination, and potentially impact human health. Spills create anxiety about the safety of subsistence foods and water quality. Quick response and containment of spills (particularly for spills in water) and a system of testing wild foods and drinking water for contaminants to give local people complete and understandable information in a timely manner could help alleviate some anxiety, and reduce potential impacts to human health. There would be potential adverse impacts to social determinants of health (HEC 1), with psychosocial stress resulting from community anxiety over a truck release. A truck release may involve a surface transportation accident or injury, but would not likely create increased risks for transportation-related injury or accident (HEC 2). As noted above, a release of concentrate could have localized impacts to subsistence, including avoidance of the area and altering harvest patterns, which in turn could temporarily impact food security and subsistence-level nutrition (HEC 4). The duration of impacts would be short-term (1 to 12 months).

Scenario: Concentrate Slurry Pipeline Rupture

This scenario addresses the probability and consequences of a release of concentrate slurry equal to 900 ft^3 (54,000 pounds; 27 tons) due to rupture of the concentrate slurry pipeline.

Alternative 3, Concentrate Pipeline Variant, would include the transport of copper-gold concentrate in slurry form through a 6.25-inch-diameter steel pipeline that would parallel the north road corridor from the mine site to the port. For most of its length, the pipeline would be buried in the same trench as the natural gas pipeline (PLP 2018-RFI 066). At major stream crossings, the pipeline would be attached to bridge infrastructure; would have additional isolation valves; and would be heavy-walled or cased for extra protection. A pressure-based leak detection system would monitor the pipeline for leaks (PLP 2018-RFI 066). Because the concentrate slurry would be a potentially corrosive material, the pipeline would have an internal high-density polyethylene liner to prevent internal corrosion. See "Avoidance and Minimization/Design Features of Concentrate Pipeline" above for additional spill mitigation features. A concentrate pipeline traversing Iliamna Lake is not being considered (PLP 2018-RFI 032). See Chapter 2, Alternatives, for further details.

In this scenario, the slurry pipeline attached to bridge infrastructure is ruptured during an earthquake, and concentrate slurry begins to flow from the pipe. The automated leak detection system would detect the leak, at which point it would take approximately 1 minute for the pipeline pumps to be shutoff. This would reduce the flow of concentrate slurry in the pipeline, so that the slurry would likely not readily flow out of the pipe for more than approximately 5 minutes. During the initial 5 minutes after rupture, approximately 700 ft^3 of concentrate slurry (42,000 pounds; 21 tons) would be released (PLP 2018-RFI 066). Even after the pumps are shut off, the static head (pressure) in the pipeline would cause additional release of slurry, on the order of 200 ft^3 (12,000 pounds; 6 tons). It would likely require approximately 30 minutes for personnel to respond on the scene and close the manual isolation valves on each side of the bridge, to block any further residual flow from spilling from the pipe. Automatic isolation valves have been suggested as additional mitigation (see Appendix M1.0, Mitigation Assessment). This scenario includes a total release of 900 ft^3 (54,000 pounds; 27 tons) of slurry from the pipeline. Some of the slurry may collect beneath the bridge, while much of it would flow into the stream.

The estimated failure rate for the concentrate pipeline under the Alternative 3 Pipeline Concentrate Variant was based on data compiled by the EPA (2014) and Cunha 2012. As described above, no published failure rates are available specific to concentrate pipelines, so the failure data analyzed come from oil and gas pipelines.

EPA focused their pipeline failure data on pipelines of a similar size (less than 20 centimeters, approximately 8 inches in diameter), run by small operators over similar short distances, and in a cold climate. Data reported by both the EPA and Cunha (2012) include pipeline failure data from urban, suburban, and industrial areas, where accidental or intentional human actions (often involving vehicle collisions) are the principal causes of pipeline failures (AECOM 2019a). Due to the remote nature of the project area and the controlled access of the road corridor, pipeline rupture from human actions is not considered a relevant factor for calculating pipeline failure rates. Cunha (2012) specifically addresses statistics on pipeline failures in Canada (mostly remote areas), which were determined to be more relevant to the project. The estimated failure rate selected for this analysis therefore considered relevant data from both of these data compilations. The heavy-wall pipe or casing for the above-ground sections of the concentrate pipeline (PLP 2018-RFI 066) also decreased the selected pipeline failure rate (AECOM 2019a).

With consideration of the length of the concentrate pipeline in Alternative 3, Concentrate Pipeline Variant, the 20-year operational life, and the heavy wall pipe or casing to be used, the resulting estimated annual failure rate for the concentrate pipeline is 0.013. This equates to a probability of one or more pipeline failures of 1.3 percent in any given year; 23 percent in 20 years; or 64 percent in 78 years (AECOM 2019a). See AECOM 2019a for complete information on failure rate calculations.

A spill of concentrate slurry would introduce fine sediment into the stream that would cause sedimentation and elevated TSS/turbidity downstream, into surface water that has naturally low TSS and turbidity. Some concentrate slurry that is carried downstream would remain suspended in the water, creating a plume of elevated TSS/turbidity downstream, which could extend into Iliamna Lake. Some of the concentrate slurry would be deposited along the streambed, covering the existing substrate and modifying the benthic habitat. Depending on the location of the spill, some of the concentrate slurry would likely be transported into Iliamna Lake, and the solids could be deposited as deltaic deposits where the stream feeds into the lake.

The metals in the copper-gold concentrate slurry solids would not be immediately soluble in water. Over years to decades, metals could leach out of the concentrate slurry into surrounding water, increasing the potential for contamination in water. Concentrate slurry in the stream would not be highly susceptible to acid generation. Stream water in the area can be well oxygenated, so that some oxidation of sulfides could generate small amounts of acid from unrecovered concentrate. Concentrate slurry that may remain unrecovered on the banks of the stream could also generate a small amount of acid (over a time period of years to decades) that could leak into the stream. Any acid produced, however, would be constantly diluted by fresh water, so that a reduction in stream water pH would likely not be measurable compared to background levels.

As noted above, the concentrate slurry would have an aqueous phase of contact water, in addition to the concentrate solids. The contact water would likely be elevated in metals, so that a spill of concentrate slurry would introduce elevated levels of metals into the environment, including copper, that would likely exceed water quality criteria.

Spill Response

PLP would have a spill plan in place that would detail the measures to prevent, respond to, contain, report, and clean up spills of concentrate slurry and other potentially hazardous materials. See the “Spill Preparedness, Prevention, and Response Measures” subsection.

Recovery of the spilled slurry material would be difficult due to its fluid nature. By the time crews would be able to mobilize for a cleanup, much of the slurry could have already been flushed downstream.

Any remaining thick accumulations of concentrate slurry along the stream bank or in the drainage could be excavated or dredged. Excavation or dredging could cause erosion or other damage to the habitat, but the use of BMPs could minimize impacts.

Deposits of concentrate slurry along the streambed could intermingle with existing substrate. This material could be dredged, although it would be difficult to judge which sediment is concentrate and which is naturally occurring, because the concentrate solids would simply look like typical very fine sediment. Dredging could be damaging to the habitat, and may not be justified. Small amounts of concentrate left in the drainage could naturally flush out over years to decades, or longer.

Concentrate suspended in water would be essentially impossible to recover. It would be left to naturally flush out of the system. Small concentrations of suspended concentrate particles could be flushed into Iliamna Lake or Iliamna Bay, where they would eventually settle out.

Alternatives Analysis

Alternative 1a, Alternative 1 and Alternative 2, and the Alternative 3 base case would not use a concentrate pipeline, so there would be no potential spill from a concentrate pipeline rupture for these alternatives. Only the Alternative 3 Concentrate Pipeline Variant would employ a concentrate pipeline to transport concentrate slurry from the mine site to the Diamond Point port.

Concentrate Return Water Pipeline Option

Under the Alternative 3 Concentrate Pipeline Variant, there would be a concentrate return water pipeline option that would involve dewatering the concentrate slurry at the port site, and returning this untreated contact water back to the mine site for treatment through an 8-inch return water pipeline (see Chapter 2, Alternatives.) Under this option, there would be a potential for spills of untreated contact water from the return water pipeline affecting water and sediment quality that would not exist under the other alternatives (addressed in Section 4.18, Water and Sediment Quality, for small spills).

Potential Impacts of a Concentrate Slurry Spill due to Pipeline Rupture

This section addresses potential impacts of a concentrate slurry spill from a rupture in the concentrate slurry pipeline, as described in the scenario above. Impacts are considered in terms of their magnitude, duration, geographic extent, and potential to occur. A concentrate slurry spill would not impact all the resources addressed in this EIS. The following resources were selected for analysis due to the higher potential significance of the impacts.

Soils

Concentrate slurry spilled onto soils in this scenario would be recovered so that there would likely be no impact. A small amount of fluid slurry could seep into the soil to a shallow depth. In the event of such a spill, soils at the spill site could be tested, and contaminated soils could be excavated. Assuming the spill response as described in the scenario, residual concentrate slurry or minor fugitive dust produced would likely not have measurable impacts on soil quality.

Water and Sediment Quality

Impacts to water and sediment quality from this scenario would be similar to those addressed above for the truck rollover release of concentrate solids, but could be of greater magnitude. The volume of release is smaller under this scenario, but this scenario assumes that most of the spilled concentrate slurry enters surface water, so that the probability of impacts to water quality would be almost certain. The geographic extent would likely be larger as well, due to more concentrate being transported a greater distance downstream. The duration of the impacts would likely be longer because the larger volume of concentrate slurry would take longer to clean up and/or to be naturally flushed out of the drainages. In addition, because the concentrate slurry contains an aqueous component of contact water that would be elevated in metals, this scenario causes elevated metals levels in downstream waters that would likely exceed water quality criteria. Contamination of groundwater with elevated metals would also be possible in this scenario.

TSS and Turbidity—Fine particles of concentrate spilled into flowing water would become suspended in the water, causing elevated TSS and turbidity, for an extent of potentially several miles downstream, and possibly into Iliamna Lake. If spilled concentrate slurry is not recovered, the duration of elevated TSS and turbidity in streams could be on the order of weeks, depending on stream energy, as concentrate slurry continues to be flushed out of the drainage. With effective cleanup, the duration of the TSS/turbidity would likely last for multiple days.

Sedimentation—If concentrate slurry is released into flowing water, some of the coarser particles of concentrate would be deposited as sediment downstream, especially in areas where the current slows. Concentrate could bury or intermingle with existing stream-bottom sediments, and fill in void spaces between gravel clasts, temporarily impacting salmonid spawning habitat. The extent of measurable sedimentation would likely be on the order of several miles downstream of the spill site. Because recovery of these dispersed concentrate particles would be impractical, the material would likely have to be naturally flushed out of the stream, which may take weeks to months, depending on the energy of the stream. Depending on the volume and location of the spill, some of the concentrate particles could be transported downstream into Iliamna Lake or Iliamna Bay, where it would settle out as deltaic deposits.

Acid Generation—For a discussion of factors that impact the ability of concentrate particles to generate acid, see "Factors Influencing Acid Generation and Metals Leaching" in the "Concentrate Spills" subsection.

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

Sulfide minerals in the concentrate slurry would slowly dissolve in the subaqueous environment over years to decades. To produce acid, the sulfur would need to be oxidized. Some dissolved oxygen gas can be present in flowing water, and very low levels of oxygen gas may be present in still or stagnant water. Circulating lake water such as that in Iliamna Lake and shallow intertidal waters such as those found in Kamishak Bay can be well oxygenated. Some acid generation from subaqueous concentrates could occur in these environments where spilled concentrate slurry is not recovered. However, due to the long time-scales required for acid generation and the constant dilution from abundance of surface water, acidification of surface water is not likely.

Any residual concentrate slurry remaining on dry land for multiple years could potentially generate acid. In low-water conditions, or in deltaic environments, additional spilled concentrate slurry could be exposed to air, increasing the potential for acid generation. In addition, concentrate particles that have settled on streambeds could be resuspended during flooding/storm events, and could be further oxidized. The acid could be flushed into surface water, potentially reducing the pH of waterbodies. The rate of acid production is so slow, however, and the dilution from fresh water so great, that any acid produced would be rapidly diluted and flushed out of the drainage so that no measurable reduction in surface water pH would be likely.

Metals Leaching—For a discussion of factors that impact the ability of concentrate particles to leach metals, see "Factors Influencing Acid Generation and Metals Leaching" in the "Concentrate Spills" subsection.

Impacts from ML would be the same as those described above for the truck rollover scenario.

The metallic minerals in the concentrate slurry are not readily soluble in water, so spilled concentrate would not immediately introduce metals in a bioavailable form. After years to decades, the minerals in the concentrate slurry would slowly dissolve, potentially leaching metals into the water. Due to the small amount of concentrate that could remain in the streams, however, and the heavy dilution factor from stream water, the ML would likely not be a measurable impact.

In this scenario, the spilled concentrate slurry would contain an aqueous component of 45 percent untreated contact water, which would be elevated in metals. In contrast to the concentrate solids, the metals in the contact water would be dissolved and bioavailable. Therefore, this scenario would impact downstream surface water by elevating the levels of metals, likely exceeding water quality criteria. See Appendix K4.24, Fish Values, for additional discussion on metals toxicity. The effect would be short-term, lasting until the fluid from the slurry has been flushed downstream and/or diluted by stream water. Measurable impacts to downstream water in Iliamna Lake would not be anticipated due to dilution. The scenario assumes that any concentrate slurry spilled on the streambanks would be cleaned up. If not, then that additional concentrate could continue to flush into the stream, prolonging the impact of elevated metals.

Residual Toxins—Ore concentrate slurry may also contain residues of chemical reagents, including sodium ethyl xanthate and sodium hydrogen sulfide, both of which can be toxic to fish in low concentrations. See "Reagent Spills," below for a discussion of reagent fate and behavior in the environment.

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

If spill recovery involves dredging, BMPs would help to lessen the potential for erosion of streambed and shoreline sediments.

Noise

Noise could be generated from spill recovery operations, including increased vehicle traffic and use of cleanup equipment. If the increased vehicular traffic would be less than double the amount of existing traffic, then the noise level increase would be less than a 3-dBA increase over existing traffic noise levels (generally less than noticeable). Noise from cleanup equipment would depend on the type of equipment used. However, equipment such as pumps, tractors, heavy-haul trucks, and Vac-trucks would have a maximum noise level of approximately 85 dBA or less at 50 feet (FHWA Roadway Construction Noise Model) and would be limited to the cleanup area for the duration of the cleanup and recovery effort.

Air Quality

Concentrate slurry deposited on land that is able to dry out has the potential to become airborne fugitive dust in the form of particulate matter and particulate hazardous pollutants. Concentrate slurry that spills on land may spread out somewhat due to its fluid nature, but could be recovered. Residual concentrate would likely remain at the spill site, and could dry out and produce fugitive dust. Assuming the spill response as included in the scenario, any impacts on air quality from fugitive dust produced would likely be temporary and localized. If spill response was delayed, a larger volume of concentrate slurry could dry out and spread more readily as fugitive dust, increasing the magnitude of impacts.

The magnitude and potential of the impacts would depend on the amount of concentrate slurry that deposited on land, and meteorological conditions at the time of the spill. A larger spill with strong winds would likely increase the air quality impacts. Concentrations of particulate matter could temporarily exceed the NAAQS concentrations; but over time, the air quality would return to pre-spill conditions. The duration of air quality impacts would be temporary, and would return to pre-activity levels at the completion of the activity. The extent of impacts would be limited to discrete portions in the project area, where the spill took place.

Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

This scenario could affect riparian vegetation on the banks of the stream and any adjacent wetlands. Special aquatic sites potentially affected could include vegetated shallows or riffle and pool complexes. The concentrate slurry may pile up beneath the bridge and immediately downstream at volumes high enough to bury the existing riparian vegetation. As the concentrate slurry is carried downstream, smaller amounts of it would likely be deposited along the streambanks, covering the existing vegetation.

Depending on the location of the spill, some of the concentrate slurry may be transported into Iliamna Lake and deposited as deltaic deposits where the stream feeds into the lake. This could affect wetlands, vegetated shallows, and riparian vegetation.

Vegetation and wetlands could be temporarily impacted by deposition of concentrate slurry along streambanks, because these resources are certain to be in the path of the spilled concentrate. Impacts to special aquatic sites may or may not occur depending on the location of the spill.

Concentrate solids would not be expected to affect wetlands through acid generation or ML in the short-term. Over years to decades, any unrecovered concentrate solids in the wetland area could produce acid or metals.

Compared to the concentrate solids release, the slurry release would have the added impact of untreated contact water that would compose 45 percent of the slurry, and would contain elevated levels of dissolved metals, including copper. See the pyritic tailings release scenario below for a discussion of elevated metals impacts to wetlands. Fluid from the slurry could seep into wetland soil to a shallow depth. Vegetation or wetlands could be affected by soils contaminated with elevated levels of metals from the released contact water. Metal-related toxicity could have acute or chronic effects on vegetation or wetlands. The results may be mortality or reduction of growth. In the event of such a spill, soils at the spill site could be tested, and contaminated soils could be excavated. See Appendix K4.24, Fish Values, for additional discussion on metals toxicity.

The magnitude of the impact depends on the season. Dormant vegetation is much less likely to be affected than actively growing plants. If the spill occurs during non-frozen conditions, especially during the growing season, the magnitude of impacts would be increased compared to during frozen conditions. The magnitude of impacts would be highest close to the spill, and would lessen with distance downstream.

The extent of the area impacted depends on the timing and location of the spill and the effectiveness of the spill response. Spills that occur into flowing water and those that occur in the open-water season are likely to affect a larger area than those that occur during the winter, because concentrate could become entrained in water and be transported. During partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), concentrate may be trapped beneath ice and spread out in flowing water. During frozen conditions with complete ice cover, concentrate is more likely to spill onto frozen surfaces and not spread out as much, and may be easier to clean up.

The duration of impacts is also related to the timing of the spill and the speed of cleanup. Spills that occur during the open-water season may require more time to clean up, and more time for wetlands to recover, maybe several growing seasons. Spills that occur during the winter would be more likely to spill onto frozen surfaces and not spread out as much, so that recovery may be faster. During partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), concentrate may be trapped beneath ice, potentially prolonging cleanup and duration of impacts.

Terrestrial Wildlife

Under this scenario, where concentrate slurry enters a flowing river beneath a bridge, the primary impact would be to terrestrial wildlife prey such as salmon and freshwater invertebrates. An immediate release of concentrate slurry could smother fish eggs, and could cause egg mortality in the localized discrete area of the spill. Impacts from elevated TSS and sedimentation would be localized, and last as long as the concentrate covers fish eggs, alevin, and fry in the area; or renders the area unsuitable for spawning. On large rivers such as the Newhalen, continual flushing and periodic high-flow events (spring break-up and fall floods) would transport the concentrate slurry downstream. The extent of the spill impact would be from the location of the spill to downstream, where the concentrate settles out and eventually is incorporated into the substrate. The duration of impacts would not extend longer than 1 year, or until the concentrate slurry is cleaned up or incorporated into the bedload. Because a spill would impact a fraction of the total eggs, alevin, and fry in a discrete reach of river, the impact on terrestrial mammals that feed on salmon would be low, and would not likely be noticeable.

Compared to the concentrate solids release, the slurry release would have the added impact of untreated contact water that would compose 45 percent of the slurry, and would contain elevated levels of dissolved metals, including copper, that would be immediately bioavailable. Wildlife species could be impacted from increased levels of metals entering waterbodies, depending on the amount of untreated contact water entering a given waterbody, and the amount of dilution. Molybdenum, one of the metals with high concentrations in the released contact water, can cause a disease in ruminants called molybdenosis. Other metals in high concentrations that would require more dilution to reach water quality standards include cadmium, copper, lead, manganese, and zinc. The relative toxicity of cadmium to mammals is considered moderate to high, because they have no effective mechanism for elimination of ingested cadmium, and it can accumulate in the liver and kidney. It is well documented that lead can cause various levels of poisoning. Copper toxicity in mammals is considered insignificant, because they possess barriers to copper absorption (Gough et al. 1979). Impacts to wildlife from these metals and others are explained in detail below under potential impacts of untreated contact water release.

A spill in a stream could directly impact small mammals such as voles, shrews, and lemmings, as well as aquatic mustelids such as beaver and muskrat, by altering or destroying feeding and denning habitat. See the pyritic tailings release scenario below for elevated metals impacts to wildlife (see Appendix K4.24, Fish Values, for additional discussion on metals toxicity to salmonid wildlife prey species).

Finally, residual amounts of chemical reagents would be released into the environment with the concentrate slurry in this scenario. The small volume of reagents released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to wildlife from these toxins would be localized and of low magnitude.

Birds

Similar to terrestrial wildlife, bird species that feed on fish and freshwater organisms could be impacted by a reduced prey base in discrete areas of a concentrate slurry spill. The magnitude is anticipated to be low; intensity would be low, because birds can forage in other nearby areas; and the duration would be short, until the concentrate slurry is carried downstream. Birds such as gulls, loons, mergansers, grebes, kingfishers, dippers, and some shorebird species that consume salmon eggs and fry may experience reduced prey availability due to smothering by concentrate at the location of the spill. However, the impact is anticipated to not be discernable, because there is suitable foraging habitat in the surrounding area. In addition, any spills that occur during winter when streams are frozen and most birds have migrated away would be cleaned up, and result in no discernible impact on birds.

Compared to the concentrate solids release, the slurry release would have the added impact of untreated contact water that would compose 45 percent of the slurry, and would contain elevated levels of dissolved metals, including copper, that would be immediately bioavailable. Birds could be impacted from increased levels of metals entering waterbodies, depending on the amount of untreated contact water entering a given waterbody, and the amount of dilution. See the pyritic tailings release scenario and the untreated contact water release scenario below for discussion of elevated metals impacts to birds (see Appendix K4.24, Fish Values, for additional discussion on metals toxicity to salmonid avian prey species).

Finally, residual amounts of chemical reagents would be released into the environment with the concentrate slurry in this scenario. The small amount of reagents released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to birds from these toxins would be localized and of low magnitude.

Fish

Impacts to fish from this scenario would be expected to be similar to those impacts noted above for a release of concentrate solids to a waterbody. Duration of impacts from sedimentation and turbidity could be from weeks to months. Depending on location and seasonality, there could be permanent impacts to an age class of fish due to the increased volume of concentrate slurry spilled. No measurable impacts to fish from acid rock drainage (ARD) or ML would be expected.

Compared to the concentrate solids release, the slurry release would have the added impact of untreated contact water that would compose 45 percent of the slurry, and would contain elevated levels of dissolved metals, including copper. These metals would be immediately bioavailable, compared to the metals present in the concentrate solids. Severall factors are likely to limit metals bioavailability when they are released to surface water, including binding by natural ligands (such as dissolved organic matter) and binding phases on particulates. EPA's recommended aquatic life WQC for copper is based on the Biotic Ligand Model to account for various factors that modify its aquatic toxicity (EPA 2007b). Metals bioavailability in the current evaluations presents uncertainties, but site-specific toxicity tests (as discussed in more detail below under Pyritic Tailings Release) are indicative of limited impacts on fish species. Aquatic toxicity testing was conducted on samples of process water generated during plant water testing by Nautilus Environmental (2012). An undiluted aqueous sample from the mine site used in the toxicity studies (Non-Gold Plant Process Water) is also representative of the contact water that would make up the concentrate slurry, although there is uncertainty regarding how well the sample represents untreated contact water. Water samples from this study are further described below for the pyritic tailings release. The toxicity tests did not demonstrate acute and chronic toxicity to fish species, including rainbow trout (*Ochorhynchus mykiss*) and fathead minnow (*Pimephales promelas*). Survival and reproduction of water flea (*C. dubia*) neonates were adversely affected when exposed to the 12.5 percent "Non-Gold Process Water" sample (by volume); or eight times dilution or less. When introduced into flowing water, the metals in the contact water component of the concentrate slurry would be further diluted and flushed downstream. Based on the above considerations, acute toxicity to fish due to metals would not occur. See further discussion of metals toxicity below under the pyritic tailings release scenario, and in Appendix K4.24, Fish Values.

Small amounts of concentrate may be entrained within streambed sediment, and may leach metals slowly over years to decades. This could cause low-magnitude, localized impacts to benthic organisms that are preyed upon by fish.

Finally, residual amounts of chemical reagents would be released into the environment with the concentrate slurry in this scenario. The small amount of reagents released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to fish from these toxins would be localized and of low magnitude.

Threatened and Endangered Species

Impacts to TES are not anticipated, because potential impacts from a concentrate pipeline break would not occur in waters that enter Cook Inlet.

Marine Mammals

Impacts to marine mammals in Cook Inlet are not anticipated, because potential impacts from a concentrate pipeline break would not occur in waters that enter Cook Inlet.

Impacts to Iliamna Lake seals would be of short duration, and the extent of impacts would likely stretch from the spill location into Iliamna Lake. There may be a limited loss of prey species for Iliamna Lake seals where the concentrate covers up and smothers fish eggs. The concentrate slurry would eventually be carried downstream into Iliamna Lake; the seals would not be at risk from bioaccumulation; and the copper would take years to decades to become bioavailable. Even then, copper toxicity is reduced when copper combines with organic matter, and any residual copper in small crevices between gravels and cobbles is not expected to cause mortality for fish. Iliamna Lake seals may temporarily avoid areas where the concentrate slurry is spilled, especially during cleanup activities. Finally, residual amounts of chemical reagents would be released into the environment with the concentrate in this scenario. The small amount of reagents released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to Iliamna Lake seals from these toxins would be localized to the immediate vicinity of the spill, and of low magnitude.

Needs and Welfare of the People—Socioeconomics

It is unlikely that cleanup and remediation activities following a pipeline rupture would result in increased employment opportunities in the region. Cleanup crews would be small, and likely consist of PLP employees or specialized contractors.

Recreation

In the event of a concentrate slurry release from a pipeline rupture, the spill and response effort would have a temporary effect on recreational resources. The movement of cleanup equipment may be noticeable to recreationists on Iliamna Lake, and (seasonally dependent) snowmachine or ATV users. The cleanup activities may displace sport fishing or hunting, depending on the area of the spill; however, there are comparable areas available throughout the region for recreation. Relatively few recreationists would be impacted.

Commercial and Recreational Fishing

A concentrate slurry spill on land or on a frozen waterbody would not be expected to affect commercial or recreational fishing. A spill into a river or stream environment could impact a fraction of the total eggs, alevin, and fry in a discrete reach of river. No immediate effect on commercial fisheries would occur, because the spill would take place outside the geographic area of commercial salmon harvests. A spill could affect the annual value of the commercial fishery to the extent that such a spill reduced the number of returning adult salmon, either in the short-term via the smothering of eggs, or the longer term if the spill lowered the long-term productivity of the system by reducing the amount of spawning habitat. Because impacts to fish are anticipated to be localized, temporary, and of low magnitude, any reduction in the value of the fishery is expected to be extremely limited under this scenario.

Recreational fishing effort could be displaced in the immediate vicinity of a spill to the extent that the spill reduces localized productivity and food availability, or displaces anglers during cleanup operations. Longer-term effects would not be expected after the concentrate slurry has flushed downstream, as long as total salmonid populations are unaffected and food/prey availability returns to pre-spill conditions. A spill could affect individual angling groups or companies disproportionately if they relied heavily on the affected section of river.

Cultural Resources

Under Alternative 3, impacts from a concentrate slurry pipeline release to cultural resources would be dependent on the location of the release, the proximity of cultural resources, and the extent of cleanup activities. The concentrate slurry could accumulate on stream shores, requiring response. In the event that such a response effort occurred in or adjacent to a cultural resource area or known or potential historic property site, direct and indirect impacts to the site would likely result in loss of integrity to the National Register (resulting from the potential for fire, as well as ground disturbance during extensive cleanup activities). The duration of impacts would be such that resources would not be anticipated to return to previous levels even after actions that caused the impacts were to cease. The extent and context of impacts would be related to the number and significance of affected resources; a release that impacted multiple cultural resources could affect resources throughout the EIS analysis area. Indirect impacts could occur to the setting (visual, noise, and olfactory impacts) of cultural resources if the spill were to occur in the vicinity. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Those impacts would be temporary, and would cease when response efforts are complete.

Subsistence

A spill of concentrate slurry over a river could smother eggs and juvenile subsistence fishes in the area of the spill, and last as long as the concentrate covers fish eggs, alevin, and fry in the area. The extent of the spill impact to subsistence resources would be from the location of the spill to the downstream extent of concentrate deposition. The duration of impacts would not extend longer than 1 year, or until the concentrate slurry is cleaned up or incorporated into the bedload. Wildlife would also be hazed from the impacted area during cleanup activities. The concentrate slurry release would likely cause concerns over contamination for subsistence users that harvest in areas near or downstream from the rupture, and could cause users to avoid the area and alter their harvest patterns. Quick response and containment of spills (particularly for spills in water) and a system of testing wild foods and communicating the results to local people in a timely manner could help mitigate these concerns.

Health and Safety

A release of concentrate slurry could cause stress to community members in close proximity from real or perceived risks of contamination, and potentially impact human health. Spills create anxiety about the safety of subsistence foods and water quality. Quick response and containment of spills (particularly for releases in water), and a system of testing wild foods and drinking water for contaminants to give local people complete and understandable information in a timely manner could help alleviate some anxiety, and reduce potential impacts to human health. There would be potential adverse impacts to social determinants of health (HEC 1), with psychosocial stress resulting from community anxiety over a truck release. As noted above, a release of concentrate slurry could have impacts to subsistence, including avoidance of the area and altering harvest patterns, which in turn could temporarily impact food security and subsistence-level nutrition (HEC 4). The duration of impacts would be short-term (1 to 12 months).

4.27.6.8 Over-Water Transfer Spill

Concentrate would be transferred between lightering vessels and bulk carriers as an over-water operation at lightering locations. Procedures for reducing the potential for spills and release of fugitive dust for the over-water transfers, as described in the previous “Mitigation” subsection, are considered robust. The probability of a large-volume release from over-water transfer is so low as to rule out the scenario as extremely unlikely. The potential impacts of fugitive dust are addressed above for the truck rollover and concentrate pipeline release scenarios.

4.27.6.9 Marine Vessel Concentrate Release

The probability of a spill of concentrate from a marine vessel would be very low.

Copper-gold concentrate would be transferred from dock facilities onto lightering vessels, and then transported to the waiting bulk carriers at a lightering location (see Chapter 2, Alternatives, for lightering locations for the different alternatives). Operations would be put on hold during periods of high seas.

A spill of concentrate from a lightering vessel (barge) could occur if an entire container of concentrate were to fall overboard. A concentrate spill from a bulk vessel would be very unlikely, because concentrate would be held deep within the hold of the ship. Fugitive concentrate dust could also be released during transfer operations over marine waters, although extensive mitigation measures would be in place to reduce the probability of occurrence and extent of release (see the previous “Mitigation” subsection).

A large spill of concentrate into Kamishak Bay between the port and the lightering locations would sink to the seafloor, and could be partially recoverable, due to the shallow (diveable) water depths. Extreme tides, currents, winds, and waves, however, would immediately begin to mobilize the fine-grained material, so that any recovery would be a partial recovery only. Small spills of concentrate, including fugitive dust, would be rapidly dispersed by waves, tides, and currents, and would not be recoverable. If a concentrate container were to fall overboard in shallow water, the container would likely be recovered, potentially with concentrate still remaining inside the container. Recovery of concentrate from deeper water could create too great of a safety risk involved in salvaging the spilled material, and the action may not be justified. In the event of a spill of concentrate from a marine vessel, either a lightering barge or a bulk vessel, the clay- and silt-sized material would contribute to a localized, short-term increased in TSS and sedimentation in Kamishak Bay. The fine-grained particles of spilled concentrate would be quickly deposited, and/or dispersed by waves, tides, and currents.

The metals in the copper-gold concentrate are not immediately soluble in water. Over years to decades, metals could leach out of the concentrate into surrounding water, increasing the potential for contamination in water. Due to extreme tidal fluctuations and strong currents in lower Cook Inlet, however, any potential contamination would be constantly diluted, and it is unlikely that there would be any measurable impacts. Some oxygen gas would likely be present in well-circulated tidal waters, to the extent that sulfide minerals could be oxidized in the marine environment, and produce a small amount of acid. However, again, due to the time required for acid generation and constant dilution, no measurable impacts would be expected.

4.27.6.10 Iliamna Lake Ferry Rupture

The probability of a spill of concentrate from the ferry is similar to or less than that of a marine vessel, and is therefore very low. There are historically low rates of spills of any type from ferries. The risk was considered very low probability, and relatively low consequence, should it occur.

As described above under Diesel Spills, the ferry would be custom-built specifically for Iliamna Lake conditions, and for hauling diesel, concentrate, and other mine materials. One-inch-thick heavy-steel shell (required for ice-breaking) would result in very low potential for damage to the ferry from grounding or a collision. Operation would include a stowage plan designed to ensure no movement of cargo at a list (tilt) of 8 degrees (e.g., in the extreme case of loss of one of the engine rooms) (PLP 2018-RFI 052).

A spill of concentrate into Iliamna Lake would introduce fine particles that would contribute to sedimentation and elevated TSS/turbidity in the lake. TSS levels are naturally low in Iliamna Lake (see Section 3.16, Surface Water Hydrology), and increased TSS and turbidity could potentially impact fish populations. A sudden increase in sediment could bury benthic organisms or habitat. Depending on the weather and time of year, natural dilution and dispersal of particles of spilled concentrate could take days to weeks.

As described above for the marine spill, metals could slowly leach out of the concentrate into surrounding water over years to decades, but any leached metals would be strongly diluted, and it is unlikely that water quality criteria for metals would be exceeded. Sulfide minerals would not be readily oxygenated in the subaqueous lake environment. Iliamna Lake does experience periodic overturning, which oxygenates the water, so a small amount of acid generation from unrecovered concentrate would be possible, over years to decades. Due to the strong dilution from abundant lake water, however, any acid generated would not be expected to cause an exceedance of water quality criteria.

Diving crews could recover spilled concentrate where practicable. Depending on the time of year and the depth of the water, such a recovery operation could be a safety risk to personnel, and could take days to weeks of logistics to mobilize.

4.27.7 Reagent Spills

Reagents are chemicals that promote or restrict certain chemical reactions in the process of separating metals from crushed ore. Most of the reagents would be added to crushed ore slurry during various phases of the flotation process.

Reagents would be transported to the mine site by marine barge, truck, and ferry in 20-ton shipping containers. They would be stored in a secure bulk reagent storage area and segregated according to compatible characteristics. The reagent storage area would be sufficient to maintain a 2-month supply at the mine site. As needed, reagents would be loaded onto a truck and delivered to the appropriate reagent receiving area in the mine site.

Reagents would be used in low concentrations for mineral processing and are primarily consumed in the process; low residual reagent quantities would remain in the tailings stream, and would be disposed of in the tailings storage facility (TSF), where they would be diluted and decompose.

The metallurgical and assay laboratories would also use small amounts of reagents. “Any hazardous reagents imported for testing would be transported, handled, stored, reported, and disposed of as required by law, in accordance with manufacturers’ instructions, and consistent with industry best practices” (PLP 2018d).

A complete list of potential reagents for the project is provided in Table 4.27-2 (PLP 2018d).

Table 4.27-2: Processing Reagents and Materials

Reagent	Use	Shipping/Preparation
Calcium Oxide (quick lime)	pH modifier; depresses pyrite in the copper-molybdenum flotation process.	Calcium oxide pebbles (80%) shipped in specially adapted shipping containers. Pebbles would be crushed and mixed with water to form lime slurry at the lime plant.
Sodium Ethyl Xanthate	Copper collector; used in the rougher flotation circuit.	Pelletized reagent shipped in 1-ton bags. Mixed with process water to form 20% solution and stored in collector storage tank. Mix and storage tanks vented externally with fans.
Fuel Oil (Diesel)	Used in the flotation process.	Shipped in tanker trucks and stored in the main head tank in the copper-molybdenum concentrator area.
Sodium Hydrogen Sulfide	Copper depressant used in the copper-molybdenum separation processes.	Pelletized reagent shipped in 1-ton bags. Mixed with process water to form 20% solution and stored in the NaHS storage tank.
Carboxy Methyl Cellulose	Depressant; anionic polymer used to depress clay and related gangue material in the bulk cleaner flotation circuit.	Pelletized reagent shipped in 1-ton bags. Mixed with process water in the agitated dispersant tank to form 20% solution and stored in dispersant storage tank.
Methyl Isobutyl Carbinol	Frother; maintains air bubbles in the flotation circuits.	Shipped in 20-foot specialized International Standards Organization containers and stored in the frother storage tank.
Depressant (sodium silicate)	Clay or silica gangue mineral depressant used in the copper-molybdenum separation process.	Pelletized reagent shipped in 1-ton bags. Mixed with process water to form 20% solution and stored in the sodium silicate storage tank.
Anionic Polyacrylamide	Thickener aid.	Pelletized reagent shipped in 1-ton bags. Vendor package preparation system composed of a bag-breaking enclosure to contain dust, dry flocculent metering, and a wet jet system to combine treated water with the powdered flocculent in an agitated tank for maturation. Prepared in small batches and transferred to a flocculent storage tank.
Polyacrylic Acid	Anti-scalant for the lime production process.	Viscous pale amber liquid shipped in 35-cubic-foot specialized container tanks in protected rectangular framework.
Nitrogen	Nitrogen used in the molybdenum flotation circuit to depress copper sulfides.	Nitrogen would be provided by a vendor-supplied pressure swing adsorption nitrogen plant. This equipment separates nitrogen from air for use in the mineral-process plant.

Note:
NaHS = sodium hydrogen sulfide
Source: PLP 2018d

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

Reagents would be shipped in both solid and liquid form, and would be housed and transported in secondary containment (PLP 2018-RFI 071).

4.27.7.1 Fate and Behavior of Spilled Reagents

This section briefly reviews the function and general properties of each reagent, and describes the general fate and behavior of spilled reagents. Detailed impact analyses of potential scenarios for reagent spills are not included in this section because there is effective secondary containment for reagents, so that the probability of a reagent being released into the environment would be extremely unlikely.

Many of the reagents would be shipped in pellet form. If spilled on dry land, the pellets would be recovered and placed back into containment. If spilled into water, pellets would sink. Solubility of reagents varies, and is further described below. Soluble reagents would dissolve if spilled into water, and could become bioavailable for a limited time, and potentially toxic to aquatic resources. Reagents that are insoluble or not immediately soluble could have long-term impacts to aquatic resources if not removed from water (PLP 2018-RFI 052). Scoping comments have noted the potential hazards of xanthates in particular (i.e., the sodium ethyl xanthate proposed by PLP).

Calcium Oxide

Calcium oxide (also known as “quick lime”) is a strong base used to increase the pH and remove pyrite in the copper-molybdenum flotation process. It would be used and transported in pellet form, with pellets crushed and mixed with water to form lime slurry (PLP 2018d). Due to its very high pH (strong base), it is considered caustic, and therefore can be hazardous to human health (e.g., skin, eye, and respiratory irritant) (Graymont 2012).

Calcium oxide is water-reactive and leads to an exothermic reaction, forming high-pH (corrosive) calcium hydroxide with much heat released before dissipating and neutralizing. If spilled in water, there would be an acute hazard to adjacent aquatic resources during the initial reaction. There are no hazardous thermal or decomposition products from the reaction (PLP 2018-RFI 052).

Sodium Ethyl Xanthate

Sodium ethyl xanthate is used for copper collection in the froth flotation process. It would be shipped in pellet form, then mixed with water and stored on site as a liquid.

Sodium ethyl xanthate is relatively soluble and highly toxic, especially to aquatic life (PLP 2018-RFI 052; Australian Government Publishing Service 1995). If spilled in water, the pellets would likely persist for some days before degrading by hydrolysis, and could create acute toxic conditions in the aquatic environment. It is biodegradable and is not expected to bioaccumulate in view of its ionic character (PLP 2018-RFI 052).

Sodium ethyl xanthate gives off carbon disulfide gas as a by-product, which can occur from contact with water. Carbon disulfide gas is both toxic and flammable (Redox MSDS 2015). Spills in Australia have included illness and hospitalization of workers and nearby residents who were exposed to the fumes; evacuation of some 100 people from a leak at a railway station; and fires. Sodium ethyl xanthate is classified as a Priority Existing Chemical in Australia due to adverse health or environmental impacts. Australian mine workers performing high-risk handling of sodium ethyl xanthate are now required by Australian regulations to use full-face respirators or self-contained breathing apparatus (Australian Government Publishing Service 1995).The EPA reports that the presence of xanthate would render the tailings slurries toxic; but that in the event of seepage from the TSF, degradation and dilution in the TSF would likely render the downstream waters non-toxic (EPA 2014). EPA notes that this would depend on xanthate’s ability to break down in the tailings facility.

Fuel Oil (Diesel)

Diesel is also used in the flotation process, and could be hazardous to human health and the environment if a release were to occur. Fuel oils are complex and variable mixtures that can impact the respiratory system at high concentrations. In addition, marine diesel fuel is considered possibly carcinogenic to humans, while the carcinogenicity of lighter diesel fuels has not been determined (ATSDR 1995). The potential impacts of small diesel spills are addressed in Section 4.18, Water and Sediment Quality; and large diesel spills, which may pose the greatest risk to human health and the environment, are addressed under Diesel Spills.

Sodium Hydrogen Sulfide

Sodium hydrogen sulfide (NaHS) would be shipped as pellets. If spilled on land, it would be recovered and placed back into containment. NaHS is very soluble, and if spilled into water, it would dissolve. Decomposition products include sodium oxides and sulfur oxides (PLP 2018-RFI 052). NaHS would be mixed with water and stored as a liquid in the NaHS storage tank. Aqueous NaHS is strongly alkaline (pH 11 to 12) and very corrosive. NaHS breaks down into hydrogen sulfide (H_2S) at below neutral pH and in the presence of heat. H_2S is highly toxic to fish (EPA 2014).

Carboxy Methyl Cellulose

Carboxy methyl cellulose would be shipped as pellets. This reagent is soluble and inherently biodegradable. No hazardous by-products or reactions are known to occur under typical conditions (PLP 2018-RFI 052). Sodium carboxy methyl cellulose, otherwise known as cellulose gum, naturally occurs in edible plants (e.g., fruits, legumes, nuts) and is an FDA-approved food additive stabilizer that is generally recognized as safe, and is permitted as an optional ingredient in standardized food (FDA 2018).

Methyl Isobutyl Carbinol

Methyl isobutyl carbinol (also known as MIBC) is a solvent that would be used as a frother to maintain air bubbles in the flotation circuits. It is a flammable liquid, with flammable vapor. It is classified as Dangerous Goods by the International Maritime Dangerous Goods Code (IXOM 2017). The MIBC would be shipped as a liquid in specialized ISO containers (PLP 2018-RFI 052). This liquid has limited solubility; and if spilled into water, it would float. MIBC is readily biodegradable (PLP 2018-RFI 052).

MIBC is considered hazardous, can cause eye and respiratory irritation, is a kidney toxin, and a carcinogen (IXOM 2017). The Material Safety Data Sheet (MSDS) recommends use only outdoors or in a well-ventilated area, and to avoid breathing mist, vapor, or spray (IXOM 2017).

Sodium Silicate

Sodium silicate would be shipped as pellets in 1-ton bags. If spilled in water, the pellets would sink. Rate of dissolution depends on the amount of water used as solvent (less soluble in large amounts of water) and temperature (less soluble in cold water). This material is inorganic and not subject to biodegradation (PLP 2018-RFI 052).

Anionic Polyacrylamide

Anionic polyacrylamide would be shipped as pellets. It is a polymer formed from acrylamide subunits and is soluble. Acrylamide is considered hazardous to the human nervous system, and is likely to be a carcinogen (IRIS 2010). At a pH greater than 6, the polymer degrades due to hydrolysis to more than 70 percent in 28 days (PLP 2018-RFI 052).

Polyacrylic Acid

Polyacrylic acid would be shipped as a liquid. It is a dense, viscous liquid that would sink if spilled into water, and would flow slowly if spilled on land (PLP 2018-RFI 052). It is considered hazardous if released into water (Owl Ridge 2018b). Exposure to acrylic acid is considered hazardous to human development and to nervous and respiratory systems, and carcinogenicity has not yet been assessed (IRIS 1994).

Nitrogen

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

4.27.7.2 Historical Data and Probability of Reagent Spills

The ADEC spills database has no records specific to spills of reagents from trucking, marine, or ferry transport. Spill rates of hazardous materials in general are lower than spills of substances such as diesel fuel or gasoline, because they are not often handled by the general public. From 1995 to 2017, only 3 percent of spills in Alaska released hazardous or very hazardous substances besides fuel oil (ADEC 2018h).

USCG and ADOT&PF/PHMSA databases contain no records of marine vessel spills specific to reagents (USCG 2018; PHMSA 2018). The NMFS Biological Assessment reports that no chemical spill risk data for Cook Inlet vessel traffic are available (Owl Ridge 2018b). The Biological Assessment also states that spills of hazardous waste have a lower probability than oil spills due to the way the goods are transported. Because reagents would be transported in relatively small volumes in secondary containment, the probability of a marine spill of reagents in lower Cook Inlet is very low. The statistical probability of such a release from the ferry into Iliamna Lake is even lower than that of a marine spill, as described above for diesel spills.

4.27.7.3 Existing Response Capacity

There are currently no organizations in Alaska that specialize in response to spills of reagents or other hazardous chemicals, besides fuels. PLP would have a spill response plan in place that would address spills of reagents and other hazardous materials. The Mine Safety and Health Administration establishes mine emergency management requirements for mine operators, including designation and training for responsible persons and the development of mine emergency response plans. PLP would have trained personnel and resources to respond to chemical reagent spills. Response plans would involve coordination and cooperation with Local Emergency Planning Committees (LEPC) and Local Emergency Planning Districts (LEPD) for the Kenai and Lake and Peninsula boroughs. See also the “Spill Preparedness, Prevention, and Response Measures” subsection for the actions that the Applicant has committed to.

4.27.7.4 Mitigation Measures

Reagents would be shipped in their original, approved-for-shipping, containers. These original containers would be placed inside steel shipping containers (secondary containment) and shipped to the mine site prior to unloading from the steel shipping containers (PLP 2018-RFI 071).

Sodium ethyl xanthate mix and storage tanks would be vented externally with fans (PLP 2018d). The ventilation is presumably provided to allow for dispersion of the toxic and flammable gas carbon disulfide, a by-product of sodium ethyl xanthate.

Alternatives Analysis

Because reagents would be transported by truck, the potential for a reagent spill could vary slightly by alternative. Road corridor lengths and road conditions, such as grade, would vary between alternatives. Alternative 1a would include 72 miles of road transport to haul reagents; Alternative 1 would include 66 miles of total road transport; Alternative 2 would include 53 miles of road transport; and Alternative 3 would include 82 miles of total road transport. The road corridor for Alternative 3 would be expected to have more road segments with higher grade, based on steeper topography in the southern and eastern portions of the road corridor. Final road design, including grades, has not yet been determined. Alternative 3 would not involve reagent transport by ferry, so there would be no potential for reagent spills from the ferry into Iliamna Lake.

4.27.8 Tailings Release

Tailings are the finely ground particles of rock material that remain after economic minerals have been extracted through ore processing. Tailings generally contain contact water, which may be elevated in metals and other constituents. Tailings could also contain residual chemical reagents, residual blasting agents, residues from the Water Treatment Plant (WTP), or other chemicals from ore processing. Reagents to be used in the project are addressed under the "Reagent Spills" section, above. Chemical reactions can take place in tailings that produce other chemicals that were not originally in the tailings. A "failure" of a TSF refers to the unintended release of tailings fluid and/or solids, and could result in impacts to the downstream environment.

Historically, mine tailings have been stored in large impoundments that were commonly referred to as tailings ponds, but are now generally referred to as tailings storage facilities (TSFs). Some TSFs maintain a full water cover over their entire surface to provide subaqueous storage of the tailings in order to prevent oxidation of sulfide minerals and generation of ARD. Other TSFs, where such oxidation is not a concern, remove much of the supernatant water for reuse in the milling process, or for treatment and discharge, and just retain smaller ponds of water that cover only part of the tailings, typically referred to as supernatant ponds. TSFs with a full water cover are more susceptible to large tailings releases. See Appendix K4.27 for additional discussion.

PLP is proposing a method of tailings storage that would eliminate the need for a TSF with a full water cover. PLP is proposing to separate mine tailings into bulk tailings, which have a relatively low potential for ARD and ML; and pyritic tailings, which have higher potential to produce acid and leach metals. The bulk and pyritic tailings would compose approximately 88 and 12 percent, respectively, of the total tailings (PLP 2018d). The two types of tailings would be stored in two separate TSFs and would have distinct fates during post-closure. During operations, the bulk TSF would have a minimal supernatant pond and the pyritic TSF would have a full water cover. As part of closure, the bulk TSF surface would be drained of water and maintained as a "dry" landform; the pyritic TSF would be dismantled, and its contents relocated to the open pit. Below is a description of the two types of tailings and their TSFs. Chapter 2, Alternatives, provides more detail on the construction and operation of the facilities. Section 4.15, Geohazards and Seismic Conditions, addresses the geotechnical aspects of the TSFs and their embankments.

4.27.8.1 Bulk Tailings and the Bulk TSF

Bulk tailings would contain the finely ground particles of rock material that remain after most metallic and sulfide minerals have been removed from the raw ore during the bulk rougher flotation, the first phase of mineral separation. Because the process of mineral separation is inherently imperfect, a small percentage of unrecoverable sulfide minerals and other metals would remain in the bulk tailings, so that bulk tailings would contain a small percentage of PAG material and have a relatively low potential for ARD and ML compared to pyritic tailings. The grain size of the bulk tailings would vary from clay- to sand-sized particles (60 percent clay and silt; 40 percent fine sand) (Knight Piésold 2018o).

The bulk TSF would provide storage capacity for 1.1 billion tons of bulk tailings, the operating supernatant pond, and additional freeboard for the required Inflow Design Flood (IDF; equal to the probable maximum flood). The main (north) embankment would be constructed by the centerline method, and the south embankment would be constructed by the downstream method. Data on dam failures around the world demonstrate that dams built by downstream or centerline construction methods are safer than dams built with upstream construction methods, especially under seismic shaking (ICOLD 2001; Rico et.al 2007a; Azam and Li 2010). Both of the bulk TSF embankments would be constructed out of earthfill and rockfill materials on bedrock foundations. See Chapter 2, Alternatives, for general descriptions of centerline and downstream dams. See Section 4.15, Geohazards and Seismic Conditions, for geotechnical aspects of both centerline and downstream dam designs.

Bulk tailings would be thickened and pumped into the bulk TSF by two pipelines as a thick slurry of 55 percent solid rock and mineral particles, and 45 percent fluid (PLP 2018d). The tailings would be deposited by spigots around the perimeter of the facility, so that the level of tailings would be higher along the TSF at the perimeter and lower towards the center of the TSF. Water that drains out of the slurry would accumulate at the low spot towards the center in a supernatant pond. Tailings higher than the level of the supernatant pond are considered the tailings "beach." Because bulk tailings have a low concentration of PAG material, they would not require subaqueous storage in a typical water-inundated TSF. Higher water content in TSFs can increase the probability of significant tailings spills. Best available technology (BAT) principles established following the Mount Polley dam failure (Morgenstern et al. 2015) include eliminating or minimizing surface water in impoundments, and promoting unsaturated conditions in tailings through drainage provisions. Best available practice (BAP) principles developed following the Mount Polley dam failure (Morgenstern et al. 2015) have been further advanced (Morgenstern 2018; Cobb 2019). The Applicant has a mine site design and layout that would reduce the amount of fluid stored in the bulk TSF by continually pumping the excess fluid to the main WMP.

The main (north) embankment of the bulk TSF would have a maximum height of 545 feet, and would operate as a flow-through zoned rockfill and earthfill embankment that would allow excess fluid in the tailings to drain out through the seepage collection system, and then either be re-used in the mill process, or treated and released. The main embankment and the adjacent tailings would therefore have a depressed or relatively low fluid level (phreatic surface) (see Figure K4.15-3 for a cross section of the predicted phreatic surface at the close of operations). The south embankment would have a maximum height of 300 feet and would be lined, and therefore would not be pervious, so that the phreatic surface would be higher on the southern end of the TSF. The majority of the tailings in the southern portion of the facility would be fluid-saturated. If the supernatant pond level were to rise, fluid could be pumped out of the TSF into the main WMP. Tailings in the beach area, especially on the northern side of the TSF, would be well-drained and relatively dry; while tailings deeper within the TSF would remain fluid-saturated. The bulk TSF would remain as a pervious structure, so that the bulk tailings would be in "relatively dry" storage and not subaqueous.

The bulk tailings that are drained and not fluid-saturated would have a consistency that would flow similar to molasses. These tailings would be quite viscous, and would not readily flow if spilled (MEND 2017). Tailings deeper in the facility that would be fluid-saturated would exhibit more fluid behavior, and would flow more readily as a slurry if spilled.

There remains some uncertainty regarding the ability of bulk tailings to drain sufficiently at the current conceptual level of design. It is uncertain whether the thickened tailings at 55 percent solids would segregate enough, with coarse tailings forming the tailings beach near the spigots and finer tailings in the middle of the TSF, to promote reduction of the phreatic surface near the bulk TSF main embankment (AECOM 2019n). Although the design is intended to promote unsaturated conditions, the majority of tailings may remain saturated throughout operations, and potentially into post-closure.

Appendix K4.27 provides additional background information on the difference between many historic subaqueous TSFs and the Applicant's "flow-through" TSF design.

Aqueous chemistry of the bulk tailings supernatant fluid is expected to be dominated by metals. Modeling results indicate that the concentrations of the following metals would exceed applicable WQC (as defined by Alaska Water Quality Standards [WQS], 18 AAC 70): antimony, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, selenium (a metalloid), and zinc (Knight Piésold 2018a) (see Appendix K4.18, Table K4.18-3). Water quality parameters, including total dissolved solids (TDS), alkalinity, hardness and sulfate in the bulk tailings supernatant, are also not expected to meet the respective WQC.

The contact water used to make up the thickened bulk tailings slurry would also likely contain elevated concentrations of some metals and other constituents relative to WQC.

4.27.8.2 Pyritic Tailings and the Pyritic TSF

The pyritic tailings would be chemically and physically distinct from the bulk tailings. The processing of the raw ore to separate minerals would leave the pyritic tailings with approximately 15 percent sulfur as sulfide minerals, so that the tailings would be PAG material. Therefore, the pyritic tailings would require subaqueous storage throughout the 20 years of mine operations, to prevent oxidation of the sulfide minerals and subsequent generation of acid (PLP 2018-RFI 045). Their potential to generate acid would be similar to that of the copper-gold concentrate. The pyritic tailings would have a much lower level of copper and molybdenum than the concentrates, but would still contain enough metallic elements to have ML potential (PLP 2018-RFI 045).

The pyritic tailings would go through a regrind process, so that the grain size of pyritic tailings would be smaller than that of the bulk tailings. Particle sizes would be mostly clay- to silt-sized, with only 2 percent fine sand sized (Knight Piésold 2018p). The pyritic tailings would be thickened and pumped in a pipeline as a thick slurry into the pyritic TSF for storage (PLP 2018d).

The pyritic TSF would be fully lined and would store approximately 155 million tons of pyritic tailings, up to 93 million tons of PAG waste rock, and an operating supernatant pond that would fully cover the tailings, with additional storage capacity for the required IDF (equal to the probable maximum flood) and additional freeboard (Knight Piésold 2018p; PLP 2020d). There would be three embankments, north, east, and south, that would be zoned rockfill and earthfill structures constructed with the downstream method on a foundation of bedrock. These embankments would form a "ring" embankment around three sides of the TSF, and would have maximum heights of 335, 225, and 215 feet, respectively. As noted above, data on dam failures around the world demonstrate that dams built by downstream or centerline construction methods are safer than dams built with upstream construction methods, especially under seismic shaking (ICOLD 2001; Rico et al. 2007a; Azam and Li 2010). See Chapter 2, Alternatives, for a description of the downstream dam construction; and Section 4.15, Geohazards and Seismic Conditions, for geotechnical aspects of the dam design.

The PAG pyritic tailings would require subaqueous storage with a minimum 5-foot depth of full supernatant water cover to be maintained on top of the tailings during operations. The predicted pH of pyritic TSF supernatant fluid at the close of operations would be 7 to 8 (Knight Piésold 2018a). The pyritic TSF would be a fully lined facility, with the liner extending up the upstream faces of the embankments. Several years after the close of mine operations, the pyritic tailings would be pumped into the open pit, which would then be allowed to fill with water, so that the pyritic tailings would be permanently stored sub-aqueously. Perpetual storage in the pit would reduce the potential for a spill of pyritic tailings after the close of operations.

Because the pyritic tailings would be submerged under water in the pyritic TSF, they would be entirely fluid-saturated. In the event of a release, the fluid stored above the pyritic tailings could entrain the fine tailings particles and release the fluid (non-thickened) tailings slurry. Such tailings slurries could exhibit fluid behavior and readily flow like water (MEND 2017).

Modeling results indicate that the pyritic supernatant would have elevated concentrations of the following metals relative to the applicable WQC: antimony, arsenic, beryllium, cadmium, cobalt, copper, lead, manganese, mercury, molybdenum, selenium, silver, and zinc (Knight Piésold 2018a) (Table K4.18-3). Other parameters, including TDS, alkalinity, hardness, and sulfate in the pyritic tailings supernatant, would fail to meet respective WQC.

The contact water used to make up the pyritic tailings slurry is also likely to contain elevated concentrations of some metals and other constituents. In addition, residuals from water treatment, including selenium sulfide, would be added to the pyritic tailings and placed in the pyritic TSF. See Section 4.18, Water and Sediment Quality, for details on water treatment. In the event of a spill, these materials could be released into the environment. See Appendix K4.24, Fish Values, for additional discussion of metals toxicity.

4.27.8.3 Fate and Behavior of Released Tailings

This section describes the general fate and behavior of released tailings for a wide range of hypothetical releases. Specific impacts from the selected release scenarios are presented below.

An unplanned release of tailings from one of the TSF facilities could cause a flood of water and/or tailings slurry downstream of the facility. Solid tailings particles could be deposited on uplands, wetlands, or in stream drainages. A flood of tailings-laden water could erode streambanks and associated habitat and modify stream morphology. Streamflow would transport some of the spilled tailings downstream, where further deposition could occur, potentially burying stream substrate and altering benthic habitats. Entrained tailings would create turbid water conditions and sedimentation downstream, which would impact downstream habitat until the tailings are completely recovered or naturally flushed from the drainage. Upstream erosion could contribute to ongoing downstream turbidity and sedimentation. Metals could leach from unrecovered tailings on a timescale of years to decades. Unrecovered tailings that are exposed to oxygen could generate acid on a timescale of years to decades or more. Acid and metals flushed into the watershed would be diluted by stream water, while acid and heavy metals that accumulate in streambed sediments, wetland soils, or isolated waterbodies could impact water quality on a timescale of decades.

The fate and behavior of tailings released into the environment would depend on several factors, including: 1) location of release (e.g., dry land, water); 2) type of tailings (bulk or pyritic tailings); 3) water content of the release (proportion of solid tailings versus fluid); 4) volume of the release (tailings and fluid); 5) speed/duration of the release; 6) downstream topography; 7) seasonality; and 8) mode of release.

1. **Location of Release**—A spill of tailings onto dry land could be recovered relatively easily with excavation, although recovery of tailings that enter flowing water would likely not be practicable.
2. **Type of Tailings**—Both bulk and pyritic tailings have the potential to generate acid and leach metals into the environment over time. Due to the low percentage of sulfides

and other metals in the bulk tailings, however, the risk of acid generation and ML from a spill of bulk tailings is low (compared to pyritic tailings). Any acid or metals generated from the bulk tailings would be produced on such a slow timescale (years to decades based on ARD and ML rates), and would be so diluted by precipitation and surface water, that impacts may not be measurable (see discussion of ARD and ML in Section 3.18, Water and Sediment Quality). The pyritic tailings, however, are elevated in metals, and would be more capable of producing acid and leaching metals, depending on conditions. Both bulk and pyritic tailings would cause elevated TSS, turbidity, and sedimentation if released into the environment.

3. **Water Content in the TSF**—Under otherwise normal operating conditions, a spill from the well-drained tailings beach of the bulk TSF would be considered a relatively dry spill scenario, in which the tailings would remain a viscous mass, not capable of flowing great distances. Based on the height of the highest (northern) bulk TSF embankment of 545 feet, the tailings would be expected to flow no more than about 2.2 miles downslope (MEND 2017). If deeper fluid-saturated tailings were to be released, they could flow readily as a liquid slurry, depending on the level of compaction. Likewise, if a water management failure led to overfilling of the bulk TSF and overtopping of an embankment, a bulk tailings release could become a wet scenario, in which the bulk tailings would become fluid-saturated, and converted into a tailings slurry. In this situation, the initial release would be a flood of water, followed by tailings slurry.

   Any release from the pyritic TSF would be a wet spill scenario, with a slurry of supernatant fluid and entrained pyritic tailings expected to flow like water (MEND 2017).

4. **Volume of Release**—A small-volume release of tailings would have less environmental impacts than a massive release. Recovery of a small spill could be relatively simple, while recovery of a massive release, especially one that reaches flowing water, would be extremely difficult.

5. **Speed/Duration of Release**—If a spill of tailings were to occur slowly, such as a slow leak through one of the embankments, personnel would have time to respond, contain the spill, and repair the leak. If response is prompt and the duration of the spill is brief, the spilled tailings would likely be of relatively low volume and would not travel far. A long-duration spill could allow a large volume of tailings to be released; and to travel downslope and into waterbodies.

6. **Downstream Topography**—Local topographical features (slope, terrain, and vicinity to waterbodies) determine the direction and speed of spilled tailings and their fate. Site-specific topographical features were incorporated in modeling the fate of spilled tailings in the scenarios presented below.

7. **Seasonality**—Frozen rivers would not transport spilled tailings downstream. Tailings spilled during frozen conditions would therefore accumulate closer to the TSF and would be easier to recover. Frozen soils would not be permeable, so that tailings slurry would not be able to percolate downward into soils and frozen sediments. During summer/non--frozen conditions, flowing water would mobilize spilled tailings downstream, so that the impacted area would be larger and recovery more complicated. A spill during partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), could potentially trap tailings beneath ice, presenting additional challenges to cleanup.

8. **Mode of Failure**—The behavior of spilled materials is dependent on the way in which a spill occurs. The most common modes of failure include overfilling with fluid leading to overtopping; slope instability leading to dam deformation; earthquake damage;

unstable foundation; excessive seepage leading to a dam breach; and structural failure from poor design/construction (ICOLD 2018). See Section 4.15, Geohazards and Seismic Conditions, for a discussion of TSF engineering design concept, including seismic design parameters. The failure modes for the scenarios presented below were determined by a panel of experts in a project-specific risk assessment, as described below under Risk Assessment for the Proposed Embankments.

Tailings Fluid Release

A release of tailings fluid from the TSFs could include untreated process water ranging in volume from excess seepage of pore water that could overwhelm the seepage control pond to a flood of supernatant fluid. In the event of overfilling of an embankment, supernatant could overtop the dam and spill downslope. A flood of supernatant fluid would flow downstream of the TSF. The speed and distance traveled by the released material would depend on the volume of fluid, the duration of the release, topography, and other factors addressed above. In the event of embankment overtopping, the resulting release could overwhelm downstream drainages and cause downstream erosion.

Elevated levels of metals and other constituents in the tailings fluids would impact water quality downstream. Released fluids would be immediately diluted by stream water, but stream water could fail to meet applicable WQC for many miles downstream.

Tailings Solids Release

In the event of a release of the thickened bulk tailings from the bulk TSF, the mass of thickened tailings could flow only a limited distance downslope on land. Previous studies suggest that thickened tailings are capable of flowing approximately 20 times the length of the height of the embankment (MEND 2017), depending on topography. In the case of a release from the bulk TSF main embankment, this distance would be about 2.2 miles. This distance does not take into account that the tailings would slump into waterbodies. Depending on the volume of the release, the area downstream of the bulk TSF could be covered by fine tailings, and the tailings could enter downstream drainages.

If the tailings reached a flowing stream, solid tailings particles would become entrained in the water and would be carried downstream, causing downstream sedimentation and elevated TSS/turbidity, as described below.

Tailings Slurry Release

If a high-volume release of pyritic tailings or release of wet bulk tailings occurred, a flood of fluid and tailings slurry would readily flow downslope. Some of the solid particles from the tailings slurry would settle out on land, while particles that reached flowing water would mostly be carried downstream as suspended sediment. Some tailings particles would settle on the streambed in areas of low water velocity. The flood waters would recede in a matter of hours to days, leaving behind deposits of the solid tailings material where flooding overtopped stream banks. Depending on the volume of release and other factors, the tailings could cover or bury the existing streambeds and/or stream banks. Further flow down the altered watershed could erode new channels into the soft tailings sediment. Downstream sedimentation and elevated TSS and turbidity would continue until spilled tailings are recovered, naturally flushed out of the drainage, or incorporated into the bedload. If no tailings were recovered or if the volume of release was extremely high, decades to centuries may be required to naturally flush tailings out of the drainages.

Elevated metals from the fluid would affect water quality in the short-term, until all the fluid is flushed downstream and diluted, as previously described. The EPA reports that this type of tailings slurry would be toxic due to the presence of xanthate (a reagent); but that if released in a spill, degradation and dilution would render the downstream waters non-toxic (EPA 2014). Xanthate and other reagents are addressed above.

Sedimentation and TSS

A spill of tailings into a waterbody would cause both sedimentation and an increase in TSS in the water. The amount of material that remains suspended as TSS versus deposited as sediment depends mostly on particle size and the energy of the water/velocity of the current.

The finest particles, including clay and silt, are so light that they would generally remain suspended in flowing water for an extended time, and be transported downstream by currents. In high-energy/high-velocity streams, even sand particles can remain suspended for a time, contributing to the TSS level. Downstream water would appear turbid, or cloudy, if the TSS remained elevated. Even in a small to moderate release of tailings, elevated TSS would extend all the way to the Nushagak River Estuary where it enters Nushagak Bay, part of the greater Bristol Bay (Knight Piésold 2018o). Stream water in and near the project area has naturally very low levels of TSS (Appendix K3.18, Water and Sediment Quality), and an increase in these levels above baseline conditions (pre-development levels) could impact aquatic habitat. Elevated TSS would continue until all spilled tailings upstream are recovered or naturally flushed downstream.

Sand-sized particles are heavier, and are more likely to sink in a waterbody, to be deposited as "bedload," or sediment on the bottom of the waterbody. High-energy streams continually transport bedload downstream. In a lower-energy stream, even clay- and silt-sized particles could be deposited as bedload, especially in areas of weak current, such as oxbows or sloughs. An increase in sedimentation could bury existing substrate, potentially smothering benthic organisms. Spilled tailings could also fill in voids between larger particles of substrate, such as between clasts of gravel, modifying the benthic habitat, and particularly reducing spawning habitat for salmonids.

Acid

Tailings Fluids

Supernatant fluids in the TSFs are predicted to be relatively neutral, with a pH of 7 to 8 (Knight Piésold 2018a). The release of these untreated fluids would therefore not be expected to create acidic conditions in the downstream environment.

Tailings Solids

In the event of a release of bulk or pyritic tailings into the environment, acid could be generated from unrecovered tailings solids, if tailings remain exposed to air over a period of years to decades. The potential for tailings to generate acid would continue until spilled tailings are recovered. Acid would be generated in amounts inversely proportional to tailings recovered. If tailings are recovered, no acid would be generated that would impact the downstream environment.

Both bulk and pyritic tailings would contain sulfide minerals (mostly pyrite, [FeS_2]) that chemically react with oxygen gas (O_2) and water to produce sulfuric acid (H_2SO_4), a strong acid. Pyritic tailings would contain a high level of sulfide minerals, and are classified as PAG. Bulk tailings would be primarily composed of non-acid generating materials, but would contain low concentrations of sulfides (PAG materials). Acid generation from oxidation of PAG materials occurs on various timescales, depending on factors including the rock type, mineralogy, local climate conditions, etc. (see "Factors Influencing Acid Generation and Metals Leaching" in the "Concentrate Spills" subsection). Geochemical studies on rocks from the mine site indicate that PAG material present in the tailings may require years to decades under local conditions to generate acid, depending on oxygen exposure (SRK 2018a) (see Section 3.18, Water and Sediment Quality, for discussion of PAG geochemistry.)

Stagnant water, such as that in small lakes, ponds, and TSFs, contains very low levels of dissolved oxygen (DO). Therefore, when PAG materials are stored sub-aqueously (submerged under water) in a quiescent environment, limited or no sulfur oxidation can occur to generate acid. Larger lakes may have increased circulation, which introduces higher levels of oxygen into the lake water. Iliamna Lake overturns (has significant circulation) twice every year (dimictic), and therefore has higher DO levels than standing/stagnant water.

Flowing water such as streams also contains limited DO, so that a small amount of oxidation can occur from exposed PAG materials in streams over timescales of decades to centuries. Streams in the analysis area contain an average DO level of 10.2 to 10.5 mg/L, and 12 mg/L is considered the saturation limit for local conditions. The DO in flowing water is capable of generating a small amount of acid from spilled concentrate; however, the process of acid generation would be slow, and any acid generated would be constantly diluted by the flowing water.

ARD generated from oxidized tailings could be flushed by surface runoff into waterbodies, potentially reducing the pH of the water in the vicinity. Due to the small amount of acid that would be generated, and the years to decades required for acid generation, it is likely that the acid would be progressively neutralized (diluted) as it moves downstream, due to the natural buffering capacity of the surface water. If generated ARD were flushed into an isolated waterbody, or collected in soil or in a wetland environment, however, the acid could measurably reduce the pH of the water or soil.

Metals

Tailings Fluids

Fluids held in tailings (pore water) and above the tailings (supernatant fluid) would have elevated concentrations of dissolved metals, as described above. Dissolved metals would be bioavailable, and could have toxic effects on aquatic biota. In the event of an unplanned release, these metals would be introduced into the downstream waters, and would cause downstream waters to exceed applicable WQC. The released fluid would be diluted by stream water, and flushed downstream. Depending on the volume and the rate of release, the downstream water quality would be in exceedance of WQC for an unknown length of time and an unknown distance before the released fluid is sufficiently diluted below water quality exceedance. See Appendix K4.24, Fish Values, for additional discussion on metals toxicity.

Tailings Solids

A release of tailings solids into downstream waters would cause elevated levels of metals in their *total form*; that is, the metals would not be dissolved, and therefore not bioavailable. Dissolution of the metals in tailings solids would require years to decades of weathering, depending on local conditions. See "Factors Influencing Acid Generation and Metals Leaching" in the "Concentrate Spills" subsection.

Tailings solids could contribute to elevated dissolved metal concentrations downstream over a period of decades if they are not recovered. The potential for tailings to leach metals would continue until spilled tailings are recovered. Complete recovery of spilled tailings would not be possible, because tailings spilled in flowing water would be widely dispersed. However, timely and effective recovery of spilled tailings would reduce impacts from ML. Impacts would depend on the volume of the spilled tailings solids, and the effectiveness of recovery.

ML is a natural process in which metallic minerals dissolve through chemical weathering, releasing the metals into the water. However, most metallic minerals are not readily soluble in water, especially those associated with sulfide minerals; and the ML process occurs very slowly over years to decades, depending on the metal and local conditions.

At the mine site, natural ML from copper-rich rocks has been occurring for millennia, so that some streams in the area have naturally elevated concentrations of copper and other metals. This is often how mineral deposits are initially discovered. In some streams near the mine site, baseline metal concentrations naturally exceed WQC (SLR et al. 2011a).

In neutral pH waters, ML would be a very slow process. Copper present in the tailings, for example, would not readily leach into surface waters. In acidic water, ML of copper and other metals is accelerated. Some stretches of the NFK and SFK are naturally acidic (see Appendix K3.18, Water and Sediment Quality). The potential for ML would depend on acid generation from the tailings, as well as the natural pH of the waterbody. In a tailings release, however, the slow rate of acid generation from PAG materials on dry land and the high level of environmental dilution would mean that no single body of water would likely become acidic enough to accelerate ML from spilled tailings.

Residual Toxins

In the past, public concern has been expressed regarding mining-related spills of mercury and cyanide, which have led to mortality of fish and other aquatic organisms. Use of mercury or cyanide in the project area is not included for the project. Potential cyanide use in the Pebble Project expansion scenario is addressed in the "Cumulative Effects," subsection.

Process chemicals that would be used for the project include the reagents described under "Reagent Spills," above. Most of the reagents are consumed during the process of froth flotation, and residual reagents mostly remain adhered to the metals in the ore concentrate. The small amount of residual reagents in the tailings is anticipated to degrade naturally. See the "Reagent Spills" section above for information on fate and behavior of spilled reagents.

The bulk tailings could have residual amounts of Ammonium Nitrate and Fuel Oil (ANFO), an emulsion-based blasting agent (explosive). ANFO may cause long-term adverse effects to the aquatic environment (Orica 2015). Ammonium Nitrate is widely used as a fertilizer, and applied to the soil in agricultural areas. Ammonium nitrate may be hazardous to water quality, but is biodegradable (New Jersey Dept. of Health 2016). Pyritic tailings would go through additional processing after separation from bulk tailings, and would not be expected to contain residual ANFO.

Residuals from the WTP, including selenium sulfide, would be added to the pyritic tailings and placed in the pyritic TSF. See Appendix K4.24, Fish Values, for a detailed discussion of metals toxicity.

4.27.8.4 Historical Examples of Tailings Releases

The number of tailings dams in the world is estimated at over 3,500 (ICOLD 2018). The International Commission on Large Dams (ICOLD) published a database of 221 tailings dam incidents, including 135 failures that occurred between 1917 and 2000 (ICOLD 2001). Numerous other tailings dam failures have occurred in the last 2 decades as well (WISE 2020).

From 1987 to 2007, there was an average of 1.7 tailings dam failures per year (Peck 2007, as reported in EPA 2014); from 1995 to 2001, the rate of major incidents was two per year (ICOLD 2001); while another source cites two to five major tailings dam failures per year between 1970 and 2001 (Davies 2002). Between 1999 and 2018, the failure rate has averaged 2.4 failures per year. The number of tailings dams increases every year as new mines are constructed, and the failure rate in recent years has risen, with a failure rate of 3.2 failures per year between 2014 and 2018 (WISE 2018). New data from WISE show six TSF failures around the world in 2019, and one failure to date in 2020 (WISE 2020). It is also worth noting that reporting of these failures has improved in recent years, and many failures likely went unreported in the past.

Most tailings dams around the world have been constructed by the upstream method, in which dams are sequentially raised by placement of fill on top of stored tailings in the upstream direction. Upstream dams are often used because they are less expensive to construct, and require a smaller footprint than downstream and centerline dams. Rico et. al. (2007a) estimated that 76 percent of global TSF failures involved upstream dams. Published failure data are therefore based on failures of mostly upstream dams. The Applicant is not proposing to construct any upstream dams.

Downstream dams, in contrast, are raised in the downstream direction by placement of fill on top of the crest and downstream slope of the previous raise. Centerline dams are raised by placement of fill on top of both stored tailings and fill materials of the previous raise. Data on dam failures around the world demonstrate that dams built by downstream or centerline construction methods are much safer than dams built with upstream construction methods, especially under seismic shaking, although downstream and centerline dams have still failed (ICOLD 2001; WISE 2020). The Applicant has proposed downstream and centerline construction for all 13 embankments. See Section 4.15, Geohazards and Seismic Conditions, for technical details on the proposed dam construction methods.

Historical failures of tailings dams have caused damage, including human casualties, destruction of homes and property, economic loss, and environmental impacts, especially impairment of aquatic habitat in drainages beneath the failed embankments.

Appendix K4.27 provides a detailed discussion of recent tailings dam failures that have occurred in British Columbia (Mount Polley 2014), Brazil (Fundão 2015; Feijão 2019), and Australia (Cadia 2018). Morgenstern (2018) and Marr (2019) discuss some of these, along with a select set of other high-profile failures and releases. Examples of some additional earlier high-profile historic failures include:

- November 1974, Bafokeng, South Africa: 3 million cubic meters (m^3) of tailings slurry flowed 45 kilometers.
- July 1985, Stava, Italy: Tailings flowed up to 8 kilometers.
- April 1998, Aznalcóllar, Spain: 4 to 5 million m^3 of toxic water and tailings slurry were released.
- October 2010, Kolontar, Hungary: Approximately 900,000 cubic yards of tailings slurry flowed downstream, and some of that amount reached the Danube River.

It is considered state-of-the-practice to design modern tailings dams to high industry standards; subject them to multi-phase risk analysis; and apply strict regulations on their design, construction, and operation. Modern dam designs include extensive site investigation, consideration of rock and soil strength, climatic variability, flood conditions, seismic potential, etc. Because recently constructed dams have relatively short performance records, there are limited data available on their rates of failure. However, investigations have found that modern dams that have experienced failures have been attributed to human error in design, construction, operations and regulation, or some combination thereof.

A recent example of a modern tailings dam failure is the August 2014 release from the Mt. Polley copper and gold mine in British Columbia, Canada. An estimated 7.3 million cubic meters of tailings solids and 17.1 million cubic meters of fluid were released during a breach of the tailings facility embankment and flowed into downstream waterways (WISE 2018). Investigations (Morgenstern et al. 2015) point to a combination of factors leading to failure, including an initial geotechnical oversight, a steeper-than-designed downstream slope, a lack of foresight in planning for dam raising, improper/insufficient observation (surveillance), and a higher-than-planned supernatant pond on the TSF surface.

Fluids released during tailings dam failures, including supernatant, seepage water, contact water and entrained water, often contain elevated levels of metals that can impact downstream water and habitat. However, these fluids are rapidly diluted and flushed out of drainages. Tailings solids that were never recovered and have been left in place for decades, however, have been shown to be a long-term source of contamination. Downstream sedimentation and increased TSS can cause immediate and long-term impacts to aquatic habitats. Over time, periods of years to decades, ARD and ML can be sources of toxicity from unrecovered tailings.

Three well-studied historic examples of unrecovered mine tailings from the United States demonstrate the potential long-term impact to water quality and aquatic habitats that can result. A tailings dam failure in the New World mining district in Montana in 1950 released 41 million m^3 of tailings with high levels of copper, gold, and other metals into Soda Butte Creek. ML from the spilled solid tailings has impaired biota in the river, and copper levels in the streambed sediments are still elevated today (Marcus et al. 2011). In the Coeur d'Alene River, Idaho, from the turn of the twentieth century until the late 1960s, multiple tailings dams failures and then state-of-the-practice dumping released about 62 million tons of tailings with high concentrations of copper, lead, silver, zinc, and other metals. ML from unrecovered tailings led to toxic levels of metals in both river water and sediment, and the loss of some fish species from the area (EPA 2014). Mining practices common around the turn of the twentieth century led to the uncontrolled dumping of tailings, which contained heavy metals, including copper, on the floodplains of the Clark Fork River, Montana. Generation of acid and ML killed vegetation in some areas; and killed most of the fish in the river for a period of several decades. Periodic rainstorms flushed leached metals into the river and caused subsequent fish kills. Sedimentation also likely contributed to low fish numbers (EPA 2014). All three sites are now Superfund sites (EPA 2014).

Due to improved modern TSF management practices, environmental regulations, and public demand, tailings spills are now more routinely recovered and cleaned up, so that the potential for severe long-term impacts from unrecovered tailings is likely lower now than in the past century. Small- to moderate-volume tailings spills from the project would likely be recovered to conditions in compliance with state regulations.

The Mount Polley dam failure is a recent example in which tailings considered "recoverable" were recovered. Timely recovery of spilled tailings and stabilization of impacted waterways have been shown to limit chemical impacts to downstream waterways (Byrne et al. 2018).

The main water quality impact of the Mount Polley release was elevated TSS and turbidity (Nikl et al. 2016). Metals in their total form (not dissolved or bioavailable) were also elevated after the release due to the suspended tailings particles. Initial water quality impacts also included elevated temperature and conductivity (Petticrew et al. 2015). Water quality downstream of the Mount Polley release was reduced for approximately 6 to 9 months, after which time the water quality returned to baseline (Nikl et al. 2016).

Geochemical predictions were that metal release potential and bioavailability of tailings would be low, which is supported by data showing that tailings have not been toxic, and copper levels were shown to be decreasing after the release (Nikl et al. 2016). Salmon in the Quesnel Lake watershed downstream of the Mount Polley release returned to spawn in high numbers in 2018, 4 years after the spill (Williams Lake Tribune, 2018).

4.27.8.5 Probability of Failure

Determining the probability of failure of tailings dams is difficult, because historic failures represent a wide range of engineering, construction, and operations quality from across the world, and include TSFs constructed over a span of more than a century. Numerous tailings releases that occurred throughout the twentieth century were likely constructed with what would be considered poor-quality engineering compared to modern state-of-the-practice standards, and many experts therefore do not believe that historical dam failure data are relevant when calculating the risk posed by modern dams.

Published tailings dam failure rates are based on historical failures, which have mostly been failures of upstream constructed dams. As noted above, Rico et al. (2007a) estimated that 76 percent of global TSF failures involved upstream dams. Published failure data presented here are therefore based on failures of mostly upstream dams. Centerline or downstream dams, like those proposed by the Applicant, have a much lower failure rate, as described above (ICOLD 2001; Rico 2007a). See Appendix K4.27 for a discussion of dam failures relevant to the proposed project.

Estimates of the probability of failure of tailings dams include: one failure for every 2,000 dam-years (one dam-year is the existence of one dam for one year) (Chambers and Higman 2011); one failure for every 2,041 dam-years (Peck 2007); one failure every 714 to 1,754 dam-years (Davies et al. 2000 as reported in EPA 2014); and one failure every 2,500 to 250,000 dam-years (EPA 2014). These leading estimates all indicate that the probabilities of failure are very low.

Another way to describe the probability of dam failure is the annual probability of failure. The historical average failure rate of tailings dams is 1 in 1,000 per year (0.001 annual failure rate) compared to 1 in 10,000 per year (0.0001 annual failure rate) for water retention dams (Marr 2019). The rate of failure of tailings dams is higher than that of water supply reservoir dams, possibly due in part to the sequential raising of tailings dams, as opposed to reservoir dams, which are constructed all at once (Chambers and Higman 2011). Regarding dam failure rates and height of dams, higher dams (such as dams higher than 300 feet) have historically *not* failed more than lower dams, but spills from higher dams are more likely to be reported by the media because the consequences of such spills can be more severe than spills from smaller dams (with lower-volume containment). In addition, historically, the numbers of higher dams in existence was fewer. One study demonstrates that dam height has an inverse correlation with the frequency of dam failure; only about 1 percent of 147 tailings dam failures documented worldwide by Rico et al. (2007a) have occurred at large dams, greater than 300 feet high. This may be due to higher levels of engineering and safety considerations required for large dams compared to smaller ones. However, this study includes a relatively small database, and other analysts do not agree that there is a demonstrated inverse correlation between dam height and failure (EPA 2014).

Some authors have noted that released volumes from recent tailings dam failures are larger than in past decades, reflecting the larger size of modern TSFs. This may be due to the mining of lower-grade ores, which necessitates storing a higher volume of tailings (Armstrong et al. 2019).

Evaluation of historical data shows that the probability of TSF failures depends on many factors, including the quantity and quality of the geological and geotechnical investigations, dam engineering and design, construction procurement and methods, construction quality control and quality assurance, site soil, rock and groundwater conditions, control of fluid levels in the facility (water management), and accordance with regular inspections and regulatory protocols, tailings gradation and strength characteristics, and tailings segregation and permeability. As noted above, most historic dam failures have been from upstream-constructed dams.

The only common factor in all major TSF failures has been human error, including errors in design, construction, operations, maintenance, and regulatory oversight. ICOLD (2001) stated "the majority of TSF failures were avoidable and a matter of control and diligence by mine owners and operators" and "…the technical knowledge exists to allow tailings dams to be built and operated at low risk, but that accidents occur frequently because of lapses in the consistent application of expertise over the full life of the facility and because of lack of attention to detail."

Those TSFs that have been shown to be the most robust and to *not* experience failures are those that have periodic technical review by qualified engineers throughout the design, construction, and operational lifetime. The Alaska Dam Safety Program (ADSP) would require periodic technical review by an Independent Engineering Review Board (IERB) throughout the life of the facilities (ADNR 2017a). ADSP also requires third-party audits of embankment projects, as deemed necessary by ADSP (ADNR 2017a).

A review of ICOLD data reveals a clear trend in the higher probability of dam failure during active dam operations. Ninety percent of tailings dam failures have occurred in active dams during operations, as opposed to dams in closure (ICOLD 2001, 2018). Data also show that failures of tailings embankments under dry storage conditions (with no ponded water above tailings) after mine closure are small compared to dams in active operations with ponded water (USACE 2018d). Therefore, the probability of a failure of the bulk TSF in closure would be expected to be even lower than the estimates above, as provided by Rico et al. 2007a and discussed in EPA 2014.

Risk assessment for individual embankments considers all of these factors, and the assessment is unique to each dam. For the purposes of this EIS, the probability of a spill from the bulk TSF and pyritic TSF (as well as the main WMP) were therefore considered in a risk assessment specific to the project.

4.27.8.6 Risk Assessment for the Proposed Embankments

A Failure Modes and Effects Analysis (FMEA) is a risk assessment tool commonly used as a preliminary step in assessment of failure risk of large dams. A typical FMEA workshop uses a facilitated group of multi-discipline experts in TSF and dam design, construction, and operations to assess the probability of failure and level of consequences for an embankment. The FMEA process can be used to strengthen engineering design, inform subsequent stages of site investigation, and provide input for the dam permitting process. The FMEA process can also provide guidance on embankment construction and operations, including evolving designs for embankment raises during the life of the mine, and for maintenance and surveillance during closure and post-closure. FMEAs are used as one step of a risk analysis to inform a higher level of risk assessment. FMEAs are subjective and can be prone to bias.

The current level of embankment design for the project is at a very early phase, considered a *conceptual* phase. Site investigation and engineering plans are still ongoing. The ADSP would require additional risk assessment prior to issuing a *Certificate of Approval to Construct a Dam* (ADNR 2017a).

In October of 2018, the US Army Corps of Engineers (USACE) hosted an EIS-Phase FMEA workshop to assess the likelihood of a spill and the severity of potential environmental impacts from the major embankments in the bulk TSF, pyritic TSF, and main WMP. The EIS-Phase FMEA recognized the early-phase conceptual-level design of the embankments, and focused on the impacts assessment of hypothetical releases for EIS purposes. See the EIS-Phase FMEA Report (AECOM 2018l).

Note that the proposed project would include 13 separate embankments as part of 10 facilities, ranging in height from 30 feet to 545 feet (see Appendix K4.15, Geohazards and Seismic Conditions). In addition to the three embankments analyzed for failure impacts herein, there would be several other substantial embankments at the mine site. The bulk TSF main seepage collection pond dam, for example, is currently designed to be 120 feet tall, with a maximum crest length of 3,400 feet, and a maximum impoundment volume of 3,000 acre-feet (Table K4.15-1). It is beyond the scope of the National Environmental Policy Act (NEPA) to address potential impacts from failures of every proposed embankment. This document addresses failures from embankments at the three largest facilities, to cover the widest range of potential impacts.

FMEA participants evaluated the design of each embankment, and assessed the likelihood of a wide range of potential failure modes, which are situations that could lead to a failure of the embankment. These included potential design errors, construction deficiencies, operations mishaps, maintenance and surveillance oversights, foundation condition underestimates, materials weaknesses such as in construction fill or liners, severe weather, earthquakes, human interference, changed conditions, etc. Potential failures in the closure/post-closure phases were considered for the bulk TSF because it would exist in perpetuity. It should be noted that the potential failure modes analyzed did not reflect any specific weakness in the design, but were developed for estimating potential release volumes to analyze impacts of a hypothetical release. See the EIS-Phase FMEA Report for a full discussion of potential failure mode evaluation (AECOM 2018l).

In accordance with NEPA guidelines, failure scenarios selected for analysis in the EIS were of relatively low probability and a comparatively high level of consequence. Minor failures that result in small releases (such as increased seepage that would exceed the capacity of the water treatment plant) have a relatively high probability of occurrence, but can be easily corrected, and therefore typically have a low impact on the downstream population and ecosystem. Massive catastrophic failures, or "worst-case scenarios," (such as a full embankment breach) would have substantial consequences, but are extremely unlikely. The FMEA considered large-scale catastrophic releases, such as that caused by a full breach of one of the embankments. The probability of a full breach of the bulk or pyritic TSF tailings embankments was assessed to be extremely low (i.e., worst-case). (Note that due to the unique design and construction of individual embankments, probabilities of failure of the proposed embankments were determined by the FMEA process, not by statistical analysis as was completed for trucking accidents, etc.)

In assessing the level of risk during the FMEA workshop, it was assumed, per USACE guidelines, that BMPs and full operational/regulatory procedures would be followed (AECOM 2018k).

For each failure mode, the FMEA participants rated the potential environmental impacts for their severity. The panel then identified those failure scenarios that have a relatively low probability of occurrence, and comparatively high level of consequence (AECOM 2018l). For each facility, one scenario was selected for impacts analysis in the EIS, included below. Selected scenarios were based on end of mine-sized dams because that represents the phase with the highest spill risk. Changes in operations were not explicitly considered during the FMEA process. See the EIS-Phase FMEA Report for a full discussion of scenario selection (AECOM 2018l).

4.27.8.7 Existing Response Capacity

An Emergency Action Plan (EAP) is required by the State of Alaska Dam Safety Program for all Class I and Class II regulated dams. The embankments constructed for both TSFs would be designed and regulated as Class I dams (AECOM 2018k). The EAP is required to be available to direct appropriate response measures in the event of a failure, or in anticipation of such failure. The EAP is to include response measures to adequately protect life and property, and provide coordination of emergency responders in the community (including mine personnel and downstream residents).

In the event of a tailings release, recovery efforts depend on the volume of the release and the distribution of tailings. A small, localized release at or near the mine site could be recovered with relatively little additional impact. If a tailings release were to occur during active mine operations, personnel would be present on site, but not necessarily have training to respond to such a release. If the tailings are actively being flushed downstream by natural waterflow, full recovery efforts may not be practical or possible.

In the event of a very large release, spill response, recovery of tailings, and remediation would be difficult. Recovery of spilled tailings would be challenging, based on the logistics of transporting large volumes of rocky material in a remote, roadless area. Winter recovery could be easier if trucks are able to operate over frozen streams/wetlands, but the impact of such vehicle traffic could be damaging to soils and vegetation, and cause increased erosion into waterways.

Impacts from tailings recovery could include damage to streambeds and riverbank environments from heavy equipment. Recovered tailings would have to be permanently stored somewhere. If it was decided to put the tailings back in the respective TSF, extensive repairs may have to be completed first. If the release occurred after mine closure, personnel would have to be mobilized to the site to respond.

4.27.8.8 Mitigation

- Tailings dam safety is regulated by ADNR Dam Safety Program under Alaska Statute (AS) 46.17 “Supervision of Safety of Dams and Reservoirs” and Title 11, Chapter 93, Article 3 (11 AAC 93), Dam Safety. Note that ADSP has provided updated draft guidelines (ADNR 2017a) referred to throughout the EIS. These draft guidelines have not yet been adopted under Alaska Statutes.
- ADNR approval is required at multiple stages of an embankment development to “construct, enlarge, repair, alter, remove, maintain, operate or abandon” a dam.
- The major embankments discussed herein would all be constructed to the Class I hazard classification (highest potential hazard), requiring that PLP and their engineering consultant provide a high level of technical risk assessment prior to request for and issuance of Certificates of Approval to Construct a Dam.
- Each raise of each dam would require pre-approval from ADNR Dam Safety Program in the form of a Certificate of Approval to Modify a Dam.
- Available storage capacity (freeboard) would always be maintained in the TSFs to account for the IDF and seismic settlement (PLP 2018d).
- Both TSFs would be constructed on bedrock, which is considered to increase the stability of tailings embankments. All surficial soils and other unconsolidated materials would be removed prior to construction.
- As per ADSP draft guidelines (ADNR 2017a), two levels of design earthquake must be established for Class I dams: an *Operating Basis Earthquake* (OBE) that has a reasonable probability of occurring during the project life (return period of 150 to more

than 250 years); and a *Maximum Design Earthquake* (MDE) that represents the most severe ground shaking expected at the site (return period from 2,500 years up to that of the Maximum Credible Earthquake [MCE]). These design earthquakes cannot be represented by a single magnitude value. Rather, impacts would vary with not only magnitude, but also with the type of earthquake, epicenter location, depth, duration of shaking, etc. A range of earthquake magnitudes and characteristics is used to represent each level of design earthquake (see Section 3.15 and Section 4.15, Geohazards and Seismic Conditions).

- Both the bulk and pyritic TSFs would be designed and constructed with acceptable static and seismic Factors of Safety (FoS) commensurate with the confidence in the available data and underlying assumptions, and in accordance with the standard-of-practice for embankment design.
- See Section 4.15, Geohazards and Seismic Conditions, for more details on FoS.
- The ADSP would require periodic technical review by an IERB throughout the life of the facilities (ADNR 2017a). ADSP also requires third-party audits of embankment projects, as deemed necessary by ADSP (ADNR 2017a).

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

Bulk TSF

A modified centerline construction method was selected for the bulk TSF main (north) embankment to limit the footprint and volume of materials required for construction (PLP 2018-RFI 075; Figure 2-8). The initial starter dam would be downstream-constructed to a height of 265 feet, followed by centerline construction of the upper 280 feet of the dam to reduce the footprint, with a buttressed downstream slope to enhance stability. The total height of the main embankment would be 545 feet.

Alternative 2—North Road and Ferry with Downstream Dams, considers downstream construction for the bulk TSF main embankment (Figure 2-66). The Factor of Safety (FoS) would be 1.9 to 2.0 for both downstream and centerline designs. The south embankment would be constructed with the downstream method for all alternatives. See Chapter 2, Alternatives, for a description of the downstream dam alternative; and Section 4.15, Geohazards and Seismic Conditions, for geotechnical comparisons of centerline and downstream dam designs.

Bulk TSF Design Features

- The main embankment of the bulk TSF is planned to be an unlined pervious structure, so that excess fluid from precipitation or added process water would constantly seep through and out of the TSF and depress the phreatic surface in the main embankment and nearby tailings. The upper portions of the bulk tailings would therefore be moist, but not fluid–saturated; while deeper in the tailings pile and towards the southern lined embankment, the tailings would be fluid-saturated. Bulk tailings that are not water-saturated are resistant to flow, while fluid-saturated would flow more readily in the event of a dam failure. The south embankment would be lined.
- Supernatant fluid would be maintained throughout operations in a minimal supernatant pond away from the edges of both embankments, and would be maintained at a low volume. Excess fluid would be pumped to either the seepage control pond or the main WMP.
- Precipitation events would temporarily increase the volume of the supernatant pond, but the seepage control system would be designed to maintain the fluid within specified

levels. The bulk TSF is designed to have additional capacity (freeboard) for a volume of water equal to the IDF precipitation event.

- Predicted pH of the bulk tailings supernatant fluid at the end of the 20-year operational life of the mine is 7 to 8 (Knight Piésold 2018a).
- At the close of operations, the TSF would remain in place under "dry storage" conditions in perpetuity. The TSF would be drained of excess fluid, and the tailings would be contoured into a permanent landform. Data show that failures of tailings embankments under dry storage conditions (with no ponded water above tailings) after mine closure are small compared to dams in active operations with ponded water (IEEIRP 2015). New seepage modeling results confirm that the phreatic surface, or the "water table" in the TSF would be expected to decline in early closure, resulting in more stable embankment conditions in post-closure (PLP 2019-RFI-006b, h, 130). See Section 4.15, Geohazards and Seismic Conditions, for more information on TSF drainage. The stability benefits to a dry surface cover are summarized by Cobb (2019) as follows: "At the end of the operating life the risk is immediately reduced if the operational pond can be removed, resulting in a 'dry' closure. After that, the risk is dependent on the nature of the design and the post-closure maintenance requirements." The bulk TSF post-closure maintenance requirements would be developed as part of the closure design and post-closure objectives.

Pyritic TSF

Pyritic TSF Design Features

- The pyritic TSF would be bounded on its northern, eastern, and southern sides by geomembrane-lined rockfill and earthfill embankments with maximum heights of 335, 225, and 215 feet, respectively.
- The geomembrane liner would extend over the full basin area to reduce seepage out of the TSF, and also reduce the risk of embankment failure due to seepage and piping.
- The geomembrane liner would be protected with processed materials to protect liner from punctures or damage during PAG waste rock material placement (PLP 2018-RFI 055).
- Pyritic tailings would be stored sub-aqueously so that supernatant fluid would not become acidic. Predicted pH of the pyritic tailings supernatant fluid at the end of the 20-year operational life of the mine is 7 to 8 (Knight Piésold 2018a).
- Pyritic tailings are PAG and capable of ML, and have the potential for downstream impacts from spills during the 20 to 30 years of operational life. During closure, the pyritic tailings would be permanently moved to the open pit, reducing the risk of downstream contamination.

4.27.8.9 Tailings Release Scenarios

The following scenarios were developed during the FMEA workshop described above. Workshop participants reviewed the conceptual designs of the bulk and pyritic TSFs and assessed the likelihood of a release; and the severity of resulting consequences for each facility. Minor releases that would have relatively minor impacts were not selected as scenarios for analysis in the EIS, because the associated impacts would be within the range of the selected scenarios. Massive, catastrophic releases that were deemed extremely unlikely were also ruled out for analysis in the EIS. The two scenarios analyzed below were therefore chosen based on their relatively low probability of occurrence, and relatively high environmental impacts. For each scenario, a reasonable volume and duration of release were also selected to evaluate potential impacts to physical, biological, and social resources (see the EIS-Phase FMEA Report [AECOM 2018l]).

The potential for tailings releases as described in the scenarios below would be the same across all alternatives; downstream versus centerline construction of the bulk TSF main embankment would not affect the selected bulk TSF release scenario.

Modeling the Release Scenarios

Information on the selected scenarios from the FMEA workshop was used as input for modeling the two release scenarios described below, to analyze potential impacts on physical, biological, and social resources. Modeling of the tailings releases in the two scenarios below provides an estimate on the extent of flooding, water quality impacts, and potential tailings deposition from the scenarios.

Modeling of the downstream routing of flows was conducted using a two-dimensional inundation model, developed by USACE for modeling open-channel flows, including flood wave propagation. The Hydrologic Engineering Center's River Analysis System (HEC-RAS) is a FEMA-approved two-dimensional hydraulic model. The HEC-RAS model accounts for attenuation of flood waves as they propagate downstream.

Hydrodynamic modeling tools were used for modeling of the propagation of the flood wave and associated inundation for the pyritic tailings release scenario. Hydrodynamic modeling was not required for inundation mapping in the bulk tailings failure scenario; however, it was used to assess the propagation and attenuation of flows from the failed pipelines.

Both types of modeling require inputs of topographic and hydrologic data from the downstream drainages. The topography used in the HEC-RAS, and hydrodynamic models was defined using a digital elevation model (DEM) for the project site. US Geological Survey (USGS) and PLP streamflow-gaging stations in the Nushagak and Koktuli river drainage basins were used to characterize hydrological conditions, and provide the necessary hydrologic data for the modeling.

The mixing of the tailings solid particles in the tailings slurries with natural stream flow was modeled using a two-dimensional analytical model for diffusion analysis. See complete details on modeling methodology and results in Knight Piésold Failure Model Bulk TSF (Knight Piésold 2018o) and Knight Piésold Failure Model Pyritic TSF (Knight Piésold 2018p). As with any modeling exercise, there are uncertainties involved in the modeling inputs, assumptions, and outcomes. See the complete Knight Piésold Failure Model reports for full details (Knight Piésold 2018o, p, q).

Knight Piésold modeling extended as far as the entrance to the 19-mile-long Nushagak Estuary, and not all the way to Bristol Bay.

Scenario: Bulk Tailings Delivery Pipeline Rupture

In this scenario, an earthquake (greater than the OBE) causes shearing of the two tailings delivery pipelines along the northwestern corner of the bulk TSF main embankment. The full pumped flow rate of 70 cfs of bulk tailings slurry would begin to spill into the NFK by way of Tributary NFK 1.130 (Figure 4.27-2). The tailings slurry, with 55 percent tailings solids and 45 percent contact water, would be expected to flow readily (as a Newtonian fluid). See Knight Piésold 2018o for details on how flow parameters were calculated. The slurry would flow downslope as a turbulent flow, with the fine particles of tailings solids remaining in suspension.

In this scenario, it is assumed that it would take 6 hours for the leak to be detected and for the tailings slurry delivery pumps to be shut off. By this time, 1.5 million ft^3 of tailings slurry would have been released. The pipeline would continue to drain an additional 60,000 ft^3 of slurry after the pumps have been shut off. The total volume of 1.56 million ft^3 of bulk tailings slurry would flow down Tributary NFK 1.130 beneath the northwestern corner of the bulk TSF in the north/northeast direction towards the NFK drainage. The total volume of solid tailings released would be 0.5 million ft^3 (40,000 tons), and the total volume of contact water released would be 1.0 million ft^3 (Knight Piésold 2018o).

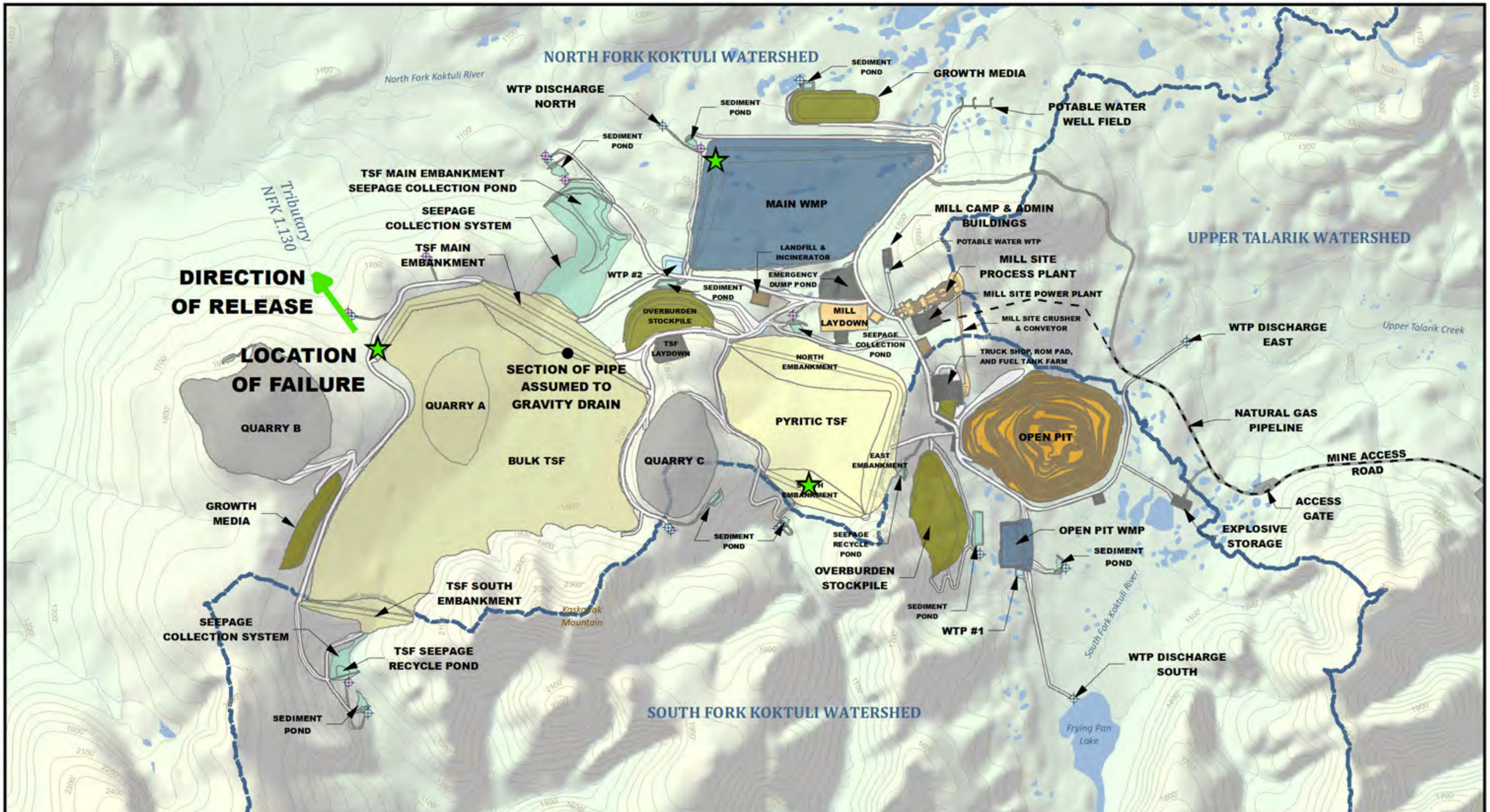
Tributary NFK 1.130 is just under 2 miles in length (about 10,000 feet) between the northwestern corner of the bulk TSF and the mainstem NFK. The upper portions of the tributary are somewhat steep, with a slope of about 15 percent. As the slurry flows out of the sheared pipelines, it would flow down into the steep upper portion of the tributary, which would accelerate the flow. At the bottom of the steep slope the land flattens out, and the slope diminishes to about 2 percent above the confluence with the NFK.

The volume of the released slurry would far exceed the MAD and the natural floods in Tributary NFK 1.130 (Knight Piésold 2018o), so that the slurry release would cause overbank flooding along the tributary's banks, and some limited deposition of tailings solids on the banks (less than 46 acres). The release would cause streambed erosion in the upper portions of the tributary drainage. In the lower stretches of the tributary and at the confluence with the NFK, the slurry release would slow down somewhat; and there would be additional deposition of tailings solids in the drainage and along the banks as the slurry flows recede. In total, solid tailings particles would be deposited on about 46 acres, mostly surrounding the confluence of Tributary NFK 1.130 with the NFK (Knight Piésold 2018o).

At the confluence of Tributary NFK 1.130 with the NFK, the flow of slurry would be comparable to flows in the NFK. The addition of 70 cfs from the bulk TSF tailings failure scenario is relatively small compared to the natural floods in the NFK and downstream drainages. This release scenario would not exceed the 2-year flood flows (bankfull condition) for the NFK, Koktuli River, Mulchatna River, or the Nushagak River. Therefore, no overbank flow and no deposition of solid tailings would be expected outside of the river channel along these downstream drainages (Knight Piésold 2018o).

The duration of increased flows along the downstream drainages would vary from 9 hours at the confluence of Tributary NFK 1.130 and the NFK, to 36 hours near the confluence of the Koktuli and the Swan rivers (Figure 4.27-3). See "Surface Water Hydrology," below, for full details on flow attenuation, arrival time, and duration of increased failure flows.

Note that the EPA (2014) and Lynker (2019) have put forth models of larger bulk tailings spill scenarios. See Appendix K4.27 for a review of these models.



Sources: KP 2018o; PLP 2019-RFI153

Legend

- Location of Failure
- Section of Pipe Assumed to Gravity Drain
- Direction of Release

Alternative 1a

- GW Quality Monitoring and Pump Back
- Water Quality Monitoring Point
- Natural Gas Pipeline
- Bulk Tailing Storage Facility
- Mine Site Infrastructure
- Mineral Processing Facilities
- Onsite Access Roads
- Open Pit
- Pyritic Tailings Storage Facility
- Quarries
- Sediment/Seepage Collection Systems
- Stockpiles
- Waste Management Facilities
- Water Management Ponds
- Water Treatment Plants

Other Features

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

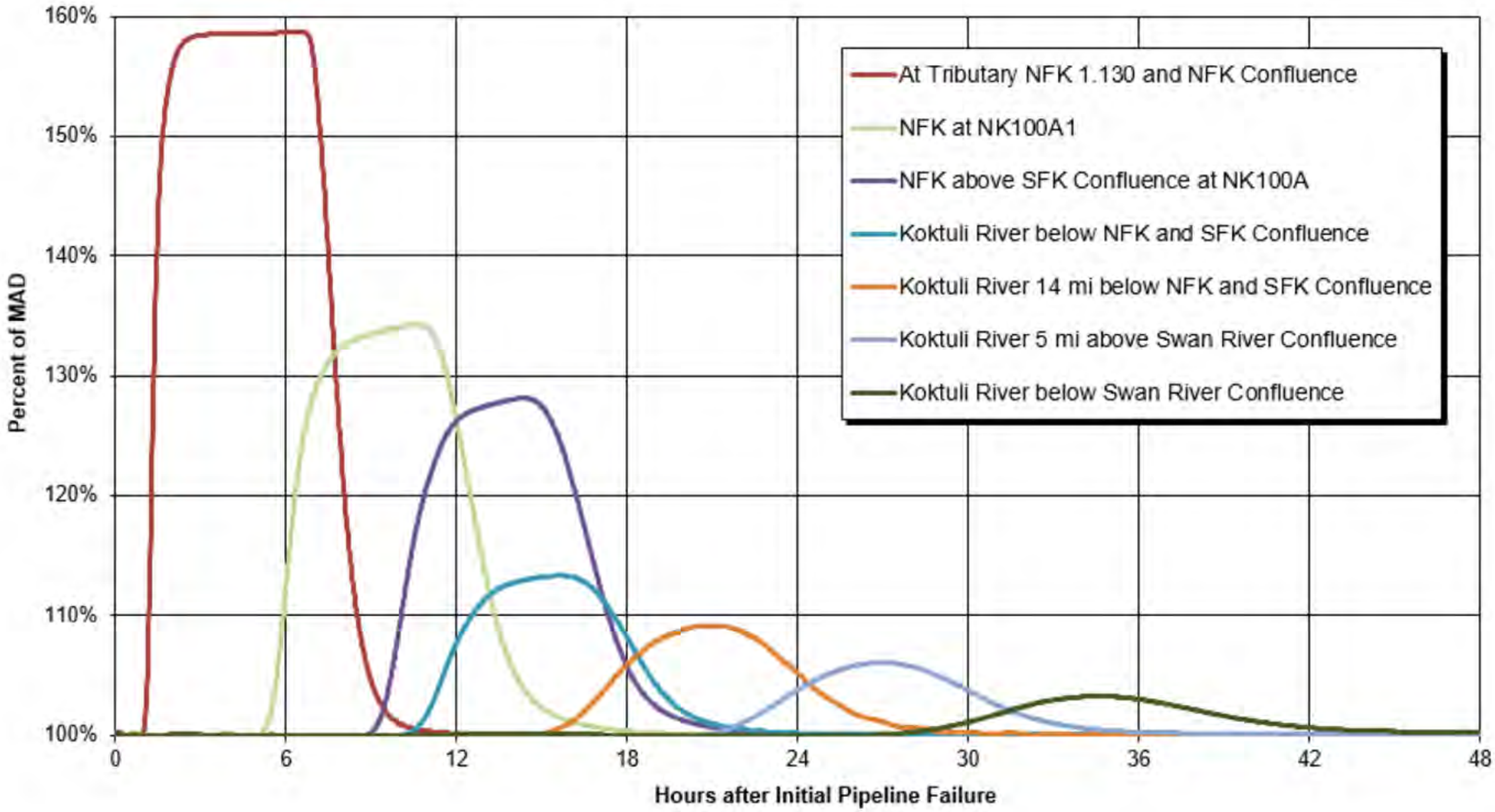
US Army Corps of Engineers

0.5 0 0.5 1
Miles

PEBBLE PROJECT EIS

BULK TAILINGS RELEASE LOCATION

FIGURE 4.27-2



Sources: KP 2018o

US Army Corps of Engineers

HYDROGRAPHS DOWNSTREAM OF BULK TAILINGS RELEASE

PEBBLE PROJECT EIS

FIGURE 4.27-3

Suspended Tailings Solids

The tailings slurry would include a mixture of fine particles suspended in fluid. The finest particles of clays and silts, which make up about 60 percent of the bulk tailings solids, are light; and would stay suspended in the water and be transported downstream. Most of this material would be flushed downstream during the initial peak flows.

The solid particles would mix with the natural stream flow of the downstream drainages, creating elevated TSS downstream. Full mixing of the slurry with natural stream water would be anticipated within about 0.5 mile or less downstream. After the pumps are shut down and the flow of slurry ceases, natural dilution of stream water would begin to decrease the turbidity.

Water in these drainages is naturally low in TSS, with average measured TSS values of 1.19 mg/L in the NFK (see Section 3.18, Water and Sediment Quality, and Appendix K3.18). The most stringent water quality criterion requires TSS to be no more than 20 mg/L. The release scenario would elevate the TSS (and turbidity) of the drainages well above the most stringent WQC all the way downstream to the Nushagak River Estuary at the mouth of Nushagak Bay, part of the greater Bristol Bay. See Water and Sediment Quality impacts, below, for complete data on TSS level across the downstream watershed.

Deposition of Tailings Solids

The fine sand-sized particles that make up about 40 percent of the bulk tailings solids may remain suspended in the water where the stream energy is high, but would likely settle out and deposit on the streambed in areas where the current is weak, especially in side-channels and backwaters. After the initial wave of increased flow has passed, some sand-sized particles could remain in these areas, covering and intermingling with the natural stream substrate. These particles would eventually be naturally flushed out of the drainage, likely when stream flows naturally peak, such as during a storm event or during the spring thaw. Sand-sized particles would be flushed downstream, largely along the streambed itself as bedload. Some of the particles would intermingle with natural bedload sediments, and may remain in the drainages for months to years; while some of the particles would eventually reach Nushagak Bay, part of the greater Bristol Bay, where they would be deposited as sediments in the bay.

Spill Response

The State of Alaska does not have specific requirements for cleanup of spilled mine tailings. As per Alaska Statute 27.19.02, the mine site must be returned to a stable condition, compatible with the post-mining land use (AS 27.19.02).

See the "Spill Preparedness, Prevention, and Response Measures" subsection for the actions that the Applicant has committed to. An EAP would be available to direct the appropriate response measures. Response measures would include ensuring the safety of downstream mine employees; shutting down the tailings pipelines; coordinating emergency responders in the community (including mine personnel and downstream residents); and implementing remedial actions to minimize impacts to affected resources.

The release flood would extend along the banks of Tributary NFK 1.130 as far as the confluence with the NFK. No mine employees would normally be working in this area. Subsequent downstream flows would be so small as to pose no safety concern to downstream residents or recreational users.

Remedial actions would include removing the tailings from the primary depositional area in the upper NFK to the extent practicable. The tailings would be excavated using a combination of heavy equipment and hand tools, and transported back to the TSF or other designated temporary storage area. Any soils impacted by the elevated metals from the contact water could also be removed, and the impacted habitats could be restored.

Access to cleanup areas in the summer would be difficult due to the lack of roads along the NFK, and would likely involve use of helicopters. Access in the winter could be simplified by travel on packed snow trails, and removal of deposited material may be more effective because the ground and streams would likely be frozen. Cleanup during partial ice conditions, such as ice-up (incomplete ice coverage) and break-up (broken ice), would present additional challenges, with tailings potentially trapped beneath ice.

Cleanup activities such as excavation or dredging could damage stream habitat, and machinery could cause soil erosion and/or compaction adjacent to streams. Additional habitat restoration could be required after tailings recovery activities.

In the event of a tailings spill, the Applicant has committed to the following remedial actions (from Knight Piésold 2018o):

Remedial actions under this failure scenario would initially include:

- Shutting down the tailings pumping system to the breached location
- Ensuring there are no health and safety concerns resulting from the breach, which may include notification of downstream mine personnel and residents
- Notifying the key individuals and regulatory contacts as per the Emergency Response Plan

Ongoing remedial actions would include:

- Repairing and replacing the damaged tailings pipeline
- Mobilizing mine equipment and staff to clean up discharged tailings where practicable, which would likely include helicopter-supported efforts to support ongoing cleanup activities
- Establishing environmental control measures downstream of the failure to reduce the potential for sediment transport from areas with settled tailings
- Repairing any erosion damage to the embankments, if required
- Repairing erosion damage in the tributary and at the confluence, if required
- Monitoring downstream water for water quality (Knight Piésold 2018o)

Alternatives Analysis

The probability and impacts of a bulk tailings release would be similar across all alternatives, with the only difference being the downstream main embankment design under Alternative 2 versus the centerline embankment design for the other alternatives. See Section 4.15, Geohazards and Seismic Conditions, for a discussion of downstream and centerline dam construction methods.

Potential Impacts of a Bulk Tailings Delivery Pipeline Rupture

This section addresses potential impacts of a release of bulk tailings in the scenario described above. Impacts are considered in terms of their magnitude, duration, geographic extent, and potential to occur. A tailings release would not impact all the resources addressed in this EIS. The following resources were selected for analysis due to the higher potential significance of the impacts.

Soils

Tailings Solids Deposition on Soils

In this scenario, less than 46 acres of soils would be temporarily covered by thin deposits of tailings. No long-term impacts to soils would be expected from this deposition.

The total mass of solid tailings released in the scenario is approximately 0.5 million ft^3, or 40,000 tons. Approximately 60 percent of this material, or 24,000 tons, are composed of fine particles of silts and clays that are expected to remain suspended in the flow, and be flushed downstream within days of the release. The remaining 40 percent of the material, or 16,000 tons, are sand-sized particles that are more likely to initially settle out near the confluence with NFK, both in the streambed and where Tributary NFK 1.130 overtops its banks. Some fraction of this material could be deposited on soils.

In this scenario, soils adjacent to Tributary NFK 1.130 could be covered by a thin layer of bulk tailings solids. Near the confluence with the NFK where the land flattens out, surrounding soils would likely be covered by a greater thickness of tailings. The average thickness of solid tailings deposition in this area could be on the order of 0.1 foot. The maximum extent of solid tailings deposition in this area would likely be on the order of 46 acres, which would include both deposits on soils along the streambanks, and streambeds in backwater channels (Knight Piésold 2018o).

Spill response covered in the scenario includes recovery of spilled tailings. Solid tailings covering soils and any soil impacted by contaminated contact water could be removed so that there would be no long-term impacts to soil. Without any recovery efforts, solid tailings would likely be flushed off of soils into the streams by precipitation, overland flow, or subsequent natural flooding within days to months, to be dispersed downstream. There is potential for the solid tailings to form a crust on top of soils and vegetation that could remain on the soils along Tributary NFK 1.130 riverbanks for months to years, without recovery efforts. No acid generation or ML would occur from the deposited tailings on these timescales under the existing environmental conditions.

Erosion

Modeling calculated the bed shear stress downstream of the release to determine the potential for erosion (Knight Piésold 2018o). The initial flood of fluid and tailings could erode the streambed, riverbanks, and surrounding soils where overbank flooding occurs. Channel erosion would be expected in the upper portion of Tributary NFK 1.130, with a greater degree of channel erosion likely in the downstream portion of the existing channel. Further erosion of fine particles up to fine gravel would be expected along channels near the confluence of Tributary NFK 1.130 with the NFK (Knight Piésold 2018o).

Spill response mitigation would include repair of any erosion damage (stream stabilization), if necessary. Localized erosion and resultant sedimentation and elevated TSS downstream could continue for months to years during stream stabilization efforts.

Erosion downstream of the confluence of Tributary NFK 1.130 with the NFK may not be measurable (i.e., may be indistinguishable from background levels of erosion).

Metals Contamination

Soil could become contaminated with elevated levels of metals from contact water in the tailings slurry. Where tailings slurry spills onto soils beneath the point of release at the bulk TSF, contact water could potentially percolate into the soil column; and metals in the contact water would adsorb onto surficial soil. Similarly, where overbank flooding occurs along Tributary NFK 1.130, bank soils would come in contact with metals in the contact water, although the contact water would be diluted by stream water in these instances. Where metals in soils exceed ADEC soil cleanup level guidelines, soils could be excavated to the extent practicable and the impacted habitats could be restored. If contaminated soil is not fully recovered, some contaminated soil would remain at the site of the release. Ongoing monitoring could detect remaining elevated levels of metals, and additional excavation could be carried out as needed.

No measurable dissolved (bioavailable) metals would be leached from deposited tailings solids because the process of ML would require decades (Section 3.18, Water and Sediment Quality). Tailings particles would be flushed off of the land surface and out of the stream drainages within months to years in areas surrounding the impacted drainages.

Surface Water Hydrology

Surface water flow would be increased above the 2-year flood level (bankfull conditions) on Tributary NFK 1.130 and would likely cause overbank flooding. Peak flows would be less than the natural 2-year flood on the NFK and other downstream drainages, and would not cause additional overbank flooding. Peak flows, arrival time, and duration of increased failure flows for downstream drainages would be as follows (from Knight Piésold 2018o):

- The exact MAD of Tributary NFK 1.130 is unknown because there has been no hydrologic monitoring in this stream. MAD and monthly flows were therefore estimated based on drainage area proration, with flows measured in nearby Tributary NFK 1.190, which has a similar aspect and topography (Knight Piésold 2018o). The estimated MAD is 5 cfs. During the release scenario, modeling predicts the peak flows at this location would exceed the natural 2-year flood during the initial flooding event, causing overbank flooding.
- Just downstream from the confluence of the NFK and Tributary NFK 1.130, the MAD of the river is about 120 cfs. During the release scenario, modeling predicts the peak flows at this location to increase to 190 cfs. The increased flow would arrive about 1 hour after the initial release, and last for approximately 9 hours (Figure 4.27-3).
- Downstream of the confluence of the NFK and SFK, the MAD of the drainage is 510 cfs. During the release scenario, modeling predicts the peak flows at this location to increase to 570 cfs; about a 13 percent increase. The increased flow would arrive about 9 hours after the initial release, and last for approximately 13 hours.
- Just downstream of the confluence of the Koktuli and the Swan rivers, the MAD of the river is about 1,430 cfs. During the release scenario, modeling predicts the peak flows at this location to increase only about 3 percent to 1,470 cfs. The increased flow would arrive about 28 hours after the initial release, and last over 20 hours.
- Modeling did not extend beyond the confluence with the Swan River, but the duration of increased flows at the Mulchatna and Nushagak river confluences can be estimated (by extrapolation of modeling results) to be about 24 hours and 36 hours, respectively. The duration of increased flows at the Nushagak River Estuary would last about 50 hours.

Water and Sediment Quality

Surface Water Quality

TSS—An increase in TSS from the released bulk tailings slurry would be a water quality impact across approximately 230 miles of drainages; from below the bulk TSF, all the way to the Nushagak Estuary at the entrance of Nushagak Bay—part of the greater Bristol Bay. TSS levels in Tributary NFK 1.130, the NFK, the mainstem Koktuli, the Mulchatna, and the Nushagak River would exceed WQC for 1 to a few days initially, and then intermittently after that for weeks to months to years, depending on the speed and effectiveness of recovery efforts.

The concentration of solid tailings in the downstream drainages is expressed herein as percent solids, and as TSS in mg/L (that is, the mass of the solid particles per volume of water). Water in these drainages is naturally low in TSS, with average measured TSS values of 1.19 mg/L in the NFK (see Section 3.18, Water and Sediment Quality, and Appendix K3.18). The most stringent WQC require TSS to be no more than 20 mg/L. Modeled peak TSS values during the initial period of peak flow are as follows (from Knight Piésold 2018o):

- At the confluence of the Tributary NFK 1.130 and the NFK, the percent solids in the water were modeled to be 13 percent. The TSS was modeled to be 171,000 mg/L during peak flow. The natural levels of TSS in the NFK average about 1.19 mg/L.
- Below the confluence of the NFK and SFK, the percent solids in the water would drop to 3 percent, with a TSS of 30,000 mg/L during peak flow.
- Below the confluence of the Koktuli and the Swan rivers, the percent solids in the water would drop to less than 1 percent, with a TSS of 6,900 mg/L.
- Downstream of the Koktuli River confluence with the Mulchatna River, the dilution of natural stream water would be very strong, so that the percent solids in the water were modeled to drop to less than 1 percent, with a TSS of 1,300 mg/L during peak flow.
- At the Nushagak River Estuary, at the mouth of Nushagak Bay, part of the greater Bristol Bay, the solids content would be less than 1 percent, but the water would still have elevated TSS, with a TSS of 320 mg/L.

Note that the modeled TSS values account for the tailings solids only, and do not consider the additional TSS from ongoing erosion near the release site.

The initial duration of the elevated TSS levels would be similar to the duration of the elevated flows, as detailed above. TSS in the downstream drainages near the mine site would initially be elevated above WQC for at least half a day; while TSS in the lower Nushagak near Bristol Bay would initially be elevated for 2 to 3 days (Knight Piésold 2018o). As residual tailings solids continue to flush into the watershed over ensuing days to weeks, there would be intermittent increases in TSS for weeks to months, depending on the speed and effectiveness of recovery efforts. It is unknown if the intermittent increases in TSS would be below the WQC.

In addition to the tailings solids, increased TSS would be introduced into downstream drainages due to erosion in Tributary NFK 1.130 during the release. After the elevated flows have diminished and most tailings solids have been flushed downstream, ongoing sedimentation and elevated TSS could continue from the unstable streambed and streambanks. Depending on the severity of the erosion, this could be a localized impact directly downstream of the release site. Spill response mitigation would include repair of any erosion damage (stream stabilization), if necessary. Erosion could continue to elevate TSS in the immediate downstream area for months to years during stream stabilization.

Acid—For a discussion of factors that impact the ability of tailings particles to generate acid, see “Factors Influencing Acid Generation and Metals Leaching” in the “Concentrate Spills” subsection.

This bulk tailings release scenario would not be expected to impact water quality due to acid. The released fluid would have a relatively neutral pH (Knight Piésold 2018a). Note that the NFK has naturally acidic water in some reaches (see Appendix K3.18, Water and Sediment Quality).

ARD from the bulk tailings solids would not be likely due to the low concentration of PAG materials in the bulk tailings, the long time periods required for acid generation, and the high level of dilution from surface water. Bulk tailings deposited along floodplains that remain exposed to air could generate acid over a period of years to decades if not recovered. Precipitation and seasonal flood waters would flush any generated acid into surface water. Any acid produced would be produced very slowly, and would be constantly diluted by surface water and flushed downstream so that measurable decreases in water pH would not be expected.

The Nushagak estuary extends for the last 19 miles of the lower Nushagak River before it feeds into Bristol Bay. This area contains abundant mud flats, which are periodically exposed during levels of lower tides. It is possible that a small amount of tailings could be deposited on the mud flats, and exposed to the air, which could increase the potential for ARD. However, the deposited tailings would likely be flushed back into the main channels by high tides and rain, and deposited in Bristol Bay prior to generating measurable amounts of acid.

Metals—For a discussion of factors that impact the ability of tailings particles to leach metals, see "Factors Influencing Acid Generation and Metals Leaching" in the "Concentrate Spills" subsection.

Under this scenario, metals in contact water used to mix the bulk tailings slurry would be introduced to Tributary NFK 1.130 and transported downstream. The contact water used to mix the bulk tailings slurry is predicted to contain the following metals above the most stringent WQC: antimony, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, selenium (a metalloid), and zinc (Knight Piésold 2018a; Appendix K4.18, Table K4.18-3).

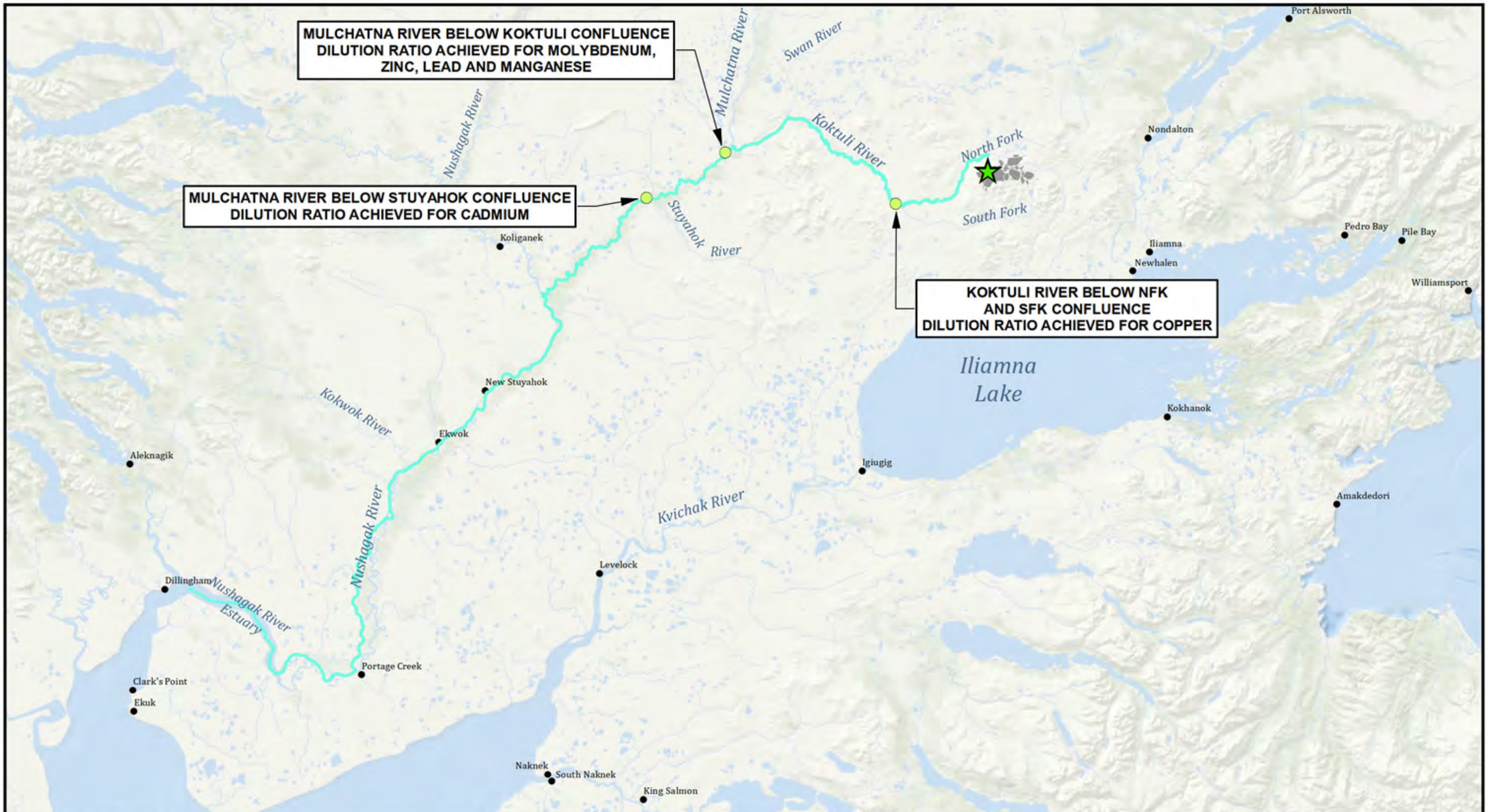
Metals concentrations resulting from the spill would be diluted progressively downstream by the stream flow. More rapid downstream dilution would occur during higher stream flow in the summer months; while during the winter, there would be less streamflow to dilute the elevated metals. Modeled downstream metals levels assumed MAD stream levels in the downstream drainages.

Note that the NFK has naturally acidic water in some reaches (see Appendix K3.18, Water and Sediment Quality). Unrecovered tailings that remained in more acidic waters would be more susceptible to dissolution, and could potentially leach metals at an increased rate.

As summarized below and on Figure 4.27-4, modeling results indicate that concentrations of several metals would exceed applicable WQC in the downstream drainages following the spill (Knight Piésold 2018o). In Figure 4.27-4, the points along the drainages labeled "Dilution Ratio Achieved" indicate the point at which those metals would be diluted to within WQC. The metals that would be present in the highest concentration would be cadmium, lead, manganese, molybdenum, and zinc (Knight Piésold 2018o). Copper was also considered in the modeling due to the abundance of copper in the area (Knight Piésold 2018o).

- Copper concentrations would exceed the most stringent WQC to the Koktuli River below the NFK and SFK confluence, about 23 miles downstream from the mine site.
- Lead, manganese, molybdenum, and zinc concentrations would exceed the most stringent WQC until the Mulchatna River below the Koktuli River confluence, about 62 miles downstream.
- Cadmium concentrations would exceed the most stringent WQC until the Mulchatna River below the Stuyahok River confluence, about 78 miles downstream from the mine site.

These metals would remain at elevated levels above WQC for several days, likely no more than a week, while the flows are flushed downstream.



Sources: KP 2018o; PLP 2019-RFI153

US Army Corps of Engineers

10 0 10 20

Miles

Location of Release

Dilution Ratio Achieved

Modeled Rivers

Mine Site

MODELED EXTENT OF ELEVATED METALS DOWNSTREAM OF BULK TAILINGS RELEASE

PEBBLE PROJECT EIS

FIGURE 4.27-4

The bulk tailings solids would not be expected to impact water quality from ML due to the low concentration of metals, the long time periods required for dissolution of metals, and the high level of dilution from surface water. Metals present in the solid tailings require a decade or more to leach into the water and become bioavailable. If tailings are recovered, there would likely be no measurable ML, and therefore, no additional levels of elevated metals. Tailings solids that are not recovered could leach metals into surface water over a timescale of decades. However, due to the relatively small volume of solid tailings that would be deposited in this scenario, and the constant dilution and continual flushing of tailings from the watershed, this impact would likely not be measurable.

The formation of secondary metal salts is not likely from this scenario, due to the limited amounts of metals that could be leached from the tailings, the strong amount of dilution from downstream waters, and the anticipated recovery efforts. The formation of secondary metal salts would require years. Impacts to water quality from dissolution of secondary metal salts would be the same as those noted above for other leached metals.

Residual Toxins—Bulk tailings may also contain minor residues from ore-processing reagents that could be released into the watershed in the event of a spill. Most of the reagents are consumed during the process of froth flotation, and residual reagents mostly remain adhered to the metals in the ore concentrate. The small amount of residual reagents in the tailings is anticipated to degrade naturally in the TSF. However, in this scenario, the release occurs from the delivery pipelines, so that residues of reagents such as xanthate would not have time to biodegrade prior to release. The EPA reports that these types of tailings slurries would be toxic due to the presence of xanthate (EPA 2014). Tailings slurry with residual xanthate that are released into downstream waters could create toxic conditions in downstream waters, although the concentration of xanthate would be low, and would be diluted in downstream waters.

As described above, bulk tailings would also contain residues of the blasting agent ANFO. ANFO is biodegradable; however, in this scenario, the release occurs from the delivery pipelines, so that the residues of ANFO would not have biodegraded prior to release.

Sediments—Some streambed sediments/substrate could be partially buried by deposited tailings particles, especially in the low-energy side channels near the confluence of Tributary NFK 1.130 and the NFK. The maximum extent of tailings solids deposition in this area would likely be on the order of 46 acres, which would include both streambeds and floodplain soils (Knight Piésold 2018o). The average thickness of deposition could be on the order of 0.1 foot (Knight Piésold 2018o). The fine-tailings particles could fill in interstitial spaces between clasts of gravel, modifying streambed habitat.

A small volume of tailings could potentially intermingle with and become incorporated into deposits of naturally occurring sediments (the bedload), particularly in low-energy drainage areas. These tailings may remain in the drainage for months to years prior to being flushed downstream. If the small volume of tailings was to remain in the drainage long enough to leach metals (years to decades), the constant dilution of stream water and the slow process of metals leaching would likely result in no measurable levels of metals.

Erosion of upstream streambed sediments from the release would also cause deposition of sediments near the confluence of Tributary NFK 1.130 and the NFK (Knight Piésold 2018o).

Trace amounts of metals from the released contact water in the bulk tailings slurry could be adsorbed to particles and incorporated into streambed sediments (the bedload). Metals incorporated into the bedload would continue to be flushed downstream and diluted, but trace amounts may remain in the sediment and slowly be released to surface water. Such trace amounts would be unlikely to have a measurable impact on sediment and water quality with respect to metals concentrations.

Groundwater Quality—There is potential for groundwater to be contaminated with elevated levels of metals from contact water in the tailings slurry. There are numerous shallow aquifers throughout the area, and metals present in the fluid portion of the release could permeate through soils into shallow groundwater. However, due to the strong dilution from surface water, it is likely that metals would be diluted to below ADEC groundwater cleanup levels. Measurable impacts to groundwater quality are not likely from this scenario. In the case of a spill resulting in groundwater contamination, the State of Alaska may require ongoing monitoring and reclamation work as it deems necessary. See Section 4.18, Water Quality, for standard monitoring and mitigation that could be implemented.

Any acid and metals generated by tailings solids that may remain in streambed sediments would be so diluted that no measurable impact on groundwater quality would be expected. This is due to the long timescales involved in acid generation and ML, and the small amount of PAG and ML material contained in the bulk tailings.

Noise

Noise could be generated from spill recovery operations, including increased vehicle and/or helicopter traffic, and use of heavy machinery and other cleanup equipment.

Air Quality

Tailings deposited on land that dry out have the potential to become airborne fugitive dust. Considering the small volume of tailings deposition expected on land, and the wet climate, any fugitive dust produced would likely not have measurable impacts on air quality.

Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

The bulk tailings release scenario would cause bank erosion and limited burial of low-lying vegetation, wetlands, and any other special aquatic sites immediately downstream of the spill. Riparian vegetation along the banks of Tributary NFK 1.130 (Knight Piésold 2018o), as well as some adjacent upland vegetation, could be buried by tailings solids up to 0.1 foot in thickness over less than 46 acres. It is unlikely that the flood flows would remove the dense vegetation growing on the valley side slopes, or scour the substrate of the Tributary NKF 1.130 (Knight Piésold 2018o).

The magnitude of the impact would be high regardless of the timing, because this type of spill would affect both dormant and actively growing vegetation through physical removal from erosion or burial. Eventually, solid tailings particles would be flushed off of the land surface and out of the stream drainages within months to years in areas surrounding the impacted drainages.

The extent of the impacts would be limited to the area covered by the solid tailings particles, estimated to be less than 46 acres, mostly surrounding the confluence of Tributary NFK 1.130 with the NFK, and areas where contact water with elevated metals and residual toxins may permeate wetland soils (Knight Piésold 2018o).

Assuming the spill response as described for the scenario, the majority of spilled tailings would be removed, and the duration of impacts to the 46 acres of wetlands could range from one to several growing seasons. Contaminated soils could be sampled and excavated if necessary. If tailings and contaminated soil are not recovered, the duration of impacts could range from a few growing seasons (for vegetation to grow on the tailings) to permanent (if wetlands are buried and not restored).

Terrestrial Wildlife

Impacts to terrestrial wildlife species would vary depending on the time of year that a spill occurs. If the spill occurred during winter, the magnitude, duration, geographic extent, and intensity would be lower, because many of the terrestrial wildlife species have reduced activity levels, and some are in hibernation. Any species that are hibernating in the area directly impacted by the spill (approximately 46 acres) may be disturbed during cleanup activities. If the NFK and surrounding streams are frozen, spill response and cleanup would be more effective and the geographic extent would be greatly reduced, because no water would be diluting the tailings or transporting them downstream. Impacts of a spill during winter would generally be low for most wildlife species, because cleanup would be more effective; there would be less environmental damage associated with the cleanup (due to frozen surfaces and snowpack); and wildlife would likely avoid the area during activities around the spill. Impacts from a spill during frozen conditions are not expected to last longer that a few weeks to months, until all material is cleaned up.

If the spill occurred during the open-water season, the geographic extent of impacts would likely extend further. The magnitude and intensity would be increased, and more species would be affected. Impacts would be greatest during the summer and fall, when wildlife are raising young and putting on fat reserves for winter. Any terrestrial wildlife in the immediate vicinity during the spill has a potential to be covered, smothered, or have habitat altered by the tailings. Up to 46 acres of vegetation and wildlife habitat may be directly affected. This is a relatively small amount of habitat given the abundance of nearby suitable habitat; and although some small mammal species (shrews, lemmings, voles, ground squirrels, hares) may suffer direct mortality from smothering during the spill, most species are expected to vacate the area. Wildlife may be indirectly impacted through reduced prey availability and altered forage. Vegetation that is covered by tailings would not be available for consumption until it grows through the tailings, or until it is washed off by rainfall.

The tailings may smother salmonid eggs and alevins, and reduce the quality of spawning habitat in the direct footprint of the spill in the NFK, and to some extent further downstream. A reduction in the NFK spawning biomass that reduced the number of returning adults would have a measurable, but small, impact on the overall number of salmon. This would impact species that feed on these life stages of salmonids, and may cause lower salmon numbers in subsequent years, depending on the extent of the spill. In addition, contact water in the tailings slurry may cause acute toxicity in fish. Any impacts to fish, detailed in the fish section below, would directly impact terrestrial species that prey on fish, such as brown bears (*Ursus arctos*) and gray wolves (*Canis lupus*). In addition, several other carnivore and omnivore species may occasionally forage on salmon, such as river otters (*Lontra canadensis*).

The cycling of marine-derived nutrients as part of the salmon cycle promotes healthy ecosystems. Fish that are fed on by terrestrial wildlife are distributed in the environment by transportation of salmon carcasses and excretion of feces and urine. This promotes healthy ecosystems that benefit wildlife; increase vegetation productivity; and promote the production of periphyton, aquatic macroinvertebrates, resident freshwater fish, and juvenile salmon (Brna and Verbrugge 2013). Impacts to salmon in the NFK may disrupt local cycling of nutrients temporarily in the immediate vicinity of the spill. Only localized mortality of eggs, alevins, fry, smolt, and freshwater invertebrates may occur in the direct footprint of the spill (depending on the time of year). This localized impact is not anticipated to cause an appreciable decrease in salmon productivity in the NFK.

Therefore, the scenario would result in a high-magnitude impact on a localized salmon-spawning area in the NFK before sediment is carried downstream, dispersed, and cleaned up. The duration is until the sediment no longer covers up the vegetation, and until salmon are able to use the area for spawning again. Overall impacts are not anticipated to be noticeable in terms of terrestrial wildlife abundance, but most species are anticipated to avoid the area until cleanup activities and rain/snowfall have removed tailings from the vegetation.

Finally, residual amounts of toxic ANFO and sodium ethyl xanthate that have not biodegraded would be released into the environment with the tailings in this scenario. However, the small amount of ANFO and xanthate released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to wildlife from these toxins would be localized and of low magnitude.

Birds

A spill during winter, when migratory birds have vacated the area, would result in low-magnitude impacts of temporary duration on resident bird species. Tailings would be more effectively contained and recovered under frozen conditions. However, if a spill occurred during the open-water season, impacts on avian prey would likely result in increased magnitude, and potentially a greater geographic extent.

According to modeled spill projections, elevated levels of TSS from the bulk tailings could extend as far downstream as the Nushagak River estuary. The Nushagak River estuary extends for the last 19 miles of the lower Nushagak River before it feeds into Bristol Bay. This area contains abundant mud flats, which are periodically exposed during levels of lower tides. It is possible that a small amount of tailings could be deposited on the mud flats. This area is important for a wide variety of avian species during important life stages. Periods of increased avian use include the April through May spring migration period and the August through October fall migration period. Birds that use the area include high numbers of waterfowl such as black scoters, northern pintail, and scaup species (NOAA 2004). Some of the birds that breed at the mouth of the Nushagak River include Aleutian terns, glaucous-winged gulls, mew gulls, herring gulls, and other species (NOAA 2004). Farther from the river mouth, large numbers of shorebirds pass through the area, feeding on exposed mudflats. Ingestion of fish and invertebrates that contain metals could be passed on to the avian species feeding in the area.

A variety of avian species rely on various life stages of salmon as food resources. According to Brna and Verbrugge (2013), of the 24 duck species that occur in the Bristol Bay region (including Nushagak Bay), at least 11 species feed on salmon eggs, parr, or smolts, or scavenge on carcasses. This includes waterbird species such as greater (*Aythya marila*) and lesser (*Aythya affinis*) scaup, harlequin duck (*Histrionicus histrionicus*), bufflehead (*Bucephala albeola*), common (*Bucephala clangula*) and Barrow's goldeneyes (*Bucephala islandica*), and common (*Mergus merganser*) and red-breasted (*M. serrator*) mergansers. Based on data presented in Section 3.23, Wildlife Values, the upper NFK near the location of the spill does not support large numbers of waterbird species.

Bald eagles (*Haliaeetus leucocephalus*) also feed on salmon during a variety of life stages. Salmon abundance can influence bald eagle population size, distribution, breeding, and behavior. Based on data presented in Section 3.23, Wildlife Values, the upper NFK is not a productive bald eagle nesting location. Species like the American dipper (*Cinclus mexicanus*) consume salmon eggs, fry, and small bits of carcasses when available (Brna and Verbrugge 2013). In addition to salmonid species, many shorebirds make use of freshwater invertebrates, and various species of small fish are consumed by yellowlegs and phalaropes.

Under the scenario, some fish life stages may experience acute toxic levels from elevated metals in the tailings slurry contact water. Impacts to birds through localized impacts on salmon may occur (by needing to find other feeding locations). There is an abundance of suitable foraging habitat both above and below the potential spill location into the NFK; although cleanup activities may disturb local breeding species, depending on the time of year. Some ground-nesting birds may have their nests covered by tailings during the initial spill; however, if the spill occurs early in the summer, some birds may be able to re-nest. Overall, impacts to salmon are anticipated to be restricted to the immediate vicinity of the spill, and downstream where eggs and alevin (if present) are smothered by tailings. A tailings release that resulted in smothered eggs or alevin and reduced spawning habitat quality or quantity could affect the prey base for some aquatic avian species. A reduction in the NFK spawning biomass that reduced the number of returning adults would have a measurable, but small, impact on the overall availability of fish prey species for birds. Overall impacts to birds are anticipated to be low-magnitude (this would vary based on extent of clean up and recovery efforts) and short duration (a few weeks to months, but could extend longer depending on impacts to salmon/prey abundance) while cleanup occurs, affected vegetation recovers, and sediment is transported downstream. The geographic extend would stretch from the spill location to the Nushagak River estuary.

Finally, residual amounts of toxic ANFO and sodium ethyl xanthate that have not biodegraded would be released into the environment with the tailings in this scenario. However, the small amount of ANFO and xanthate released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to birds from these toxins would be localized and of low magnitude. They may have acutely toxic effects on avian prey, but due to flushing, are anticipated to be rapidly diluted in the system. Birds that prey on species killed by ANFO and sodium ethyl xanthate may experience sublethal toxicity, but due to system flushing and ingestion of multiple prey items, are unlikely to experience lethal toxicity.

Fish

Under this spill scenario, impacts on stream hydrology and several stream water quality parameters (TSS and metals concentrations) would occur generally simultaneously in similar spatial durations and extents. Therefore, impacts on fish would occur simultaneously, via physical injury, loss of habitat and food, and toxicity of metals.

A tailings spill would introduce fine sediment into the stream, causing sedimentation and elevated TSS/turbidity in downstream surface water that has naturally low TSS and turbidity. Fine sediment could infill void spaces between gravel clasts, altering benthic habitat. Continual flushing and periodic high-flow events (spring break-up and fall floods) would transport the tailings downstream. The spill impact would extend from the spill location about 230 river miles downstream of the mine site.

Potential impacts on fish include decreased success of incubating salmon eggs; reduced food sources for rearing juvenile salmon; modified habitat; and in extreme cases, mortality to eggs and rearing fish. The degree of potential impacts on salmon life stages would depend on the timing and magnitude of the spill. The duration of impacts would not extend longer than 1 year, or until the tailings are cleaned up or incorporated into the bedload. Increased turbidity and TSS could injure juvenile salmon and reduce their ability to sight-feed on surface and near-surface invertebrates (USACE 2008b). At lower turbidity, juvenile salmon may use turbid waters as cover to hide from predators. Salmonids can encounter naturally turbid conditions in estuaries and glacial streams, but this does not mean that salmonids in general can tolerate increases of suspended sediments over time (Bash et al. 2001). Relatively low levels of anthropogenic turbidity may negatively affect salmonid populations that are not naturally exposed to relatively high levels of natural turbidity (Gregory and Levings 1996). The feeding efficiency of juvenile salmonids has been shown to be impaired by turbidity levels exceeding 70 NTU (Pentec 2005). The flows associated with this scenario would not be sufficient to mobilize bedload material as in a large flood. The low-level use of the habitat to be impacted (based on the distribution and densities of juvenile and adult salmon observed in the area) indicates that drainage-wide or generational impacts to salmon from direct habitat losses associated with the scenario would not be expected.

Release of metals from contact water in the tailings slurry is predicted to cause increases in surface water concentrations above the WQC for copper, lead, manganese, molybdenum, and zinc. The magnitude of these exceedances for each metal would decrease with time, and with distance downstream of the spill. In the short-term, and immediately downstream of the spill where relatively lower dilutions occur in the surface water, acute toxicity (lethality) may occur in fish and other sensitive aquatic species. Over days to weeks in downstream locations, sub-lethal effects, such as impairment of olfaction, behavior, and chemo/mechanosensory responses, may also occur in these receptors, specifically due to copper (Meyer and DeForest 2018). The magnitude of specific impacts cannot be known because of the relative sensitivities of the species and the type of effects. However, within days to weeks of potential impacts, toxic effects of metals on fish would be indistinguishable from the concurrent effects due to sedimentation and turbidity described above.

Tailings submerged in the stream could potentially generate small amounts of acid if oxidized by DO in the stream water, but the dilution of the flowing water and the slow rates of acid generation would prevent water from becoming measurably acidic. Tailings that may remain exposed on the stream banks could generate acid over a time period of years to decades that could reach the NFK. Any acid produced, however, would be diluted by fresh water, so that a reduction in stream water pH would likely not be measurable.

The metallic minerals in the tailings are not readily soluble in water, so metals would not immediately be introduced in bioavailable form. If the tailings are promptly removed from the NFK, there would be no measurable leaching of metals. After a number of years, however, if the tailings are not recovered, the minerals would slowly dissolve, leaching metals into the water, some of which could bioaccumulate in the food chain. Due to the small amount of tailings that would likely remain in the NFK, however, and the heavy dilution from stream flow, incremental impacts on fish (via toxicity and bioaccumulation) due to metals leaching would likely not be measurable. See Section 4.24 and Appendix K4.24, Fish Values, for an expanded discussion of metals impacts to aquatic resources.

The WQC exceedances are expected for several days under this scenario. A more detailed discussion of impacts via metals toxicity is provided for the pyritic tailings release scenario, below. As discussed subsequently, the comparison of the predicted concentrations to WQCs assumes that the metals are 100 percent bioavailable. That is not the case, as exemplified by the EPA's recommended WQC for copper, based on the Biotic Ligand Model, which accounts for various factors that modify its aquatic toxicity (EPA 2007b). Metals bioavailability in the current evaluations presents uncertainties. Site-specific toxicity tests (as discussed below) are indicative of limited impacts on fish species. In a study by Nautilus Environmental (2012), aqueous samples from the mine site were used to evaluate aquatic toxicity to fish species and aquatic invertebrates. Two samples were tested: Gold Plant Process Water and Non-Gold Plant Process Water. The bioavailability of metals in the "Non-Gold Plant Process Water" sample, which represents undiluted tailings fluids, would be similar to the contact water portion of the tailings slurry released under this spill scenario, although there is uncertainty as to how well the sample represents the contact water. These toxicity tests are described in detail below for the pyritic tailings release.

The toxicity tests did not demonstrate acute and chronic toxicity to fish species, including rainbow trout and fathead minnow in 4- and 7-day exposures, respectively. Survival of water flea neonates was adversely affected in a 48-hour test at 25 percent (by volume) "Non-Gold Plant Process Water" sample. Reproduction was adversely affected in the 7-day test at 12.5 percent aqueous sample; that is, at eight times dilution or less. These results indicate chronic exposures for 7 days or more to tailings fluid at lower dilutions in the streams could have sub-lethal effects on sensitive aquatic species and to fish indirectly by impacting their diet, but direct toxic impact on fish species is less likely. Under this current spill scenario and assuming 100 percent bioavailability, the WQC exceedances do not extend beyond several days; that is, chronic exposure is not expected. Based on the site-specific toxicity results and the predicted exposure regime (several days), impacts on fish due to metals toxicity would be limited, and likely overshadowed by impacts via physical injury, and loss of habitat and food.

Although predicted mercury concentrations in the tailings are low, even very low amounts of total mercury that may incorporate into anoxic sediments, such as those occurring in wetlands in the project area, could result in methylation to form MeHg, the toxic and bioavailable form of mercury. MeHg is toxic, bioaccumulates, and biomagnifies in fish (see Appendix K4.24, Fish Values, for an expanded discussion of potential impacts from MeHg in fish).

Finally, residual amounts of toxic ANFO and sodium ethyl xanthate that have not biodegraded would be released into the environment with the tailings in this scenario. However, as discussed in EPA (2014), the small amount of ANFO and xanthate released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to fish from these toxins would be localized and of low magnitude (Xu et al. 1988).

Threatened and Endangered Species

There would be no impacts to federally listed TES, because none occur in areas where a tailings release is projected to reach. According to Brna and Verbrugge (2013), based on a preliminary assessment, no breeding or otherwise large occurrences of TES are known to occur in the Nushagak watershed. Although there are TES in Bristol Bay, they are beyond the anticipated area that would be impacted by the bulk tailings release scenario (do not normally occur around the mouth of the Nushagak River) and are not discussed herein. Therefore, no impacts to TES are anticipated.

Marine Mammals

A bulk tailings release may potentially impact the habitat and occurrence of marine mammal prey species that inhabit the NFK. Changes to salmon spawning and rearing habitat and impacts to salmon due to acute and chronic toxicity from the bulk tailings failure may reduce the prey base for several marine mammals. Salmon and other fish in the NFK and downstream would be impacted. The duration would last until affected spawning and rearing habitat is restored and salmon are no longer impacted. The geographic extent would stretch from the spill location in the NFK downstream for tens of miles until metals are diluted, and TSS would be elevated all the way to the Nushagak River estuary. In particular, the non-federally listed Bristol Bay stock of beluga whales are known to swim at least 18 miles up the Nushagak River; occur year-round in Bristol Bay; and may be impacted by a tailings release. Citta et al. (2016) described the annual distribution of beluga whales in Bristol Bay using data from 31 satellite-linked transmitters during 2002-2011. They found that during salmon migrations, beluga whales were restricted to the river entrances in the inner bays that comprise Bristol Bay. In early spring (typically April), beluga whales move up rivers (including the Nushagak) in pursuit of spawning rainbow smelt. As the smelt run ends in late May, beluga whales begin to feed on outmigrating salmon smolt until late June, when they shift their diets again to focus on eating adult salmon returning to spawn (Citta et al. 2016). The study found that beluga whales did not relocate to different river entrances or change bays during peak salmon periods. This suggests that beluga whales were either selecting locations that were good for catching salmon, or there were more salmon than beluga whales needed to supply their nutritional needs. Based on salmon population estimates, there is an abundance of salmon for beluga whales. After the completion of the salmon runs, beluga whales ranged farther beyond the inner bays.

In terms of salmon prey, a tailings release that resulted in smothered eggs or alevin and reduced spawning habitat quality or quantity could result in a reduction in the NFK spawning biomass that reduced the number of returning adult salmon. However, based on current salmon populations, a small reduction in spawning adults in the NFK is unlikely to impact the overall number of salmon available for beluga whales.

There are other marine mammal species that use the Nushagak River for feeding, such as harbor seals. Similar to beluga whales, a minor impact on NKF spawning adults from the bulk tailings scenario is not likely to impact the overall abundance of prey for harbor seals.

Needs and Welfare of the People—Socioeconomics

The cleanup and remediation activities following a bulk tailings delivery pipeline rupture in which a large volume of slurry is released into the environment would briefly increase employment opportunities and expenditures in the Iliamna Lake area, and potentially in the Bristol Bay region. Manpower requirements would be especially high if labor-intensive response efforts such as mechanical recovery and physical removal were used. Employment increases for cleanup activities would likely be brief (less than 1 year).

Over the longer term, the impacts on employment, income, and sales would be negative if commercial and recreational fishing and/or tourism were to suffer due to the real or perceived impacts of the spill. Real or perceived water contamination could also negatively impact local business and consumers.

Environmental Justice

Impacts from a tailings release would impact the socioeconomics, subsistence, and health and safety of those in the region. There could be increased employment for a brief time for cleanup and remediation; however, there could be declines in employment, income, and sales from commercial and recreational fishing and/or tourism if impacted by real or perceived impacts of the spill. A release could impact subsistence harvest quantities and harvest patterns, and there could be impacts to health and safety. Taken as a whole, adverse impacts from the spill event would disproportionately impact minority and low-income communities. There would be interrelated subsistence, health, and socioeconomic impacts to the minority and low-income communities in the area.

Recreation

In the event of a tailings release, impacts to the recreational setting would be acute or obvious. The levels of recreational activities downstream from the mine site are higher than at the mine site itself, but are still estimated to be low. The recreational activities that may be affected could include sport fishing, recreational snowmachining, and sport hunting. A release may cause probable loss or damage to anadromous fisheries, which could impact sport anglers. There would be impacts to recreational sightseeing, because visual resources would be impacted. Sightseeing and flightseeing are typically secondary recreational activities done in conjunction with travel for sport fishing and sport hunting, and would also be impacted from visual impacts.

Commercial and Recreational Fishing

A tailings release that resulted in smothered eggs or alevin and reduced spawning habitat quality or quantity could affect commercial fishery value through lost harvest opportunities. The magnitude and duration of these lost harvest opportunities would be relative magnitude and duration of reduced salmonid productivity. Roughly 1 in 1,000 eggs turns into a returning adult salmon; and historically, the commercial fishery has harvested nearly 70 percent of returning adult sockeye. Therefore, roughly 1 in every 1,400 to 1,500 eggs is harvested as an adult by the commercial fishery; and over the last 20 years, the 10-year average ex-vessel value per harvested sockeye has ranged from $4.75 to $7.62 in 2019 US dollars. A reduction in the NFK spawning biomass that reduced the number of returning adults would have a measurable, but small, impact on the overall value of the fishery.

The commercial fishery has expressed concern that a large-scale spill event would affect the value of the fishery by changing the value of harvested salmon in the open market. Historical experience shows the extent to which large-scale spills tend to affect the value of seafood products. After the *Exxon Valdez* oil spill, the Eshamy District of the Prince William Sound (PWS) Management Area was closed for the duration of the 1989 season, while PWS Management Area districts experienced at least some fishing. That event resulted in direct financial losses associated with lost harvest opportunities. However, post-event statistical analyses found no effect on salmon prices in 1989, 1990, or 1991. An Alaska jury also found no decline in salmon prices for 1990 and 1991, but did make an award for an effect on prices in 1989 (Owen 1995). In 2016, Japanese researchers found statistically significant, but “negligible” effects on seafood prices in the wake of the Fukushima nuclear disaster (Wakamatsu and Miyata 2015). These studies indicate that seafood price effects associated with industrial accidents tend to be very small or undetectable, and of limited duration. At the same time, in the wake of such disasters, a specific name can be associated with lower consumer desirability if the name is firmly connected with the disaster itself. For example, consumer choice research conducted after the Fukushima nuclear disaster found that labeling seafood as being from Fukushima Prefecture resulted in lower willingness-to-pay, compared to unlabeled seafood or labels from other prefectures (Wakamatsu and Miyata 2017). The study notes that preference research associated with an oceanside nuclear disaster where radioactivity entered the food chain may not be applicable to a hypothetical mine disaster, where pollutants would be less likely to accumulate in seafood.

Recreational fishing effort in the NFK is very limited. Not enough returned surveys include the NFK for ADF&G to publish an estimate of recreational angling effort for that waterbody. The NFK is aggregated with the estimate for the entire Mulchatna drainage, which averaged 1,600 to 1,700 angling days per year between 2007 and 2016. ADF&G Freshwater Guide Logbook data estimate that just over 340 guided angling days a year occur in the Mulchatna drainage, including the NFK.

Far more days are spent angling on the Mulchatna River, which has a 10-year estimated effort of 1,700 angler days per year, including roughly 340 guided angler days, and the Nushagak River. Statewide Harvest Survey (SWHS) data indicate that between 2004 and 2016, the Nushagak River averaged just over 12,000 angler days between the Mulchatna confluence and Black Point. In a bulk tailings spill, the released tailings would pass through the Mulchatna River into the Nushagak River. The increased TSS and turbidity associated with the spill could temporarily (on the order of several days to a week) affect anglers’ success rates, because salmonid species feed partially by sight.

The impacts on the recreational fishery would be limited in the Nushagak River by the duration of increased turbidity or TSS affecting the ability of target species to see or smell prey. Fishing packages in the region cost between $600 and $1,000 per night. A spill before or during the peak summer months could result in trip cancellations and associated economic impacts for guide companies, and the business and communities that support them.

Cultural Resources

A bulk tailings delivery pipeline failure would impact cultural resources along the shore of the NFK if tailings were carried to a known or potential historic property site, or response efforts with ground-disturbing activities occurred near cultural resources. Resources may not be anticipated to return to previous levels even after actions that caused the impacts were to cease. The probability of ground-disturbing cleanup activities occurring at historic property sites is low due to the dispersed geographical distribution of sites downstream of the mine site. Impacts would occur in a discrete geographic area, but could affect rare cultural resources in the region. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Clean-up activities would likely require a mitigation plan to limit impacts to known or potential historic properties, and would occur in accordance with the Programmatic Agreement. It is not possible to identify specific cultural resources that could be affected. Indirect impacts could occur to the setting (visual and noise impacts) of cultural resources if the spill were to happen in the vicinity. Those impacts would be temporary, and would cease when response efforts are complete.

Subsistence

A tailings pipeline release would impact subsistence resources, particularly salmon, at and downstream from the release site. The tailings may smother salmonid eggs and alevins, and reduce the quality of spawning habitat in the direct footprint of the spill in the NFK—and to some extent further downstream. Fish could experience acute and chronic toxicity from heavy metals in the released tailings. Wildlife would also be hazed from the area by cleanup efforts. The impacts to subsistence resources would persist until the tailings are cleaned up or incorporated into the bedload. The most persistent and widespread impact of a tailings spill would likely be concern among subsistence users about contamination of subsistence fish resources in the greater watershed. Subsistence users would likely avoid fishing and other subsistence activities downstream from the release, affecting harvest patterns, as well as harvested quantities of highly valued resources.

In the aftermath of the 2014 Mount Polley Mine tailings dam failure, described previously, most of the indigenous communities surveyed by Shandro et al. (2017) reported impacts to personal fishing practices, increased emotional stress, and increased administrative burden on community leaders related to the tailings and tailings water release. Shandro et al. (2017) found that traditional fishing areas were avoided by some communities due to concerns over contamination in the Fraser River system, and that members of these communities reported traveling greater distances to harvest fish. Community leaders (also subsistence users) reported increased administrative workloads to gather credible information about the tailings release, remediation efforts, and the safety of salmon and the Fraser River system (Shandro et al. 2017). Quick response and cleanup of tailings, and a system of testing wild foods and communicating the results to local people in a timely manner, could help mitigate contamination concerns.

Health and Safety

There are no nearby downstream human habitations. The closest village downstream is New Stuyahok, 105 miles downstream from the mine site by way of the NFK. Modeling suggests that at that distance from the potential release, there would be no observable rise in water level.

Residents of the village would likely see an increase in turbidity and TSS in the river for days to weeks after the release (see the Surface Water Hydrology subsection).

Downstream communities rely on groundwater wells for drinking water. No measurable impacts to groundwater would be expected from this scenario, although groundwater contamination could be perceived. Perceived contamination of the environment and subsistence foods (e.g., salmon) may affect community concerns about access to, quantity, and quality of subsistence foods, which can affect the socio-economic status, emotional well-being, food security, and dietary patterns of local communities; this concern may extend throughout the extended spills analysis area. A tailings release in winter could impede snowmachine travel by subsistence hunters. Restricted access to the environment (e.g., due to real or perceived contamination) may result in decreased mental health and increased psychosocial and family stress, substance use, suicidal tendencies, and cardiovascular disease (Dillard et al. 2012; Gibson and Klinck 2005).

There are potential adverse impacts to social determinants of health (HEC 1), with psychosocial stress resulting from community anxiety over a tailings release, particularly in areas of valued subsistence and fishing activities. There could be exposures to potentially hazardous materials, including metals (HEC 3). Subsistence and food security may be impacted, with potential perceptions of subsistence food contamination that extend throughout the area (HEC 4). Reliable and prompt communications about environmental and subsistence food impacts and precautions about both acute and chronic exposures would alleviate psychosocial stress, reduce impacts to subsistence and food security, and allay public health concerns. Impacts would vary in duration; be limited to the area of the spill; and would vary in intensity depending on the season.

Scenario: Pyritic Tailings South Embankment Release into the SFK

In this scenario, operational error(s) and lift construction difficulties result in an overtopping failure, which results in a partial breach (6 feet downcutting/21 feet wide) of the south embankment. The partial breach results in the full release of the supernatant pond of 155 million ft^3, and the upper 1 foot of solid pyritic tailings of 30 million ft^3 (871,200 tons), for a total release of 185 million ft^3 (release volume determined by the FMEA panel) (AECOM 2019l). The full modeled release would take approximately 500 hours, or nearly 21 days, although most of the material would be released in the first 10 days (Knight Piésold 2018p). In this scenario, no additional tailings would slump out of the facility following the release.

The south embankment is at the upper catchment of Tributary SFK 1.240 in the SFK drainage. This hypothetical release from the south embankment would be to the southwest, and would flow directly into Tributary SFK 1.240 (Figure 4.27-5).

The initial release of supernatant pond water would cause a large flood wave to flow down Tributary SK 1.240 at high velocity, up to 1,000 cfs, inundating the complete width of the vegetated valley bottom. The flood wave along Tributary SFK 1.240 would overtop the banks during the first 2 days of the release (inundation maps provided in Knight Piésold 2018p). Tributary SK 1.240 is confined by narrow valley walls, so the flow through the drainage would not slow down substantially until it arrived at the mainstem of the SFK, about 1 mile downstream (Knight Piésold 2018p). This segment of the SFK may be seasonally dry during summer months.

The flooding would cause erosion in the existing stream channel, and potentially on surrounding soils in areas of overbank flooding (Knight Piésold 2018p).

The initial release would begin with supernatant pond fluid only, and essentially no tailings solids. As the release continues and the pond level draws down closer to the level of the tailings (5 feet below the pond surface), more of the solid tailings would become entrained, or mixed into the flow, so that it would become a slurry of fluid and tailings. The slurry would flow as a turbulent flood of water, with the fine particles of tailings solids remaining in suspension. The increase in solid tailings would make the release increasingly more viscous over time[2]. Increased viscosity would slow down the flow, and more of the solids would be likely to be deposited during later stages of the release.

The model cannot predict the exact volume or thickness of solid tailings that would be deposited, but the banks along Tributary SK 1.240 would have at least a thin veneer of solid tailings deposition in areas of overbank flooding.

When the wave reaches the confluence with the mainstem SFK, the flood of water and tailings would overtop the banks and spread out over a large area. The flood wave would still be a high-energy, high-velocity flow at this point, to the extent that modeling predicts some of the flood would even flow upstream on the mainstem SFK (Knight Piésold 2018p). Along the SFK downstream from the confluence of Tributary SFK 1.240, overbank flooding would leave a thin layer of tailings solids on an estimated 220 acres. The high-energy flow continues to flood over the top of the SFK banks as it moves for about 15 miles downstream of the pyritic TSF.

After 15 miles of overbank flooding downstream, the flood wave is able to spread out and attenuate. Stream levels would remain elevated past this point, but the release would be contained in the natural channel for the rest of the downstream drainages, causing no more overbank flooding. Stream levels would remain elevated for at least 52 miles downstream, past the Swan River confluence (Figure 4.27-6).

In this scenario, on-site mine operations teams would be unable to stop the flow of fluid exiting the breach, but would be expected to stop the flow after an approximately 1-foot depth of tailings escapes.

Suspended Tailings

The pyritic tailings would be composed of 98 percent clay- and silt-sized particles, and 2 percent very fine sand (Knight Piésold 2018p). Because the tailings solids are entirely very fine, light particles, most of the solids would stay suspended in the water and be transported downstream, except where overbank flooding occurs and in areas of minimal current, such as low-energy side channels. Most of the released solid material would be flushed downstream during the initial peak flows.

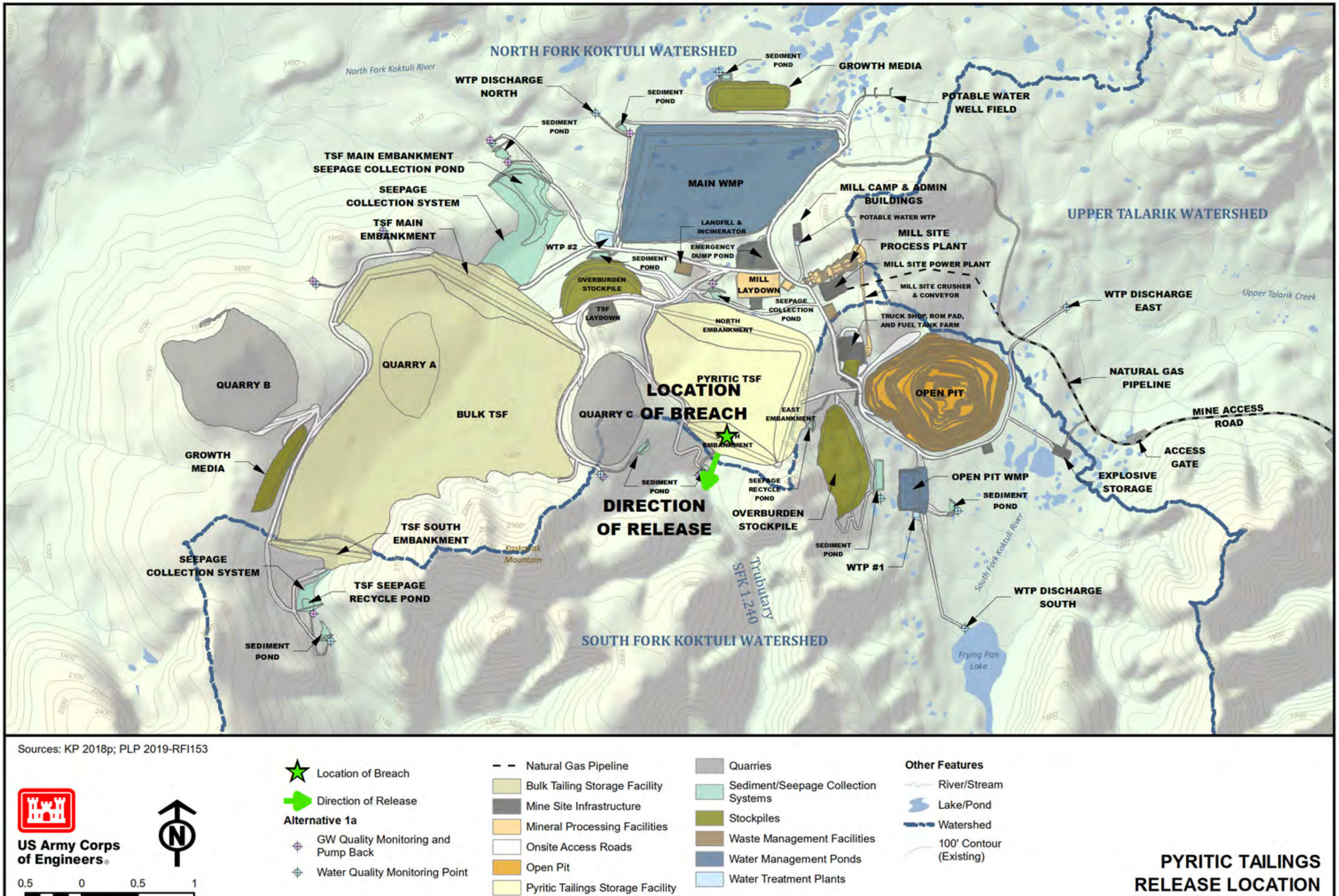
The solid particles would mix with the natural stream flow of the downstream drainages, creating elevated TSS downstream. After all of the tailings solids have been released, natural dilution of stream water would begin to decrease the levels of TSS.

Water in these drainages is naturally low in TSS, with average measured values of 1.69 mg/L in the SFK (see Section 3.18, Water and Sediment Quality, and Appendix K3.18). Applicable WQC require TSS to be no more than 20 mg/L. This release scenario would elevate the TSS and turbidity of the drainages above the WQC downstream for approximately 230 river miles to the Nushagak River Estuary, where it enters Nushagak Bay, part of the greater Bristol Bay.

TSS at the confluence of Tributary SFK 1.240 and the SFK was modeled to be about 241,500 mg/L; while at the Nushagak River Estuary, modeled TSS values are predicted to be about 9,400 mg/L. TSS would remain elevated in the downstream drainages for 3 weeks or more.

---

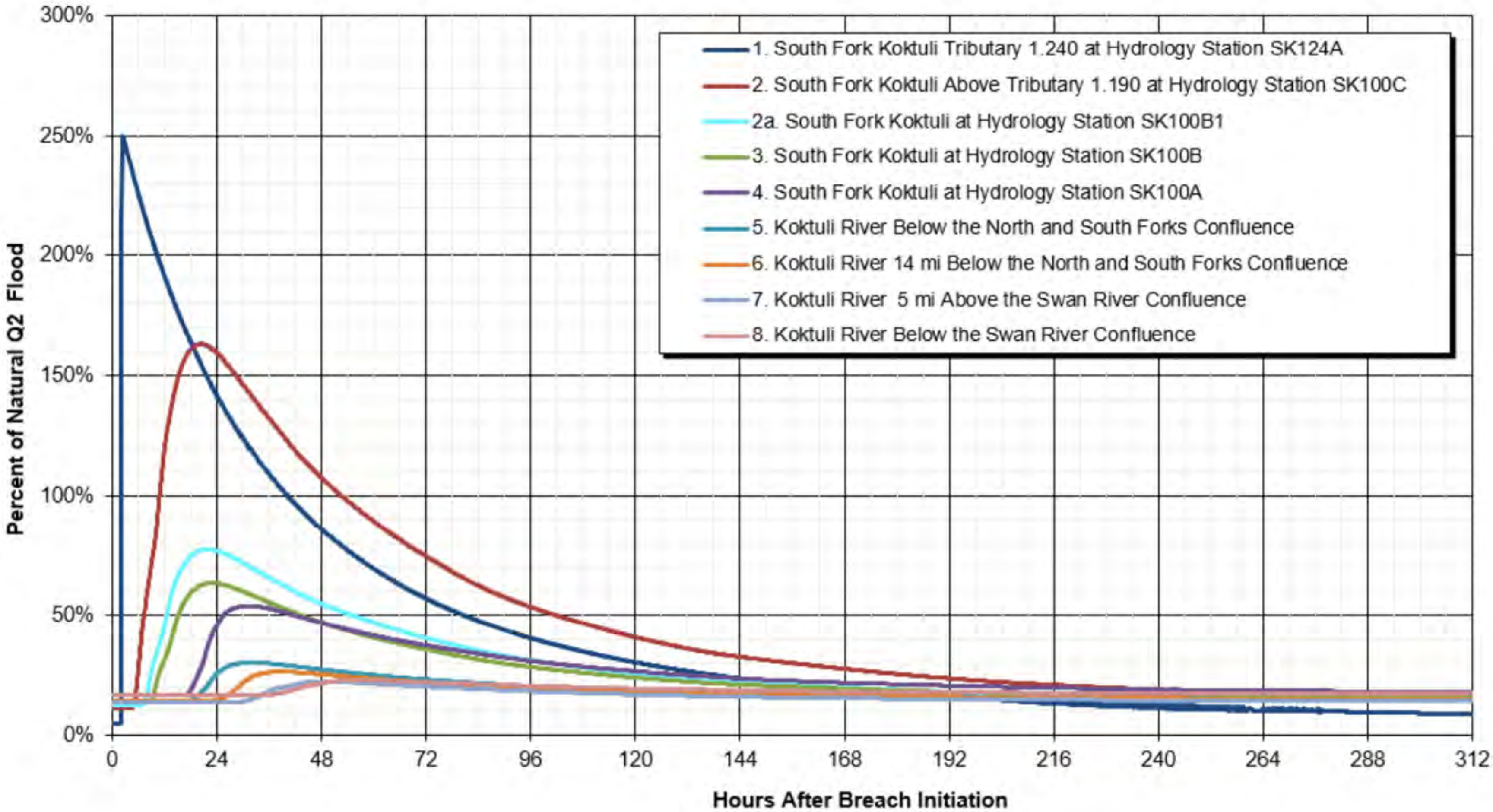
[2] The HEC-RAS model cannot model changing solids concentrations throughout a flood event. Due to this limitation in the model, it was assumed for modeling purposes that the released pond water and tailings were fully mixed, so that the released slurry would have a constant solids content of 23 percent (by mass). In reality, flow type would change as the solids concentration in the fluid increases throughout the event, with the flow becoming more viscous, and potentially slowing somewhat over time.



PEBBLE PROJECT EIS

PYRITIC TAILINGS RELEASE LOCATION

FIGURE 4.27-5



Sources: KP 2018p

US Army Corps of Engineers®

HYDROGRAPHS DOWNSTREAM OF PYRITIC TAILINGS RELEASE

Deposition of Tailings Solids

Where overbank flooding occurs, receding floodwaters are likely to deposit a thin layer, or veneer, of the fine solid tailings on the floodplains. Also, where floodwaters enter low-velocity side channels or ponds, the slower water could allow settling of solids.

At the confluence of Tributary SFK 1.240 and the SFK, the floodwaters are modeled to spread out widely, covering about 220 acres. In this area, more widespread deposition of the solid tailings would be expected.

In low-velocity, low-energy areas in the active downstream channels or along the banks, a small volume of solid tailings could potentially settle out and be deposited. Because the particles are so fine, however, they would be re-entrained by subsequent flow and flushed downstream.

As the flow continues down the SFK, there are many areas where the stream channel widens, and many side channels and small ponds where the MAD stream waters do not typically flow (Knight Piésold 2018p). For the first 15 miles downstream from the TSF, overbank flooding could allow the pyritic release to flow into these areas. Once released into these areas, the floodwaters would slow, and deposit the suspended tailings. The fine particles could remain on the surface in these areas until a larger flood event passed through the side channels and flushed the particles back downstream. Depending on conditions, it could take several years to flush out all of the fine material.

Spill Response

As noted above, the State of Alaska does not have specific requirements for cleanup of spilled mine tailings. As per Alaska Statute 27.19.02, the mine site must be returned to a stable condition, compatible with the post-mining land use (AS 27.19.02).

See the “Spill Preparedness, Prevention, and Response Measures” subsection for the actions that the Applicant has committed to. An EAP would be available to direct the appropriate response measures. Response measures would include ensuring the safety of downstream mine employees; shutting down the tailings pipelines; coordinating emergency responders in the community (including mine personnel and downstream residents); and implementing remedial actions to minimize impacts to affected resources.

Overbank flooding would extend down Tributary SFK 1.240 past the confluence with the SFK for a total of about 15 miles downstream of the TSF. No mine employees would normally be working in these areas. Subsequent downstream flows would be so small as to pose no safety concern to downstream residents or recreational users.

Remedial actions could include removing the pyritic tailings from the primary depositional areas at the base of the pyritic TSF, along the margins of Tributary SFK 1.240, and near the confluence of Tributary SFK 1.240 and the SFK, to the extent practicable. The tailings could be excavated using a combination of heavy equipment and hand tools, and transported back to the TSF or other designated temporary storage area.

If the SFK is experiencing dry conditions during a spill, recovery of spilled tailings would be facilitated. Tailings would be less likely to be carried downstream, and would accumulate on the dry riverbed. Tailings could be recovered by excavation.

Depending on the thickness of deposited spilled tailings, recovery of the solid tailings may not be justified in all areas. The amount of solid tailings deposition in most downstream areas would include a very thin layer of clay and silt deposition. Such a thin layer of very fine tailings particles would naturally be dispersed, and flushed downstream by precipitation and/or any naturally elevated streamflow events within months to years. Recovery efforts, including excavation or dredging of spilled tailings, could potentially cause erosion, compaction, and/or damage to vegetation that may exceed the impacts of the tailings remaining in place. Additional habitat restoration could be required after tailings recovery activities.

There would be no immediate risk of acid generation or ML from the spilled tailings.

Any soils impacted by the elevated metals from the supernatant fluid could also be removed, and the impacted habitats could be restored.

Access to cleanup areas in the summer would be difficult due to the lack of roads along the NFK, and would likely involve heavy use of helicopters. Access in the winter could be simplified by travel on packed snow trails, and removal of deposited material may be more effective because the ground and streams would likely be frozen.

Cleanup activities such as excavation or dredging could damage stream habitat, and machinery could cause soil erosion and/or compaction adjacent to streams. Additional habitat restoration could be required after tailings recovery activities.

In the event of a tailings spill, the Applicant has committed to the following remedial actions (from Knight Piésold 2018p):

Remedial action under this failure scenario would include:

- Notification to downstream residents, including individuals and regulatory contacts per the Emergency Response Plan, regarding the incident to minimize the health and safety risks associated with the breach

Ongoing remedial actions would include:

- Mobilizing mine equipment and staff to clean up discharged tailings where practicable, which would likely include helicopter-supported efforts to support ongoing cleanup activities
- Establishing environmental control measures downstream of the breach to reduce the potential for sediment transport from areas of settled tailings, repairing the pyritic TSF south embankment
- Repairing erosion damage in the tributary and at the confluence, if required
- Monitoring downstream water for water quality (Knight Piésold 2018p)

Alternatives Analysis

The probability and impacts of a pyritic tailings release would be the same across all alternatives.

Potential Impacts of a Pyritic Tailings South Embankment Release into the SFK

This section addresses potential impacts of a release of pyritic tailings into the SFK scenario described above. Impacts are considered in terms of their magnitude, duration, geographic extent, and potential to occur. A tailings release would not impact all the resources addressed in this EIS. The following resources were selected for analysis due to the higher potential significance of the impacts.

Soils

Tailings Solids Deposition on Soils—In this scenario, a minimum of 220 acres of soils would be temporarily covered by thin veneers of fine tailings solids. No long-term impacts to soils would be expected from this deposition.

The total mass of tailings solids released in the scenario would be approximately 30 million ft^3 (871,200 tons). Particle sizes would be mostly clay- to silt-sized, with only 2 percent fine sand size. Due to the very fine particle size, most of the tailings solids would remain suspended in the flow, and very little would be expected to settle out.

Soils adjacent to Tributary SFK 1.240 would likely be covered by a thin veneer of tailings solids deposited during overbank flooding. Downstream of the confluence with the SFK where the land flattens out, soils on the banks of the SFK could be covered by a somewhat greater thickness of tailings. Modeling results do not indicate the thickness of solid tailings deposition. The extent of solid tailings deposition in this area would likely be on the order of 220 acres (Knight Piésold 2018p).

Due to the very fine particle size and expected thin layers of deposition, these fine particles would be easily flushed back into the drainage by precipitation, overland flow, or subsequent natural flooding events within days to months. In areas where tailings are deposited in side-channels, future flooding events would naturally flush the tailings back into the drainages within months to years. No acid generation or ML would occur from the deposited tailings on that timescale. The thickest deposits of solid tailings covering soils could be recovered, as needed, although erosion or damage to vegetation from recovery activities could occur.

Erosion—Modeling calculated the bed shear stress downstream of the release to determine the potential for erosion (Knight Piésold 2018p). The flood of fluid and tailings would flow downstream initially at high velocity, up to 1,000 cfs, and would erode the streambed throughout the length of Tributary SFK 1.240. Some sections of the tributary could be eroded/scoured to bedrock, especially immediately downstream of the pyritic TSF. The sudden release of water may cause localized bank erosion that could result in chronic erosion until the banks stabilize. Soils on the banks along Tributary SFK 1.240 could also be eroded somewhat where overbank flooding occurs, especially where vegetation is not present (Knight Piésold 2018p).

Near the confluence of Tributary SFK 1.240 with the SFK, streambed sediments would be eroded, and surrounding soils on the banks of the SFK could be eroded in areas of overbank flooding, especially in areas where no vegetation is present. Some soil erosion could occur for about 13 miles along the mainstem SFK, in areas of overbank flooding. No measurable erosion would be expected farther downstream.

Mitigation would include the repair of erosion damage in the tributary and at the confluence (stream stabilization) if required. Depending on the severity of the erosion, months to years may be required to stabilize the altered stream morphology.

Metals Contamination—Soil could become contaminated with elevated levels of metals from pyritic supernatant fluid in the release. Where supernatant spills onto soils beneath the point of release at the pyritic TSF, it could potentially percolate into the soil column, and metals in the supernatant would adsorb onto surficial soil. Similarly, where overbank flooding flows over soils along the banks of Tributary SFK 1.240, bank soils would come in contact with metals in the supernatant, although the fluid would be diluted by stream water in these instances. Where metals in soils exceed ADEC soil cleanup level guidelines, soils could be excavated to the extent practicable and impacted habitats could be restored.

Metals would not be immediately leached from deposited tailings solids because the process of ML would require years to decades (Section 3.18, Water and Sediment Quality). Tailings particles would be flushed off the land surface and out of the stream drainages within months to years in areas surrounding the impacted drainages.

Surface Water Hydrology

Stream Morphology—The sudden release of supernatant water would result in bed scour and bank erosion throughout the length of Tributary SFK 1.240. The confined reach immediately downstream of the embankment could be scoured to bedrock. The combined volume of tailings slurry and existing bedload could permanently alter the existing geomorphic characteristics of this stream, and result in lateral and vertical instability. This would result in chronic severe bank erosion and increased sediment loads throughout this tributary and the SFK, requiring stream restoration. Ongoing erosion would also contribute to increased TSS downstream for months to years, depending on stream stabilization efforts.

Elevated flows—Surface water flow would be increased above the 2-year flood level on Tributary SFK 1.240, and on the mainstem SFK until the confluence with Tributary SFK 1.190 (Knight Piésold 2018p). This would cause overbank flooding in this area for approximately 2 days (Figure 4.27-6). The sudden release of water and the resulting erosion could potentially modify the stream morphology of Tributary SFK 1.240 and immediate downstream areas of the SFK.

Peak flows would be less than the natural 2-year flood on the remainder of the SFK and other downstream drainages, and there would be no additional overbank flooding. Elevated flows downstream would last for several days to weeks (Figure 4.27-6). Peak flows, arrival time, and duration of elevated flows for downstream drainages are as follows (from Knight Piésold 2018p):

- The MAD of Tributary NFK 1.240 is 18.6 cfs. During the release scenario, modeling predicts the peak flows at this location to increase to 1,004 cfs. This would exceed the natural 2-year flood flow (402 cfs) during the pyritic tailings release event, so that overbank flooding would be expected for the first 2 days of the release.
- Just downstream from the confluence of Tributary SFK 1.240 and the SFK, the MAD of the river is about 47.9 cfs. During the release scenario, peak flows at this location would increase above the natural 2-year flood flow (422 cfs) to 688 cfs, causing overbank flooding in the area. Overbank flooding would persist for approximately 2 days (Figure 4.27-6). Flows would remain elevated for several days to weeks after that, but would be maintained in the stream channel.
- Downstream of the confluence of the NFK and SFK, the MAD of the drainage is 508 cfs. During the release scenario, modeling predicts the peak flows at this location to increase to 1,075 cfs, which would be less than the natural 2-year flood flow of 3,558 cfs. No overbank flooding would occur in this area. The increased flow arrives about 18.3 hours after the initial release and lasts for several days to weeks.
- At the confluence of the NFK and the Swan River, the MAD of the river is 1,431 cfs. During the release scenario, modeling predicts the peak flows at this location to increase to 1,940 cfs. No overbank flooding would occur in this area. The increased flow arrives about 38 hours after the initial release and lasts for several days to weeks.

Water and Sediment Quality

Surface Water Quality

TSS—An increase in TSS from the released pyritic tailings would impact water quality for approximately 230 miles of drainages, from below the pyritic TSF all the way downstream to the Nushagak River Estuary, where it enters Nushagak Bay, part of greater Bristol Bay. The turbidity of the downstream water would be elevated above baseline conditions (pre-development levels) in Tributary SFK 1.240, the SFK, the mainstem Koktuli, the Mulchatna, and the Nushagak River where it feeds into Nushagak Bay, part of the greater Bristol Bay.

Elevated TSS would likely be an intense impact for several weeks while the clay- and silt-sized particles are initially transported downstream.

The concentration of solid tailings in the downstream drainages is expressed herein as percent solids, and as TSS in mg/L (that is, the mass of the solid particles per volume of water). Water in these drainages is naturally low in TSS, with average measured TSS values of 1.69 mg/L in the SFK (see Section 3.18, Water and Sediment Quality, and Appendix K3.18). The most stringent WQC require TSS to be no more than 20 mg/L. Modeled TSS values are somewhat of an overestimate, because the model assumed that all of the solid tailings remained in suspension. Modeled peak TSS values during the initial period of peak flow are as follows (from Knight Piésold 2018p):

- At the confluence of Tributary SFK 1.240 and the SFK, the TSS was modeled to be 241,500 mg/L during peak flow.
- Below the confluence of the SFK with the NFK, the TSS would reach about 71,800 mg/L during peak flow.
- Below the confluence of the Koktuli and the Swan River, the peak TSS would be about 31,200 mg/L.
- Downstream of the Koktuli River confluence with the Mulchatna River, the dilution of natural stream water would be very strong, so that the TSS would be about 17,800 mg/L during the peak flow.
- At the Nushagak River Estuary, which feeds into Nushagak Bay, part of the greater Bristol Bay, the water would still have elevated TSS of 9,400 mg/L, many orders of magnitude above WQC.

Note that the modeled TSS values account for the tailings solids only, and do not consider the additional TSS from ongoing erosion near the release site.

If not recovered, settled tailings would likely flush out of the drainages naturally during subsequent periods of elevated flow. During these periods of elevated flow, deposited tailings would be re-entrained in stream water, and would cause a brief increase in TSS and turbidity in the downstream drainages.

In addition to the tailings solids, additional TSS would be introduced into downstream drainages due to the erosion of the streambed during initial flooding. After the elevated flows have diminished and most tailings solids have been flushed downstream, ongoing sedimentation and elevated TSS would likely continue due to the actively eroding banks of Tributary SRK 1.240 and the SFK near the confluence with the tributary.

Mitigation would include the repair of erosion damage in the tributary and at the confluence (bank stabilization) if required. This would reduce the duration of the elevated TSS. Depending on the severity of the erosion, it could require months to years to stabilize the altered banks.

For this scenario, it could take months to a few years to flush out remaining tailings deposited during the initial flow, depending on climatic conditions. During this time, the re-entrained tailings would cause periodic modest increases in TSS and turbidity as they are flushed downstream. These periodic increases in TSS could exceed WQC.

In addition to tailings solids flushed down the SFK drainage, a small amount of solid tailings would likely enter a large pond near the confluence of Tributary SRK 1.240 and the SFK, due to overbank flooding in this area. The pond would measure approximately 1,000 feet by 1,000 feet (23 acres). Tailings solids in the pond would likely settle to the bottom within days; but due to the fine particle size, they would easily be remobilized and cause periodic increases in TSS in the waterbody. Recovery of these fine particles from the pond may not be practicable.

Acid—For a discussion of factors that impact the ability of tailings particles to generate acid, see “Factors Influencing Acid Generation and Metals Leaching” in the “Concentrate Spills” subsection.

Impacts from acidic conditions would not be expected in this scenario. Supernatant fluid would have a relatively neutral pH of 7 to 8 (Knight Piésold 2018a), and would therefore not contribute to acidic conditions. Note that the SFK has naturally acidic water in some reaches (see Appendix K3.18, Water and Sediment Quality).

Pyritic tailings solids would contain a substantial percentage of sulfide minerals (15 percent sulfur as sulphide; PLP 2018-RFI 045) capable of generating ARD. Deposition of pyritic tailings solids along streambanks that remain exposed to air could generate acid over a period of years to decades if not removed. Precipitation, runoff, and seasonal flood waters could flush any generated ARD into surface water, while some of the acid could percolate into the soil and reach shallow groundwater. Any ARD would be generated very slowly and would be constantly diluted by river water and flushed downstream, so that measurable decreases in water pH may not be observed. Pyritic tailings have a greater potential to impact downstream water quality than bulk tailings due to the higher concentration of PAG materials.

As noted above, the Nushagak River Estuary extends for the last 19 miles of the lower Nushagak River before it feeds into Bristol Bay. This area contains abundant mud flats that are periodically exposed during levels of lower tides. It is possible that a small amount of tailings could be deposited on the mud flats and exposed to the air, which could increase the potential for ARD. However, the deposited tailings would likely be flushed back into the main channels by high tides and rain, and deposited in Bristol Bay prior to generating measurable amounts of acid.

Metals—For a discussion of factors that impact the ability of tailings particles to leach metals, see “Factors Influencing Acid Generation and Metals Leaching” in the “Concentrate Spills” subsection.

Under this scenario, pyritic tailings fluid (the supernatant and pore water) with elevated metals concentrations would be released to Tributary SFK 1.240, and transported downstream (Knight Piésold 2018p). Pyritic tailings fluid is predicted to contain the following metals above the most stringent WQC: antimony, arsenic, beryllium, cadmium, cobalt, copper, lead, manganese, mercury, molybdenum, selenium, silver, and zinc (Knight Piésold 2018a) (see Appendix K3.18, Table K3.18-1, and Table K4.18-3).

Metals concentrations resulting from the spill would be diluted progressively downstream by the stream flow. More rapid downstream dilution would occur during higher stream flow in the summer months; while during the winter, there would be less water to dilute the elevated metals. Modeled downstream metals levels assumed MAD stream levels in the downstream drainages.

Note that the SFK has naturally acidic water in some reaches (see Appendix K3.18, Water and Sediment Quality). Unrecovered tailings that remained in more acidic waters would be more susceptible to dissolution, and could potentially leach metals at an increased rate.

As summarized below and in Figure 4.27-7, modeling results indicate that concentrations of several metals would exceed applicable WQC in the downstream drainages following the spill (Knight Piésold 2018p). Note that in Figure 4.27-7, the points along the drainages labeled “Dilution Ratio Achieved” indicate the point at which those metals would be diluted to within WQC. The metals that would be present in the highest concentration would be cadmium, lead, manganese, molybdenum, and zinc. Copper levels in the released fluid would also be elevated above the most stringent WQC. Due to the large volume of fluid released in this scenario, downstream water quality would be impacted for tens to hundreds of miles downstream (Knight Piésold 2018p):

- Copper would remain at levels exceeding the most stringent WQC until the Mulchatna River below the Koktuli River confluence, about 80 miles downstream of the mine site.

- Lead, manganese, and zinc would remain at levels exceeding the most stringent WQC until the Nushagak River below the Mulchatna River confluence, about 122 miles downstream of the mine site.
- Cadmium and molybdenum would remain at levels exceeding the most stringent WQC as far downstream as the Nushagak River Estuary, approximately 230 miles downstream from the mine site.

These metals would remain at elevated levels above WQC for several weeks while the flows are flushed downstream.

The pyritic tailings solids would not be expected to impact water quality from ML due to the long time periods required for dissolution of metals, and the high level of dilution from surface water. Metals present in the tailings solids (for example, 0.26 percent copper; PLP 2018-RFI 045) would require decades to leach into the water in a bio-available form. If tailings are recovered, there would likely be no measurable ML. Tailings solids that are not recovered could leach metals into surface water over a timescale of decades. However, due to the relatively low percentage of metals in the tailings, the small volume of solid tailings that would be deposited in this scenario, and the constant dilution and continual flushing of tailings from the watershed, this impact would likely not cause water quality exceedances.

The formation of secondary metal salts is not likely from this scenario, due to the limited amounts of metals that could be leached from the tailings, the strong amount of dilution from downstream waters, and the anticipated recovery efforts. The formation of secondary metal salts would require years. Impacts to water quality from dissolution of secondary metal salts would be the same as those noted above for other leached metals.

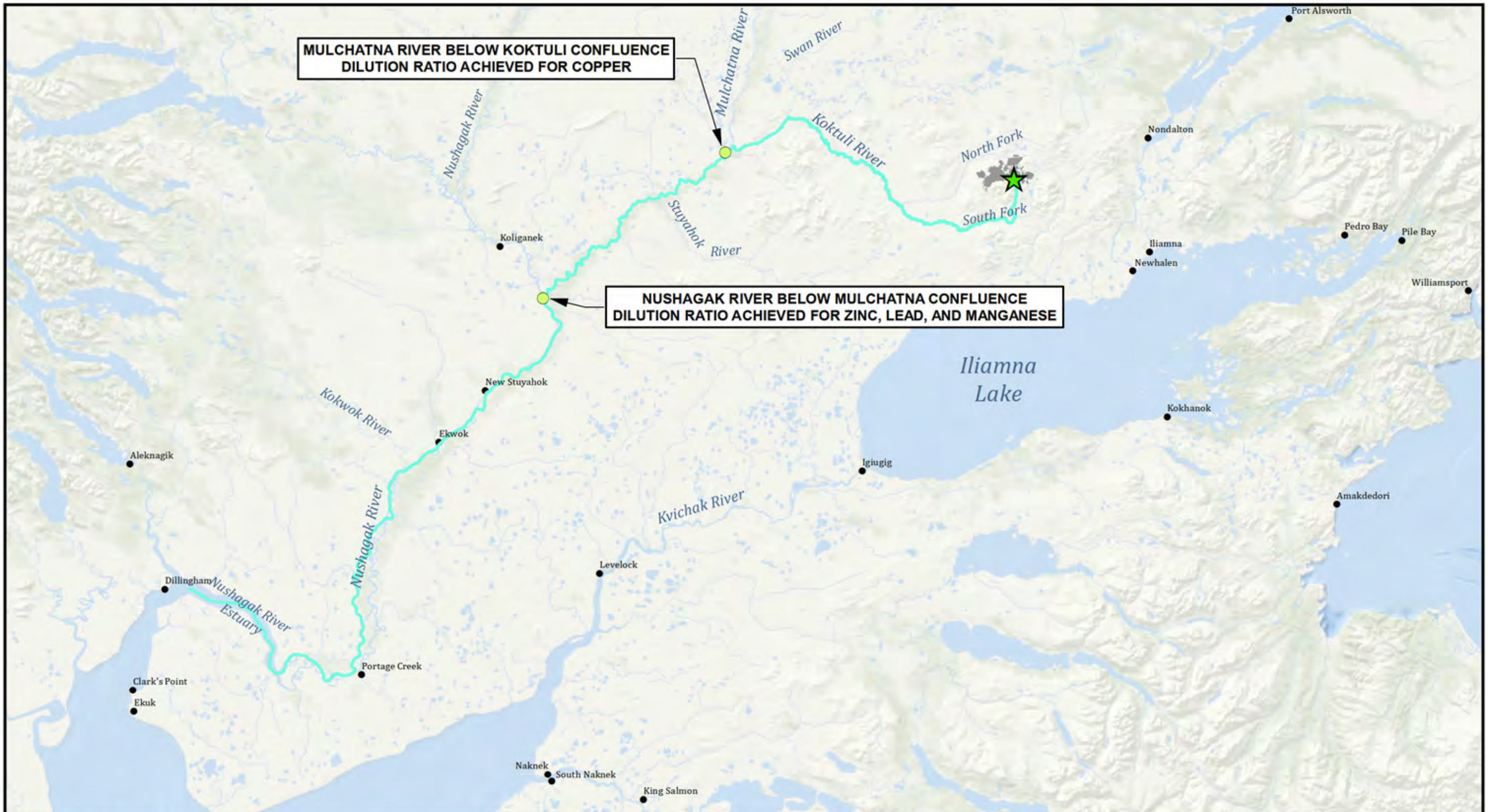
Residual Toxins—Pyritic tailings may contain minor residues from ore-processing reagents that could be released into the watershed in the event of a spill. Most of the reagents are consumed during the process of froth flotation, and residual reagents mostly remain adhered to the metals in the ore concentrate. The small amount of residual reagents in the tailings is anticipated to degrade naturally.

Pyritic tailings would also contain residues from the WTP, which would contain elevated levels of selenium sulfide. See Appendix K4.24, Fish Values, for a discussion of the potential toxicity of selenium and other metals.

Sediment Quality—In low-energy segments of streams, a small volume of tailings could potentially intermingle with and become incorporated into deposits of naturally occurring streambed sediments (substrate). A small volume of tailings could remain in streambed sediments for years to decades, potentially long enough to leach metals. However, the volume of tailings solids would be so low, the ML rate so slow, and the dilution from surface water so strong, that no measurable ML would be anticipated. PAG tailings would not generate measurable acid while under water.

Erosion of upstream streambed sediments from the release would also cause deposition of sediments near the confluence of Tributary SFK 1.240 and the SFK, and for some miles downstream (Knight Piésold 2018p). These redeposited sediments would become part of the bedload, and would continue to migrate downstream and potentially alter the streambed for months to years or more.

Trace amounts of metals from released pyritic supernatant fluid could potentially be incorporated into streambed sediments (the bedload). Metals incorporated into the bedload would continue to be flushed downstream and diluted, but trace amounts could potentially remain held in the sediment and slowly released to surface water. Such trace amounts would be unlikely to have a measurable impact on water quality.



Sources: KP 2018p; PLP 2019-RFI153

US Army Corps of Engineers

10 0 10 20
Miles

Location of Release
Dilution Ratio Achieved
Modeled Rivers
Mine Site

Note: Cadmium and molybdenum do not appear on the map, as their dilution ratios are not achieved before the Nushagak River Estuary.

MODELED EXTENT OF ELEVATED METALS DOWNSTREAM OF PYRITIC TAILINGS RELEASE

PEBBLE PROJECT EIS

FIGURE 4.27-7

Groundwater Quality—Groundwater could become contaminated with elevated levels of metals from the pyritic supernatant fluid. There are numerous shallow aquifers throughout the area. Due to the 3-week duration of the release, metals present in the fluids could permeate through soils into shallow groundwater. Elevated metals in groundwater close to the release site could exceed ADEC groundwater cleanup levels. In the event of a spill, monitoring wells could be installed to assess the extent of contamination. Containment of affected groundwater would be monitored using monitoring/pumpback wells to assess groundwater quality (Knight Piésold 2018a), and the groundwater in the area could be monitored for metals content. Any impacted groundwater would be expected to be detected in these wells. Additional pumpback systems may be installed downstream if necessary, as determined by monitored water quality. No measurable impacts to groundwater would be expected beyond several miles downstream of the mine site. In the case of a spill resulting in groundwater contamination, the State of Alaska may require ongoing monitoring and reclamation work as it deems necessary. See Section 4.18, Water and Sediment Quality, for other standard monitoring and mitigation that could be implemented.

Some surface water flow in the SFK naturally seeps into a shallow groundwater aquifer several miles south of the pyritic TSF. This aquifer releases an estimated annual average of 22 cfs into the Upper Talarik Creek (UTC) basin (Knight Piésold 2018p). There is potential for some fluid with elevated metals from the pyritic release to permeate shallow groundwater aquifers in losing stretches of the SFK watershed. If this were to occur, there is potential for some of this contaminated groundwater to flow into the UTC watershed. Inundation modeling does not model potential seepage of the pyritic tailings release into the shallow aquifer (Knight Piésold 2018p). Due to the strong dilution from surface water and the distance from the release site, however, it is likely that any metals entering groundwater would be diluted to below ADEC groundwater cleanup levels. Measurable impacts to groundwater quality in the UTC drainage basin are not likely from this scenario.

Noise

Noise could be generated from spill recovery operations, including increased vehicle and/or helicopter traffic, and use of heavy machinery and other cleanup equipment.

Air Quality

Tailings deposited on land that are able to dry out have the potential to become airborne fugitive dust. Considering the small volume of tailings deposition expected on land, and the wet climate, any fugitive dust produced would likely not have measurable impacts on air quality.

Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

The impact would be similar to the bulk tailings scenario above, causing a high likelihood of burial and/or erosion of mostly riparian and some adjacent upland vegetation along Tributary SFK 1.240 and the SFK, with additional risk of a metal-related toxic effect from the supernatant. The effects could extend downstream to the Nushagak Estuary.

Burial/erosion—The intensity of physical impacts to wetlands, vegetation, and any special aquatic sites are anticipated to be high intensity as 185 million ft^3 of water, slurry, and material are transported rapidly downstream. The effects would be highest closest to the release, and would diminish with distance downstream. Wetlands and any special aquatic sites present would be buried by a thin veneer of tailings. Vegetation would also be adversely affected by erosion of streambanks and floodplains. The magnitude of the impact would be high, regardless of the timing, because this type of spill would affect both dormant and actively growing vegetation through physical removal from erosion or burial.

The extent of the impacts would be limited to the area covered by the solid tailings particles, estimated to be a minimum of about 220 acres, mostly downstream of the confluence of Tributary SK 1.240 with the SFK (Knight Piésold 2018p).

Toxicity-related impacts—The spill would introduce elevated levels of metals from the supernatant that would temporarily exceed WQC. Some amount of these metals may be bioavailable. See Appendix K4.24, Fish Values, for additional discussion of metals toxicity. Pyritic tailings may also contain residues from reagents and residuals from the WTP, including selenium sulfide. The elevated levels would last for a few weeks while the flows are flushed downstream. Remaining contaminants would then be flushed downstream and released into Nushagak Bay, part of greater Bristol Bay, where they would become heavily diluted. Any changes to the pH, texture, or chemistry of the soil would likely not exceed soil quality criteria.

Assuming the spill response as described for the scenario, spilled tailings would be removed and the duration of initial impacts would be brief, potentially on the order of weeks to months. Mitigation would include the repair of erosion damage in the tributary and at the confluence (bank stabilization) if required. Depending on the severity of the erosion, it could require months to years to stabilize the altered banks, which would delay recovery of the riparian vegetation. For areas affected by burial, re-growth of vegetation may take a few growing seasons.

Terrestrial Wildlife

Impacts to terrestrial wildlife species would be similar to those stated above under the bulk tailings spill scenario, but the magnitude and extent would be greater. Impacts would be in the SFK, and the pyritic tailings pond failure would result in a large pulse of water and tailings downstream into the SFK, causing scouring of material in the SFK, flooding, and habitat loss and alteration (220 acres). This may cause wildlife (particularly small mammals and species that cannot easily avoid flood conditions) to get washed downstream, or be forced to seek higher ground during the initial pass of water. Based on data in Section 3.23, Wildlife Values, and ABR 2011a, the SFK, where the initial release would occur, does not support large numbers of medium to large terrestrial wildlife. There are a few scattered bear dens on slopes above the SFK, which would not be directly impacted. The area does not appear to concentrate moose or caribou, although the occasional brown bear has been detected in the area. Several beaver colonies are in the SFK, and may experience potential damage to their lodges and dams (including potential blow-out) as a result of a pulse of released water. Overall physical impacts to the vegetation and wildlife habitat are anticipated to be high intensity, as 185 million ft^3 of solid and fluid tailings and additional eroded streambed materials are transported rapidly downstream. Sourcing of vegetation, removal of soil, and deposition of sediment into new areas would alter the habitat in the area downstream of the spill.

In addition to vegetation and habitat impacts, fish in the SFK would be impacted. Fish in Tributary SK 1.240 may get flushed downstream, and smothered, crushed, or killed by the force of water and material flowing down the tributary. Some species may be able to seek refuge, but the impacts to salmon and resident fish would be high intensity. Depending on the timing of the pyritic tailings pond release, salmonid spawning habitat, close to 9 river miles downstream of the release location, may be impacted. The portion of the SFK immediately below the pyritic tailings dam is rearing habitat for salmon, but does not provide suitable spawning habitat for several miles. It is possible that large amounts of sediment may be washed far enough downstream to cause egg smothering at spawning locations, and potentially alter spawning substrates.

The released fluid would be elevated in metals and may cause acute toxicity to fish, especially young salmon that are rearing in the upper reaches of the SFK. A discussion of impacts from metals and the various confounding environmental variables to fish (prey for some terrestrial wildlife) is detailed below in the fish section (see Appendix K4.24, Fish Values, for additional discussion of metals toxicity).

Acute toxicity of salmonid species may result in wildlife exposure to fish that have been impacted by increased metals. The magnitude of impacts would be high, because wildlife habitat and salmon in the area would be altered. The duration of initial impacts would likely be short (up to several weeks), because the initial pass of fluids would displace some species, and impacts to salmon would last longer, until enough flushing reduces acute and chronic toxicity levels to permit salmon rearing again. It may take years for the 220 acres of wildlife habitat and salmonid spawning and rearing habitat to be restored. The extent of impacts would stretch from the pyritic TSF downstream in the SKF for many miles until salmon are no longer impacted.

Finally, residual amounts of chemical reagents and WTP residuals, including selenium sulfide, could be released into the environment with this scenario. The small amount of these toxins released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to wildlife from these toxins would be localized and of low magnitude.

Birds

Impacts would be similar to those detailed above for the NFK. The area south of the pyritic TSF adjacent to the SFK does not provide high-quality habitat for many waterbird species, and it does not appear to support large numbers of migrating or resident waterbirds (as detailed in Section 3.23, Wildlife Values and ABR 2011a). Depending on the time of year the spill occurs, if waterbird broods (such as harlequin ducks and mergansers) are present, they may be displaced or pushed downstream during the initial release of fluids. If the spill occurs during winter, impacts to birds would be low, because only resident species would be present. If the spill occurs between spring and fall, birds that forage along the water's edge or broods may be temporarily displaced during the initial pulse of water, and any ground nesters in the immediate vicinity may have nests covered by tailings or washed away. Up to 220 acres of habitat may be impacted.

If metals in the soil and water are not fully cleaned up, there is a potential for metals to accumulate in vegetation. Birds that feed on vegetation (and the surrounding sediment) with elevated metals may experience injury and mortality, depending on the metal loads in the vegetation. This is described in greater detail under "Untreated Contact Water Release," below. The full extent and duration of impacts would depend on cleanup and recovery efforts, but it may take several years for the vegetation and habitat to recover.

Impacts to avian prey (invertebrates, resident fish, and some salmonid life stages) would occur. Some prey would be washed downstream, while others may suffer mortality through smothering. Given the duration and spatial extent of predicted WQC exceedances, chronic aquatic exposures to cadmium, copper, lead, and zinc could have impacts on aquatic invertebrates and fish. Even at low concentrations, cadmium is toxic to aquatic organisms (Gough et al. 1979). Decreased abundance of invertebrates as a food source also could impact juvenile salmon and resident fish, in turn impacting a variety of avian species. It is expected that most invertebrate and fish communities would eventually come back to pre-spill conditions, but this may take several years, depending on the extent of habitat removal from the spill. Overall, impacts are anticipated to be of high magnitude to bird species in the immediate area, and the geographic extent would range from the pyritic tailings pond downstream in the SFK until salmon and avian prey are no longer impacted. This may extend down to the mouth of the Nushagak River, where TSS and metals (such as cadmium and molybdenum) would be elevated following the pyritic tailings release. Impacts to avian species at the mouth of the Nushagak River and estuary were detailed previously under the bulk tailings release scenario. The duration of impacts would last until avian prey return to pre-spill conditions, which may take several years. A more thorough discussion of impacts to fish is detailed below in the following section.

Finally, residual amounts of chemical reagents and WTP residuals, including selenium sulfide, could be released into the environment with this scenario. As detailed in the untreated contact water release scenario, elevated selenium has caused adult avian mortality, reproductive failure, embryonic mortality, and developmental abnormalities in several aquatic bird species (Martinez 1994) in lakes and other ponded waterbodies. Selenium is bioaccumulated in aquatic habitats, and selenium poisoning may persist for several generations and can be passed from parents to offspring through their eggs (Mann et al. 2011). However, the small amount of reagents and selenium sulfide released, coupled with the dilution that would occur in the downstream environment (due to flushing from rain and snow melt), would suggest that impacts to birds from these toxins would be localized and of low magnitude.

Fish

Tributary SFK 1.240—Increased TSS from the release of tailings solids would occur simultaneously with increased sediment loads due to erosion. The increased TSS due to the tailings solids would likely diminish within several weeks. Increased sediment loads due to erosion could continue to impact fisheries habitats and aquatic functions in this tributary for an indeterminate length of time, likely months to 2 years, depending on the effectiveness of stream restoration efforts. Potentially toxic effects of metals would be indistinguishable from the concurrent effects of elevated TSS.

South Fork Koktuli River—The pyritic tailings release would increase the flows above the MAD elevation in the South Fork of the Koktuli River. This reach of the Koktuli is characterized by low width-to-depth ratios with non-cohesive bank materials of silts and clays. The sudden release of water may cause localized bank erosion, which could result in chronic erosion until the banks stabilize. Any sediment from upstream erosion could have acute effects by smothering spawning habitat throughout this reach.

In the SFK River, the majority of salmon adults and spawners were observed in the lower reaches of the rivers (PLP 2011). This suggests the presence of higher-quality habitat, or simply adequate quantities of suitable habitat, readily available to accommodate the numbers of salmon entering the streams without the need to distribute further upstream. Low numbers of spawning coho salmon have been documented in the lower reaches of Tributary SFK 1.240 near the confluence with the SFK. Spawning has not been documented for any other salmon species.

Rearing sockeye salmon have been documented in the tributary of the drainage, although in lower densities (1 to 3 fish per 100 m^2) than in the mainstem SKF, indicating overall lower habitat quality or adequate quantity and quality habitat in other areas of the drainage. Rearing Chinook salmon have been documented in a sub-tributary, but in low numbers. Rearing has not been documented for any other salmon species.

The low-level use of habitat that would be impacted (based on densities of juvenile Chinook and coho salmon captured in these habitats), and the low numbers of coho spawning near the confluence of Tributary SFK 1.240 with the SFK, indicates that drainage-wide or generational impacts to populations of salmon from direct habitat losses associated with the scenario would not be expected.

During initial flooding, the concurrent effects of erosion, scour, and sedimentation would be indistinguishable from metal toxicity. As the water levels recede, potential for metals toxicity would be a concern. As described previously and shown on Figure 4.27-7, concentrations of several metals would exceed their WQC in the downstream areas, including cadmium, copper, lead, manganese, molybdenum, and zinc. The WQC for cadmium, copper, lead, and zinc are associated with the protection of aquatic life, whereas those for manganese and molybdenum are associated with drinking and irrigation water, respectively. Given the spatial extent and duration of predicted WQC exceedances, chronic aquatic exposures to cadmium, copper, lead, and zinc could have impacts on aquatic invertebrates and fish. Decreased abundance of invertebrates as a food source also could impact juvenile salmon and resident fish.

Cadmium is known to accumulate in the liver and kidneys of fish (EPA 2016b). Even at low concentrations, cadmium is toxic to aquatic organisms (Gough et al. 1979). Specifically, cadmium has been documented to cause lesions and necrosis in liver; cellular swelling and congestion of blood vessels; alter the metabolism of essential trace elements; altered blood count; disrupt the endocrine system (interfere with formation of steroids, eggs, and sperm); altered growth rate; and a variety of other toxic effects (Authman et al. 2015).

Copper is an essential micronutrient, but fish exposed to elevated concentrations of copper show alteration in their gills, such as an increased amount of mucus under the gill covers and between gill filaments (edema). Damaged gills result in decreased oxygen consumption (Authman et al. 2015). Low levels of copper/chronic effects can include reproductive effects such as blockage of spawning, reduced egg production in female fish, abnormalities in newly hatched fry, reduced survival of young, poor growth, and decreased immune response, among others (Authman et al. 2015). Impairment of olfaction, behavior, and other sensory responses in aquatic organisms exposed to copper has been observed, sometimes at very low concentrations. Such sub-lethal effects could affect fish life history traits including feeding, reproduction, avoidance of predators, and natal homing. Some water samples collected from streams proximal to the Pebble deposit contained naturally elevated concentrations of copper from local geologic deposits, sometimes exceeding the most stringent WQC (Section 3.18, Water and Sediment Quality).

Lead adversely affects invertebrate reproduction and can be taken up by algae, macrophytes, and benthic organisms (EPA 2016b). Lead is deposited in fish organs such as the liver, kidneys, spleen, digestive tract, and gills, which can lead to disorders in fish (Authman et al. 2015). Acute lead toxicity is characterized by damage to the gill cellular lining, which leads to suffocation. Chronic lead toxicity includes changes in blood parameters, damage to the nervous system, oxidative stress, and adverse effects on fish health and reproduction (Authman et al. 2015).

Zinc is an important element and micronutrient in living organisms; but at increased waterborne levels, may cause direct toxicity in fish. Zinc toxicity affects the gills of fish by disrupting uptake of calcium, which can lead to hypocalcemia and eventually death (Authman et al. 2015). High zinc concentrations/toxicity also leads to growth retardation; respiratory and cardiac changes; inhibition of spawning; gill, liver, kidney, skeletal muscle damage; and mortality (Authman et al. 2015).

Predicted exceedances imply the potential for toxic effects on sensitive aquatic organisms, including adverse effects on fish described in the above paragraphs. However, impacts on a wider range of species are uncertain for the three reasons discussed below.

First, as metals toxicity generally decreases with increasing hardness, hardness correction is applied to establish aquatic life criteria protective of sensitive aquatic organisms. However, the most stringent WQC representing aquatic life criteria for cadmium, copper, lead, and zinc assume a highly conservative hardness correction; the 25th percentile of the baseline hardness of the watershed streams are used to streamline the impact assessment (see Table K3.18-1). This assumed hardness may underestimate the hardness resulting from the spill. Therefore, realistic exceedances of WQC for these metals would be more limited (in extent and duration) than those predicted on Figure 4.27-7. The most stringent WQC for manganese and molybdenum are not associated with aquatic life, and their exceedances do not necessarily reflect the potential impacts to aquatic life.

Second, the predicted downstream concentrations resulting from the tailings fluid spill are assumed to be 100 percent bioavailable. Several factors are likely to limit metals bioavailability when they are released to surface water, including binding by natural ligands (such as dissolved organic matter) and binding phases on particulates. EPA's recommended aquatic life WQC for copper is based on the Biotic Ligand Model to account for various factors that modify its aquatic toxicity (EPA 2007b). Recently, Meyer and DeForest (2018) showed that hardness-based WQC were reasonably protective of the adverse effects of copper on behavior- and chemo/mechanosensory-responses in aquatic organisms, including invertebrates and fish; Biotic Ligand Model-based WQC were more protective. Based on uncertainties regarding metals bioavailability in the current evaluations, the impacts of the predicted exceedances of metals WQC on fish and invertebrates is not known. However, site-specific toxicity tests are indicative of limited impacts on fish species, as described below.

Third, simply comparing predicted metals concentrations to the most stringent WQC misrepresents the potential impacts to a range of aquatic species, including fish. Toxicity tests using undiluted aqueous samples representing the tailings fluid from the mine site did not demonstrate acute and chronic toxicity to fish species, including rainbow trout and fathead minnow. Aquatic toxicity testing was conducted on samples of process water generated during plant water testing by Nautilus Environmental (2012). In this study, test organisms, including juvenile rainbow trout, fathead minnow neonates, and water flea neonates, were exposed to two aqueous samples: "Gold Plant Process Water" and "Non-Gold Plant Process Water." At the laboratory, the test samples were prepared by serial dilution of these aqueous samples using laboratory dilution water. The specifics of how the aqueous samples were generated and their geochemical characterization is not available, so there is some uncertainty about how well the samples represent mine site fluids. It is understood that the "Non-Gold Process Water" sample is representative of contact water in the main WMP and the undiluted (via precipitation) supernatant in the TSFs. Hence, the discussion of the results here is limited to that of the "Non-Gold Plant Process Water" dilution series. Rainbow trout and fathead minnow juveniles were exposed to the test samples for 96 hours to assess acute toxicity (survival) and fathead minnow neonates were exposed for 7 days to assess sub-chronic toxicity (survival and growth). In the acute tests, the "Non-Gold Plant Process Water" did not adversely affect the survival of the juvenile fish, both rainbow trout and fathead minnow in all dilution series, including in 100 percent or undiluted aqueous samples. Similarly, in the sub-chronic test, the "Non-Gold Plant Process Water" did not adversely affect the survival and growth of the fathead minnow neonates (Nautilus Environmental 2012). The study also exposed water flea neonates to the "Non-Gold Plant Process Water" dilution series for 48 hours to assess acute toxicity (survival) and for 7 days separately to assess chronic toxicity (survival and growth). Adverse effects were observed on survival in the acute test and reproduction in the chronic test at 25 percent (by volume) and 12 percent (by volume) of the "Non-Gold Plant Process Water," respectively. These results indicate that adverse effects are not expected at dilutions greater than eight times during tailings release. Unlike the WQCs, which are based on toxicity of individual metals, the results of these toxicity tests represent exposure of the test organisms to a combination of metals in the sample. Therefore, results reflect a combined effect of the mixture of metals and other constituents in the tailings fluid, whether individual metals in a mixture act additively, synergistically, or antagonistically. These results indicate chronic exposures for 7 days or more to tailings fluid at lower dilutions in the streams could have sub-lethal effects on sensitive aquatic species, on which the fish may feed, but direct toxicity is less likely on fish species. See Appendix K4.24, Fish Values, for additional discussion of metals toxicity.

In conclusion, the results of the aquatic toxicity tests on water flea, fathead minnow, and rainbow trout using aqueous samples representative of contact water in the main WMP and undiluted supernatant in the TSFs indicate that acute impacts (lethality) on fish due to metals toxicity would not occur within the predicted time frame and extent of WQC exceedances. Sub-lethal impacts could occur to sensitive aquatic invertebrates in the upstream areas beyond approximately two weeks, where lower dilution to metals concentrations would occur. Sub-lethal impacts on fish are unknown, especially because these sub-lethal impacts, if any, would occur at the longer time frame beyond a week after the initial physical impacts subside. However, chronic exposures to elevated metals above baseline are not predicted beyond several weeks.

Although predicted mercury concentrations in the tailings are low, even very low amounts of total mercury that may incorporate into anoxic sediments, such as those occurring in wetlands in the project area, could result in methylation to form MeHg, the toxic and bioavailable form of mercury. MeHg is toxic, bioaccumulates, and biomagnifies in fish (see Appendix K4.24, Fish Values, for expanded discussion of potential impacts from MeHg in fish).

Small amounts of metals-rich tailings may be entrained in streambed sediment, and may leach metals slowly over years to decades. This could cause low-magnitude, localized impacts to benthic organisms that are preyed on by fish.

Finally, residual amounts of chemical reagents and WTP residuals, including selenium sulfide, could be released into the environment with this scenario. The small volume of reagents and selenium sulfide released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to fish from these toxins would be localized and of low magnitude.

Threatened and Endangered Species

There would be no physical impacts to federally listed TES, because none occur in areas where a tailings release is projected to reach. According to Brna and Verbrugge (2013), based on a preliminary assessment, no breeding or otherwise large occurrences of TES are known to occur in the Nushagak watershed. There are several TES that occur in Bristol Bay (Limpinsel 2013), but physical impacts (and those related to WQC exceedances) are not anticipated to extend that far downstream out into Bristol Bay where they occur. However, any reduction in salmon and other fish populations from the pyritic tailings release scenario could indirectly impact TES. This is expected to be relatively minor because TES feed across a broad range of areas.

Marine Mammals

Impacts would be similar to the bulk tailings scenario but would occur in the SFK and extend further downstream. Elevated TSS and metals (cadmium and molybdenum) would extend to the mouth of the Nushagak River. A tailings release may potentially alter the habitat and occurrence of marine mammal prey species that inhabit the Nushagak River watershed. A potential reduction in salmon due to reduced spawning habitat and toxicity from the pyritic tailings failure would reduce the prey base for several marine mammals. The duration would last until affected spawning and rearing habitat is restored and salmon are no longer impacted; the geographic extent of impacts would extend from the spill location in the SFK downstream until metals are diluted to within WQC. Because TSS and some metals would be elevated all the way to the mouth of the Nushagak River, both the non-federally listed Bristol Bay stock of beluga whales and harbor seals may be impacted. As detailed previously under the bulk tailings release scenario, beluga whales range several miles upstream in the Nushagak River, feeding on a variety of fish at different life stages. Therefore, in terms of salmon prey, a pyritic tailings release that results in smothered eggs or alevin and reduced spawning habitat quality or quantity could result in a reduction in the SFK spawning biomass that alters the number of returning adult salmon.

One of the metals that would exceed WQC all the way to the mouth of the Nushagak River is cadmium; which even at low concentrations, is toxic to aquatic organisms (Gough et al. 1979). Although dilution through flushing would reduce some impacts from elevated levels of cadmium in the Nushagak River, the impacts on salmon that are present in the river during the spill event are difficult to predict. Any impacts to salmon could reduce the overall prey abundance for beluga whales and harbor seals. Although a small reduction in spawning adults in the SFK is unlikely to impact the overall number of salmon available for beluga whales and harbor seals, the impacts of increased cadmium (and other metals) levels in the Nushagak River would be harder to predict (given the metals discussion under the fish section detailed previously). The duration of impacts to marine mammals would extend until impacts to their prey are no longer noticeable.

Finally, residual amounts of chemical reagents and WTP residuals, including selenium sulfide, could be released into the environment with this scenario. The small volume of reagents and selenium sulfide released, coupled with the dilution that would occur in the downstream environment, would suggest that impacts to marine mammals from these toxins would be localized and of low magnitude.

Needs and Welfare of the People—Socioeconomics

The cleanup and remediation activities following a bulk tailings delivery pipeline rupture in which a large volume of slurry is released into the environment could briefly increase employment opportunities and expenditures in the Iliamna Lake area, and potentially in the Bristol Bay region. Labor force requirements would be especially high if labor-intensive response efforts such as mechanical recovery and physical removal were used. Employment increases for cleanup activities would be brief (less than 1 year).

Over the longer term, the impacts on employment, income, and sales would be negative if commercial and recreational fishing and/or tourism were to suffer due to the real or perceived impacts of the spill. Real or perceived water contamination could also negatively impact local business and consumers.

Environmental Justice

A tailings release could impact the socioeconomics, subsistence, and health and safety of those in the region. There could be increased employment for a brief time for cleanup and remediation; however, there could be declines in employment, income, and sales from commercial and recreational fishing and/or tourism if impacted by real or perceived impacts of the spill. A release could impact subsistence harvest quantities and harvest patterns, and there could be impacts to health and safety. Taken as a whole, potential adverse impacts from the spill event would disproportionately impact minority and low-income communities. There would be interrelated subsistence, health, and socioeconomic impacts to the minority and low-income communities in the area.

Recreation

Impacts to the recreation setting from this tailings release scenario would be acute or obvious for at least several weeks. The levels of recreational activities downstream from the mine site are higher than at the mine site itself, but are still estimated to be low. The recreational activities that may be affected could include sport fishing, recreational snowmachining, and sport hunting. A release may cause probable loss or damage to anadromous fisheries, which could impact sport anglers. There would be impacts to recreational sightseeing, because visual resources would be impacted (i.e. increased downstream turbidity). Sightseeing and flightseeing are typically secondary recreational activities done in conjunction with travel for sport fishing and sport hunting, and would also be impacted from visual impacts.

Commercial and Recreational Fishing

The sudden release of supernatant water into Tributary SFK 1.240 could impact the ex-vessel and first wholesale value of the Bristol Bay commercial fishery. First, the long-term contribution of Tributary SFK 1.240 and the SFK downstream of SFK 1.240 could be affected for some time, depending on the efficacy of stream rehabilitation efforts. As noted above and in Section 3.6, Commercial and Recreational Fisheries, and over the last 20 years, the 10-year average ex-vessel value per harvested sockeye has ranged from $4.75 to $7.62 in 2019 US dollars. Over the last 20 years the Nushagak District, which includes the Nushagak, Mulchatna, Wood, Igushik, Snake, and Nuyakuk rivers, has averaged a total inshore sockeye run of 8.5 million fish, with spawning escapement of 2.6 million fish. In addition, the Chinook salmon run in the district averages 180,000 fish per year. Under this scenario, the productivity of the Nushagak, Wood, Snake, and Nuyakuk rivers are not likely to be affected. The productivity of the Mulchatna drainage outside the SFK is also unlikely to be affected, but greater uncertainty exists about the magnitude and duration of these effects. Overall effects on ex-vessel and first wholesale values and concurrent economic activity would be on a scale relative to fish impacts in the SFK and the Koktuli rivers.

The commercial fishery has expressed concern that a large-scale spill event would affect the value of the fishery by changing the value of harvested salmon in the open market. Historical experience shows the extent to which large-scale spills tend to affect the value of seafood products. After the *Exxon Valdez* oil spill, the Eshamy District of the Prince William Sound Management Area was closed for the duration of the 1989 season, while PWS Management Area districts experienced at least some fishing. History shows that that event resulted in direct financial losses associated with lost harvest opportunities. However, post-event statistical analyses found no effect on salmon prices in 1989, 1990, or 1991. An Alaska jury also found no decline in salmon prices for 1990 and 1991, but did make an award for an effect on prices in 1989 (Owen 1995). In 2015, Japanese researchers found statistically significant, but “negligible” effects on seafood prices in the wake of the Fukushima nuclear disaster (Wakamatsu and Miyata 2015). These studies indicate that seafood price effects associated with industrial accidents tend to be very small or undetectable, and of limited duration. At the same time, in the wake of such disasters, a specific name can be associated with lower consumer desirability if the name is firmly connected with the disaster itself. For example, consumer choice research conducted after the Fukushima nuclear disaster found that labeling seafood as being from Fukushima Prefecture resulted in lower willingness-to-pay, compared to unlabeled seafood or labels from other prefectures (Wakamatsu and Miyata 2017). The study notes that preference research associated with an oceanside nuclear disaster where radioactivity entered the food chain may not be applicable to a hypothetical mine disaster, where pollutants would be less likely to accumulate in seafood.

Directed recreational fishing on the SFK itself is limited. Over the last 20 years, an average of 3.6 anglers per year returned Statewide Harvest Surveys to ADF&G recording activity on the Koktuli (including the NFK), with point estimates of effort ranging from approximately 50 to 850 recreational days per year (median estimate 352 angler days). Far more days are spent angling on the Mulchatna River, which has a 10-year estimated effort of 1,700 angler days per year, including roughly 340 guided angler days, and the Nushagak River. SWHS data indicate that between 2004 and 2016, the Nushagak River averaged just over 12,000 angler days between the Mulchatna confluence and Black Point. In a pyritic tailings spill, the released tailings would pass through the Mulchatna River into the Nushagak River. The increased TSS and turbidity associated with the spill would affect anglers' success rates, because salmonid species feed partially by sight. The impact on the recreational fishery would be limited in the Nushagak River by the duration of increased turbidity or TSS affecting the ability of target species to see or smell prey. The TSS and turbidity could be elevated for weeks to months to years, depending on the success of stream restoration and the resultant decrease in ongoing erosion. Fishing packages in the region cost between $600 and $1,000 per night. A spill before or during the peak summer months could result in trip cancellations and associated economic impacts for guide companies, and the business and communities that support them.

Cultural Resources

A release of pyritic tailings would be similar to the bulk tailings release. Impacts would occur to cultural resources along the shore of the SFK if tailings were carried to a known or potential historic property site, or response efforts with ground-disturbing activities occurred near cultural resources. Resources may not be anticipated to return to previous levels, even after actions that caused the impacts cease. The probability of ground-disturbing cleanup activities occurring at historic property sites is low due to the dispersed geographical distribution of sites downstream of the mine site. Impacts would occur in a discrete geographic area, but could affect rare cultural resources in the region. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Clean-up activities would likely require a mitigation plan to limit impacts to known or potential historic properties, and would occur in accordance with the Programmatic Agreement. It is not possible to identify specific cultural resources that could be affected. Indirect impacts could occur to the setting (visual and noise impacts) of cultural resources if the spill were to occur in the vicinity. Those impacts would be temporary, and would cease when response efforts are complete.

Subsistence

Impacts to subsistence resources would be similar to the bulk tailings release, although the magnitude and geographic extent would be larger. The impacts to subsistence resources, particularly fish, could persist well beyond cleanup efforts due to chronic erosion and increased sediment loads caused by the initial flooding. The most persistent and widespread impact of a tailings spill would likely be concern among subsistence users about contamination of subsistence fish resources in the greater watershed. Subsistence users would likely avoid fishing and some other subsistence activities for a great distance downstream from the release, affecting harvest patterns, as well as harvested quantities of highly valued resources. Contamination concerns resulting from the release may last for several years. Quick response and cleanup of tailings, and a robust system of testing wild foods and communicating the results to local people in a timely manner, could help mitigate contamination concerns.

Health and Safety

The release flood would flow at a maximum of 1,000 cfs initially, which could create a safety hazard if mine personnel were present in the immediate vicinity downstream of the pyritic TSF. However, mine workers would not normally be present in this area.

There are no nearby downstream human habitations. The closest village downstream is New Stuyahok—113 miles downstream by way of the SFK. Modeling suggests that at that distance from the potential release, there would be no observable rise in water level. River water at the village site would be elevated in several metals above applicable WQC for several weeks. Residents of the village would likely see an increase in TSS and turbidity in the river for several weeks after the release.

Downstream communities rely on groundwater wells for drinking water. No measurable impacts to groundwater would be expected from this scenario, although groundwater contamination could be perceived. Perceived contamination of the environment and subsistence foods (e.g., salmon) may affect community concerns about access to, and quantity and quality of subsistence foods, which can affect the socio-economic status, emotional well-being, food security, and dietary patterns of local communities; this concern may extend throughout the extended spills analysis area. Restricted access to the environment (e.g., due to real or perceived contamination) may result in decreased mental health and increased psychosocial and family stress, substance use, suicidal tendencies, and cardiovascular disease (Dillard et al. 2012; Gibson and Klinck 2005).

There are potential adverse impacts to social determinants of health (HEC 1), with psychosocial stress resulting from community anxiety over a tailings release, particularly in areas of valued subsistence and fishing activities. There could be exposures to potentially hazardous materials, including metals (HEC 3). Subsistence and food security may be impacted, with potential perceptions of subsistence food contamination that could extend throughout the area (HEC 4). Reliable and prompt communications about environmental and subsistence food impacts and precautions about both acute and chronic exposures could alleviate psychosocial stress; reduce impacts to subsistence and food security; and allay public health concerns. Establishment of a grievance process and compensation fund for affected individuals and communities could also help reduce potential impacts to socioeconomic and food security concerns. Impacts would vary in duration and be limited to the area of the spill.

4.27.8.10 Release from North Embankment of Pyritic TSF/Flow into Main WMP

A release from pyritic TSF north embankment would likely flow into the main WMP, and be contained in the freeboard. A very high-volume rapid release could potentially spill into the main WMP, and cause a cascading effect, and a flood of combined pyritic tailings plus contact water. This type of release would be dominated by contact water, with very diluted pyritic slurry. Such a scenario is very unlikely (AECOM 2018k).

4.27.9 Untreated Contact Water Release

Contact water is defined as surface water or groundwater that has contacted mining infrastructure. This includes “mine drainage” defined in 40 CFR Part 440.132(h) as any water drained, pumped, or siphoned from a mine, as well as stormwater runoff and seepage from mining infrastructure. Examples of contact water include seepage from waste rock piles, seepage from stockpiles (except ore), and water from horizontal drains that accumulates in the pit. Contact water would also be used and recycled for various mine activities, including the milling process, concentrate production, and mixing of tailings slurries.

The chemistry of contact water would vary, depending on what the water was used for and where it was stored. Contact water in general would have elevated concentrations of metals and other constituents, such as TDS and hardness (as $CaCO_3$). Contact water would therefore not meet discharge water quality standards, and would require treatment to meet applicable WQC prior to release to the environment. At the mine site, contact water would be treated in one of two water treatment plants by various methods (see Section 4.18 and Appendix K4.18, Water and Sediment Quality).

Contact water would be stored in several facilities, including the main WMP, the open pit WMP, and six seepage collection ponds adjacent to (downstream of) the TSFs. Supernatant ponds in the TSFs and fluid in the open pit are also considered contact water, and would be pumped out of those facilities as needed, to be recycled and/or treated and released. The lowest-quality contact water is expected to be in the bulk TSF main seepage collection pond (Appendix K4.18.3,

Table K4.18-3). This facility would remain in post-closure indefinitely, or until no longer required for water management and treatment.

A “failure” of a contact water storage facility refers to the unintended release of contact water. Such a release could occur as a result of overfilling of storage facilities, a failure in the embankments or liners, or an emergency release.

In the event of an unplanned release, untreated contact water with elevated constituent concentrations would be introduced to the environment. Depending on the release volume, the rate of release, the source of contact water, etc., downstream water could cause adverse effects on aquatic organisms in the receiving waters.

4.27.9.1 Main Water Management Pond

The main WMP is the largest contact water storage facility, and the subject of the scenario analyzed below. The main WMP would be in the NFK watershed, and would be a fully lined facility that would supply water for the milling process and storage of surplus water for the mine site. The main WMP would include a 750- to 825-acre reservoir contained by an embankment with a maximum height of 190 feet. It would be among the largest lined water storage reservoirs in the world. It has been designed as a very high-capacity water storage facility to store excess water pumped from the bulk TSF. This is a key part of the mine site layout designed to reduce water storage in the bulk TSF to promote unsaturated conditions in the tailings, and maintain a minimal supernatant pond (see Appendix K4.27, Spill Risk, for further discussion of the Applicant’s proposed mine site layout.)

The main WMP is designed to safely manage surplus contact water from the mine site under the full range of climate conditions, including prolonged wet and dry periods. The average volume of anticipated contact water stored in the main WMP would be approximately 1,470 million ft^3, with *maximum* storage of approximately 2,440 million ft^3. Storage capacity would also include storage of the required IDF (equal to the probable maximum flood) and additional freeboard (Knight Piésold 2018q).

The embankment would be a zoned rockfill and earthfill dam with a maximum height of 190 feet and geomembrane liner over the entire upstream slope. Overburden material under the embankment would be excavated, and the embankment would be constructed on bedrock (per design changes made during the 2018 FMEA workshop; AECOM 2018k; AECOM 2018l). The facility would cover a total of 955 acres, with a maximum crest length of approximately 2.8 miles, and a maximum dam height of 190 feet (Table K4.15-1). See Chapter 2, Alternatives, for details on the main WMP facility; see Section 4.15, Geohazards and Seismic Conditions, for details on the seismic stability and other geotechnical features of the embankments.

Development of the main WMP would be a major undertaking in line with the largest geomembrane-lined water storage reservoirs in the world. The technology for designing, constructing, and operating such lined facilities is well developed (Scuero et al. 2017a, b, c; Vaschetti 2019; Carpi 2020). Comparable examples of large geomembrane-lined basins are the Columbus Upground Reservoir (CUGR) in Ohio (EPI 2020), which is an 843-acre pump-storage water reservoir; the Panama Canal Expansion Water Savings Basin of 147 acres, and Tampa Bay Reservoir of 97 acres. Comparable geomembrane-lined embankment examples are the water retention and tailings storage facility at Las Bambas Mine in Peru that is now 443 feet high, and is planned to be 754 feet high; the 298-foot-high rockfill Runcu Dam in Romania; and the 182-foot-high concrete-type Filitranos Dam in Greece.

4.27.9.2 Fate and Behavior of Released Untreated Contact Water

This section describes the general fate and behavior of released untreated contact water across a wide range of potential accidental releases. Specific impacts from the analyzed release scenario are presented below.

In the event of an unintended release of untreated contact water, impacts could range from temporary, local water quality impacts to a large flood and extensive contamination that could threaten downstream environments.

The fate and behavior of released contact water would depend on several factors, as described above for tailings releases, including location of release, chemistry of contact water, volume of release, speed/duration of release, downstream topography, summer versus winter, and mode of failure.

Flooding

A large-volume release from a contact water storage facility could lead to a large downstream flood. Flooding could lead to safety concerns for mine site personnel, and potentially for downstream residents and/or recreational land users. Flooding could also cause erosion, sedimentation, increased TSS, and damage to downstream habitat.

Contamination from Metals and Other Constituents

Contact water would have elevated concentrations of metals and other constituents that could impact downstream water quality. Aqueous chemistry of contact water across the mine site would vary by storage facility. Modeling predicts that contact water in the main WMP would have concentrations of the following metals at levels exceeding the most stringent WQC: aluminum, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, nickel, selenium (a metalloid), silver, and zinc (Knight Piésold 2018a; Table K4.18-3). In addition, levels of TDS, alkalinity, hardness, and sulfate would also fail to meet applicable WQC.

The magnitude of the impact of an untreated contact water release would depend on many factors, as described above. For small releases, downstream dilution would minimize potential impacts due to constituent contamination. In the event of a large volume or a persistent ongoing release, however, the elevated metals could cause a more intense impact.

The predicted pH of contact water would vary from 7 to 8; therefore, acidification of downstream water would not be an anticipated impact of a release.

4.27.9.3 Historical Examples of Contact Water Releases

Historical contact water releases have caused damage, including human casualties, destruction of homes and property, economic loss, and environmental impacts, especially impairment of aquatic habitat in downstream drainages. Examples of some historic failures (from WISE 2018) include:

- In June of 2017, 100,000 cubic meters of acidic wastewater was accidentally discharged from a phosphate mine in Mishor Rotem, Israel. The toxic wastewater surged through the dry Ashalim riverbed and damaged habitat for more than 20 kilometers downstream.
- In November of 2012, in Sotkamo, Kainuu province, Finland, hundreds of thousands of cubic meters of contaminated wastewater leaked from a pond, resulting in nickel, zinc, and uranium concentrations in nearby Snow River that exceeded water quality criteria.

- In December of 1998, 50,000 cubic meters of acidic and toxic water were released from a phosphate mine in Huelva, Spain, from a dam failure during a storm.

4.27.9.4 Probability of Release/Spill Frequency and Volume

Water reservoir dams (often constructed of concrete) are generally built to last for decades to centuries. Water management ponds and other water storage facilities at mine sites (usually constructed of earthen materials) are generally not built to last beyond the operational life of a mine.

Most mine water management ponds are generally much smaller than the main WMP. As noted in the "Main Water Management Pond" subsection, there are few precedents for such a large lined WMP, and therefore, there are limited statistics on their failure rates. This introduces uncertainty to the performance of the proposed main WMP. Large earthen water reservoirs that are in use around the world could be considered as an analogue. Their failure rates fall within the range of failure rates for many types of dams, on the order of 1×10^{-4} to $1 \text{ X } 10^{-5}$ annual probability of failure, or a 0.01 to 0.001 percent chance of failure in any given year (Stanford 2020; NID 2020).

4.27.9.5 Risk Assessment for the Proposed Embankment

In October of 2018, AECOM hosted an EIS-FMEA workshop in Anchorage, Alaska. The objective of the workshop was to develop reasonable failure scenarios for the bulk TSF, the pyritic TSF, and the main WMP to be analyzed as part of the EIS. It is recognized that this EIS-Phase FMEA was not intended to be a complete risk analysis, but rather one risk assessment tool used for EIS purposes.

To be in accordance with the NEPA guidelines, the failure scenarios selected for analysis in the EIS need to have a reasonable level of probability and a comparatively high level of consequence (AECOM 2018k).

At the time of the workshop, the design for the main WMP involved construction of the embankments on overburden materials. The expert panel addressed potential problems with the stability of such embankments constructed on overburden, rather than on bedrock. The initial risk rating of some failure modes was rated as a "low" probability. PLP proposed a design change in which the overburden materials would be excavated and removed, and the embankment would be constructed directly on bedrock. This reduced the risk rating for the relevant failure modes down to a "very low" probability. (Note that due to the unique design and construction of individual embankments, probabilities of failure of the proposed embankments were determined by the FMEA process, not by statistical analysis of historical spills, as was completed for trucking accidents, etc.)

Due to the early-phase conceptual design and recent modification to the conceptual design, limited data are available on the quality of the underlying bedrock.

4.27.9.6 Existing Response Capacity

There is no existing response capacity for a spill of untreated contact water in the mine area. The Applicant would have a spill response plan in place by the onset of the construction phase. An EAP is required by the State of Alaska Dam Safety Program, as described above for the tailings sections. Recovery of spilled contact water once it enters the NFK would not be possible. The general spill response protocol is provided under the "Spill Response" subsection.

4.27.9.7 Mitigation

- Dam/embankment safety is regulated by the ADNR Dam Safety Program under AS 46.17, Supervision of Safety of Dams and Reservoirs; and Title 11, Chapter 93, Article 3 (11 AAC 93), Dam Safety. Note that ADSP has provided updated draft guidelines (ADNR 2017a) referred to throughout the EIS. These draft guidelines have not yet been adopted under Alaska Statutes.
- ADNR approval is required to "construct, enlarge, repair, alter, remove, maintain, operate or abandon" a dam.
- The embankment would be constructed to the Class I hazard classification (highest potential hazard), requiring that PLP and their engineering consultants provide a high level of technical risk assessment prior to request for and issuance of Certificates of Approval to Construct a Dam.
- Available storage capacity (freeboard) would always be maintained in the TSFs to account for the IDF (PLP 2018d).
- The embankment would be constructed on bedrock, which is considered to increase its stability. All surficial soils and other unconsolidated materials would be removed beneath the embankment areas prior to construction. (The facility reservoir would rest on overburden.)
- Per ADSP draft guidelines (ADNR 2017a), two levels of design earthquake must be established for Class I dams: an OBE that has a reasonable probability of occurring during the project life (return period of 150 to more than 250 years); and an MDE that represents the most severe ground shaking expected at the site (return period from 2,500 years up to that of the MCE). These design earthquakes cannot be represented by a single magnitude value. Rather, impacts would vary with not only magnitude, but also with the type of earthquake, epicenter location, depth, duration of shaking, etc. A range of earthquake magnitudes and characteristics is used to represent each level of design earthquake (Section 3.15 and Section 4.15, Geohazards and Seismic Conditions).
- The main WMP would be constructed with an FoS of 1.9 to 2.0. See Section 4.15, Geohazards and Seismic Conditions, for more details on FoS.

See Section 4.15 and Appendix K4.15, Geohazards and Seismic Conditions, for further discussion of seismic stability design for the main WMP.

4.27.9.8 Untreated Contact Water Release Scenario

Modeling the Scenario

Information on the selected scenario from the FMEA was then used as input for modeling the release scenario described below to analyze potential impacts on physical, biological, and social resources. Because the flow rate of the release scenario is so low (2 cfs), there would be no potential for flooding; therefore, inundation modeling (as described for the tailings releases) was not required to model the contact water release.

Modeling of the contact water release scenario focused on estimating water quality in the receiving waterbodies. A mass balance analytical approach was used to determine mixing rates and dilution factors to model downstream water quality. Dilution ratios were calculated along the NFK, Koktuli River, Mulchatna River, and Nushagak River to estimate the amount of dilution that would be provided by natural flows. This allowed for calculation of the downstream distance required to dilute contaminated water to below water quality exceedance.

USGS and PLP streamflow-gaging stations in the Koktuli and Nushagak river drainage basins were used to characterize hydrological conditions, and provide MAD and natural 2-year flood levels. See Knight Piésold 2018q for full details on the modeling methodology, inputs, and assumptions used for the analysis.

Scenario: Failure of the Main WMP

The contact water release scenario presented here is a slow release failure of the main WMP, in which 2 cfs of untreated contact water leaks from the facility over a period of 1 month, for a total release of 5.3 million ft^3 (120 acre-feet) into the NFK (Figure 4.27-8). This volume represents only 0.4 percent of the average contact water stored in this facility.

This hypothetical failure is due to liner damage from ice hitting the geomembrane liner during spring break-up. The resulting seepage through the liner is powerful enough to begin internally eroding the embankment. Intervention is successful at preventing a full breach of the dam, but seepage overwhelms the seepage collection system, resulting in downstream discharge (AECOM 2018l). This failure scenario was selected by the FMEA workshop as the most reasonable probability of occurrence of the failure modes evaluated that would have relatively high consequences.

Released contact water would flow into Tributary NFK 1.120, which feeds into the NFK. The NFK joins with the SFK to form the Koktuli River, which is a tributary of the Mulchatna River; which in turn is a tributary of the Nushagak River that flows into Nushagak Bay, part of the greater Bristol Bay, about 230 miles downstream of the mine site.

The constant outflow of 2 cfs in this scenario is relatively small compared to the natural flows in the NFK and other downstream drainages. This scenario would not increase the discharge into downstream drainages above the natural 2-year flood level during average stream levels, and no downstream overbank flooding would occur. There would be no flood wave and no downstream flooding safety concerns in this scenario.

Released contact water would immediately begin to mix with natural stream water. Modeling results show that full mixing would occur within no more than 3.6 miles downstream (Knight Piésold 2018q).

Untreated contact water released into the downstream drainages would contain elevated levels of aluminum, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, nickel, selenium (a metalloid), silver, and zinc in exceedance of the most stringent WQC (Knight Piésold 2018a; Table K4.18-3). The metals that would be at the highest concentrations, and therefore require the most dilution to meet water quality standards, would be molybdenum, cadmium, lead, zinc, and manganese. Molybdenum would require the most dilution, at a ratio of 213 parts natural stream water to 1-part untreated contact water. Depending on flow conditions, the required stream distance to dilute molybdenum to within applicable WQC would be approximately 15 to 45 miles downstream of the mine site (estimated from Figure 5.2 in Knight Piésold 2018q). Most other metals would be diluted to within WQC farther upstream. Copper would require a dilution ratio of 19 parts stream water to 1 part untreated contact water, so that it would be diluted to within WQC by about 10 miles downstream of the mine site (values estimated from Knight Piésold 2018q).

Depending on the flow conditions at the time of the unintended release, water quality would fail to meet applicable WQC for up to 45 miles downstream. This would continue for the entire month of the release.

Spill Response

See the “Spill Preparedness, Prevention, and Response Measures” subsection for the actions that the Applicant has committed to. Any soils impacted by the elevated metals from the contact water could be removed, and the impacted habitats could be restored.

The Applicant has committed to taking the following remedial actions under this failure scenario:

- Investigating the increased flows in the downstream monitoring/collection system to identify the general area of the embankment where the increased seepage is occurring
- Lowering the water level in the Main WMP
- Inspecting the liner and repairing any liner damage, as necessary
- Repairing the Main WMP embankment/seepage collection system, if required
- Monitoring downstream water for water quality

Alternatives Analysis

The potential for a release of contact water as described in the scenario would be the same across all alternatives.

4.27.9.9 Potential Impacts of Untreated Contact Water Release from the Main WMP

Soils

Metals Contamination

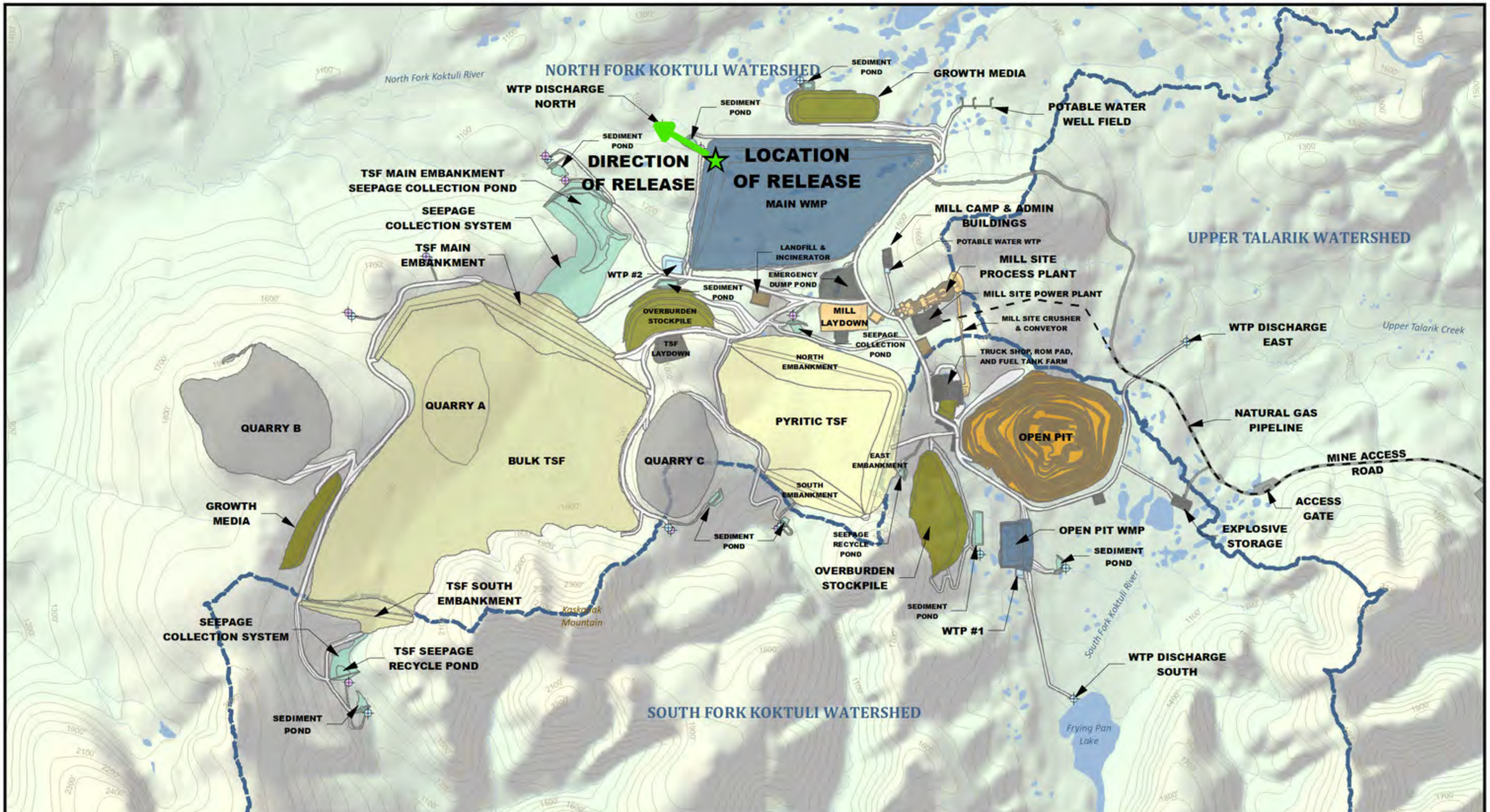
Soil could become contaminated with elevated levels of metals from the release of untreated contact water. Where contact water spills onto soils beneath the point of release at the main WMP for 1 month, some of the fluid would likely percolate into the soil column, and metals present in the contact water would adsorb onto surficial soil. Where metals in soils exceed ADEC soil cleanup level guidelines, soils could be excavated to the extent practicable and the impacted habitats could be restored. If contaminated soil is not fully recovered, some contaminated soil would remain at the site of the release. Ongoing monitoring could detect remaining elevated levels of metals, and additional excavation could be carried out as needed.

Erosion

Some temporary, low-intensity soil erosion could occur at the point of release beneath the failed embankment. No significant soil erosion would occur downstream due to the very low volume and slow release of the contact water. Soil erosion damage beneath the embankment could be stabilized following the release.

Surface Water Hydrology

There would be no measurable impact to surface water hydrology due to the low volume of the release. The released flow would be well within the range of the natural 2-year flood.



Sources: KP 2018q; PLP 2019-RFI153

US Army Corps of Engineers

0.5 0 0.5 1
Miles

Location of Release
Direction of Release

Alternative 1a

GW Quality Monitoring and Pump Back
Water Quality Monitoring Point

Natural Gas Pipeline
Bulk Tailing Storage Facility
Mine Site Infrastructure
Mineral Processing Facilities
Onsite Access Roads
Open Pit
Pyritic Tailings Storage Facility

Quarries
Sediment/Seepage Collection Systems
Stockpiles
Waste Management Facilities
Water Management Ponds
Water Treatment Plants

Other Features

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

UNTREATED CONTACT WATER RELEASE LOCATION

PEBBLE PROJECT EIS

FIGURE 4.27-8

Water and Sediment Quality

Surface Water Quality

Metals—Under this scenario, untreated contact water with elevated metals concentration would be released to Tributary NFK 1.120 and transported downstream (Knight Piésold 2018q). Metals that would be present at levels above WQC in the untreated contact water include aluminum, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, nickel, selenium (a metalloid), silver, and zinc (Knight Piésold 2018q) (see Table K3.18-1 and Table K4.18-3).

Released contact water would be rapidly diluted by stream water. The amount of dilution is dependent on the level of streamflow in the drainage at the time. The scenario would occur during spring break-up, so downstream modeling of metals concentrations was completed for streamflows during the months of April, May, and June.

As summarized below and in Figure 4.27-9, modeling results indicate that concentrations of several metals would exceed applicable WQC in the downstream drainages following the spill. In Figure 4.27-9, the points along the drainages labeled "Dilution Ratio Achieved" indicate the point at which metals would be diluted to within WQC for the particular mean monthly streamflow. The metals that would be present in the highest concentration would be cadmium, lead, manganese, molybdenum, and zinc. Copper levels in the released fluid would also be elevated above the most stringent WQC (Knight Piésold 2018q). Depending on flow conditions, several metals would exceed their WQC as follows (downstream distances estimated from Figure 4.27-9):

- Molybdenum would exceed its WQC for about 15 to 45 miles downstream.
- Cadmium would exceed its WQC for a shorter downstream distance than molybdenum; cadmium would require 60 percent of the dilution required by molybdenum.
- Lead, zinc, and manganese would require less than one-quarter of the dilution compared to molybdenum; therefore, concentration of these metals would exceed their WQC for a shorter downstream extent compared to molybdenum.
- Copper would require about 10 percent of the dilution required by molybdenum, and would be diluted to below its WQC within several miles of the release site.

These metals would remain at elevated levels above WQC for a month or more during and after the release. See Appendix K4.24, Fish Values, for discussion of metals toxicity.

The formation of secondary metal salts is not likely from this scenario, due to the strong amount of dilution of released metals by downstream waters. The formation of secondary metal salts would require years. Impacts to water quality from dissolution of secondary metal salts would be the same as those noted above for other released metals.

Acid—Impacts from acidic conditions would not occur in this scenario. Contact water from the main WMP would have a relatively neutral pH of 7 to 8 (Knight Piésold 2018a), and would therefore not contribute to acidic conditions.

Sediment Quality

A small amount of metals carried in downstream flows could be incorporated into streambed sediments over the month-long release. Due to the high level of surface water dilution, however, this would likely not be a measurable impact.

Groundwater Quality

At the release site adjacent to the main WMP, some of the untreated contact water would likely mix with shallow groundwater. To reduce the potential for discharge of contaminated groundwater into the NFK watershed, monitoring/pumpback wells would be installed in the area around the main WMP (see Section 4.17, Groundwater Hydrology). Should monitoring of these wells show groundwater contamination from the release, the wells would be used to intercept and recycle shallow groundwater back to the main WMP, to then be treated and released.There is also potential for shallow groundwater downstream of the release site to be contaminated with elevated levels of metals from the month-long release of untreated contact water. There are numerous shallow aquifers throughout the downstream area, and many losing segments of downstream drainages where surface water enters groundwater. Metals present in the released contact water could potentially permeate through soils and sediments into shallow groundwater during the month-long release.

Due to the strong dilution of surface water and groundwater that would occur, it is likely that metals would be diluted to below ADEC groundwater cleanup levels. However, in the event of a spill, monitoring wells could be installed to assess the extent of contamination, and the site could be remediated, as addressed above for Groundwater Quality under the pyritic tailings release scenario. Containment of affected groundwater would be monitored using monitoring/pumpback wells to assess groundwater quality (Knight Piésold 2018a), and the groundwater in the area could be monitored for metals content.

The State of Alaska may require ongoing monitoring and reclamation work as it deems necessary. See Section 4.18, Water and Sediment Quality, for additional potential monitoring and mitigation of contaminated groundwater.

Noise

No impacts.

Air Quality

No impacts.

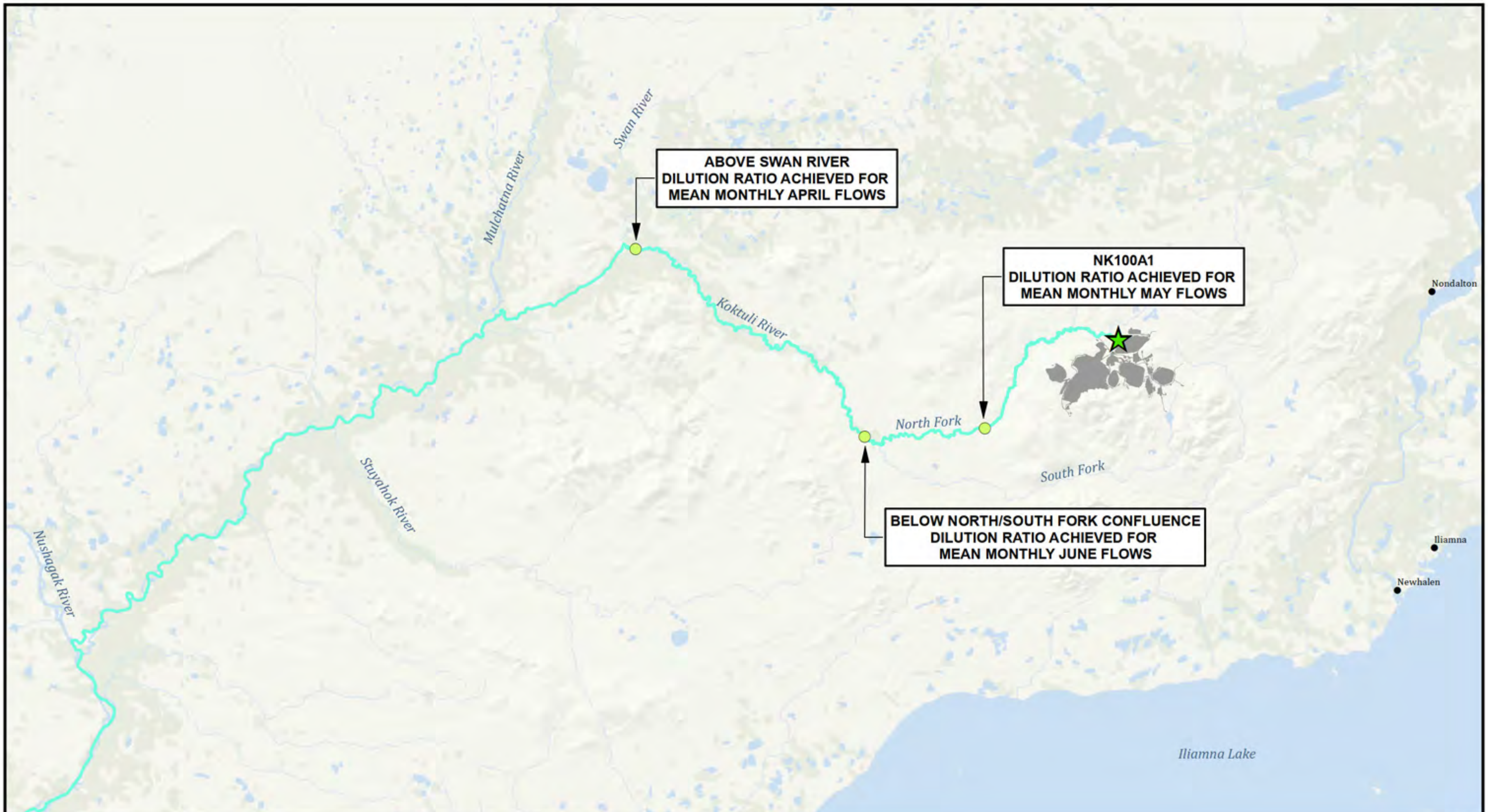
Wetlands and Other Waters/Special Aquatic Sites, and Vegetation

There is a high likelihood that vegetation or wetlands near the seepage area at the main WMP would be affected by soils contaminated with elevated levels of metals from the released contact water. Metal-related toxicity could have acute or chronic effects on vegetation or wetlands. The results may be mortality or reduction of growth.

Any soil erosion at the point of release beneath the embankment would also affect vegetation, and any wetlands or special aquatic sites present. No significant soil erosion is expected due to the very low volume and slow release of the contact water.

Vegetation would be impacted because it would occur during early spring, when plants are actively growing and more likely to absorb contaminants. See Appendix K4.24, Fish Values, for discussion of metals toxicity.

The geographic extent of impacts would be limited to the area directly downgradient from the seepage area. The duration of impacts could range from a few growing seasons (for vegetation recovery in eroded areas) to long-term (if metal-related toxicity occurs), pending habitat restoration efforts.



Sources: KP 2018q; PLP 2019-RFI153

US Army Corps of Engineers

5 0 5 10
Miles

Location of Release
Dilution Ratio Achieved
Modeled Rivers
Mine Site

MODELED EXTENT OF ELEVATED METALS DOWNSTREAM OF UNTREATED CONTACT WATER RELEASE

PEBBLE PROJECT EIS

FIGURE 4.27-9

Terrestrial Wildlife

Several potential impacts can be inferred based on a literature review of toxicology for several metals on various wildlife species. An analysis of the various metals and their acute and chronic levels for fish are detailed in Chapter 8 of the EPA Bristol Bay Watershed Assessment (EPA 2014). Because fish are an important part of the food chain for terrestrial mammals such as brown bears, wolves, and others, impacts to fish may result in impacts to these species. Impacts may include altered foraging locations (if fish levels are reduced), potential for increased competition, and decreased fitness through increased energy expenditure to find resources.

There are multiple pathways that metals in the environment can have impacts on wildlife species. Species can directly consume water that is high in metals; they can consume vegetation that has absorbed metals; they can consume contaminated soil; and they can consume various trophic levels of organisms that have in turn consumed metals. One way to predict the ecological risk of metals to species is to understand the ability of different metals to bioaccumulate and biomagnify in the environment and within organisms (Mann et al. 2011). The metals with the highest concentrations in the released water, which would require the most dilution to reach water quality standards, are discussed in the following paragraphs (see Appendix K4.24, Fish Values, for additional discussion of metals toxicity).

Molybdenum, the metal with the highest concentration in the released contact water (that would remain above WQC for 45 miles downstream of the release location for a month), can cause a disease in ruminants called molybdenosis. Water-soluble molybdenum is readily absorbed by plants (especially aquatic plants/macrophytes and riparian plants) and incorporated into vegetation (Fitzgerald et al. 2009). Water-soluble molybdenum is also taken up by fish and mammals and excreted by the kidneys. However, when ruminants such as moose and caribou feed on molybdenum-rich vegetation, the molybdenum reacts with sulfur in the rumen and causes copper to become biologically unavailable (Swank and Gardner 2004). This causes molybdenosis, in which copper deficiency has been implicated in the death of moose in Sweden (Fitzgerald et al. 2009). The proper balance between molybdenum and copper in ruminant forage is necessary to prevent the disease. Several studies have been conducted around mines in British Columbia, Canada to assess the potential for molybdenosis in ruminants in the surrounding habitat. One study associated with Brenda Mines looked at the potential risk for moose contracting molybdenosis by consuming forage high in molybdenum (Fitzgerald et al. 2009). Field studies in 1999 and the following decade documented no moose suffering from molybdenosis despite elevated levels of molybdenum in the vegetation. Therefore, although a ratio of too much molybdenum to copper may cause molybdenosis, the exact ratio for moose is unknown, and the ability of moose to browse on a variety of forage species across a wide area makes them less likely to suffer the impacts of the disease.

Other metals in higher concentrations that would require more dilution to reach water quality standards include cadmium, copper, lead, manganese, and zinc. The relative toxicity of cadmium to mammals is considered moderate to high, because they have no effective mechanism for elimination of ingested cadmium, and it can accumulate in the liver and kidney. In addition, cadmium is considered highly toxic to aquatic organisms at low concentrations (Gough et al. 1979). Lead is a well-documented metal that causes various levels of poisoning. Lead can be ingested, inhaled, and directly consumed (as fragments in prey sources). Both acute and chronic lead poisoning has been detected in a variety of species from cattle and horses near smelters, to wildlife in zoos (Gough et al. 1979). Zinc and manganese are relatively non-toxic to mammals; therefore, elevated levels based on the spill scenario are not considered to be a risk to wildlife. The final metal at elevated levels that would require several miles of dilution is copper. Copper at high concentrations in bioavailable form is acutely toxic to fish; it does not readily bioaccumulate and does not biomagnify (Cardwell et al. 2013). Copper toxicity in mammals is insignificant because they possess barriers to copper absorption (Gough et al. 1979). Therefore, fish that are killed by exposure to copper are unlikely to pose a hazard to species that may feed on them.

Other metals in the released water may cause impacts to terrestrial wildlife species, but on a small, more localized scale due to lower concentrations in the released water. One such metal is mercury, which biomagnifies when present as methyl mercury, which is formed under anoxic conditions; is readily bioaccumulated by algal species; and subsequently biomagnified through trophic transfer (Mann et al. 2011). Species such as river otters and bears can bioaccumulate mercury from fish (Mann et al. 2011).

In summary, terrestrial wildlife species would be impacted from increased levels of metals in the NFK, given the wide range of potential metals, varying concentrations, their abilities to be absorbed and cause toxicity, and impacts to fish. Generally, carnivorous species show higher biomagnification compared to herbivorous species (Mann et al. 2011). The duration of impacts is expected to occur for at least a month during the spill, and for several months afterwards, depending on the actual toxicity levels for fish. The duration may increase to years depending on impacts to fish. The extent would stretch from the location of the spill downstream in the NFK until the confluence of the Swan River, at which point all metals would be diluted. The distance for which various metals would be diluted would vary, depending on stream flows during the release. The actual extent of impacts from metals on various wildlife species is expected to be much shorter, occur closer to the location of the spill, and be directly related to altered prey. Therefore, the extent to which salmon and other prey species experience impacts would parallel the extent of impacts to wildlife species.

Birds

Impacts are anticipated to primarily affect piscivorous (fish-eating) birds and birds that consume aquatic invertebrates and aquatic vegetation. The magnitude of impacts would be highest during spring, summer, and fall when migrating and breeding birds and their young are present. Although direct impacts of toxic metals biomagnification in birds is dependent on the specific concentrations of metals in prey items, some metals are known to cause serious deleterious impacts on avian species. Lead poisoning in birds is a well-documented occurrence and may occur through ingestion of lead particles (Mann et al. 2011), as well as ingestion of lead in soil substrates and aquatic vegetation. In some cases, lead poisoning in waterfowl has led to several population declines. A study of tundra swan (*Cygnus columbianus*) mortality events from 1987 to 1989 in the Coeur d'Alene River system in northern Idaho revealed that swans were ingesting lead and cadmium from contaminated sediment and aquatic vegetation (Blus et al. 1991). In the Coeur d'Alene River system, die-offs of waterfowl have occurred since at least the early 1900s from mining and smelting activities, in which large quantities of mining wastes were dumped into the South Fork of the Coeur d'Alene River for several decades. The lead levels examined by Blus et al. (1991) indicated that tundra swans accumulated high levels of lead from ingestion of sediment. Even though birds only spent a few weeks in the areas during spring migration, the amount of lead consumed through sediment and vegetation was lethal. Although the die-off events of birds analyzed by Blus et al. (1991) are not comparable to predicted impacts from the project, the study highlights how birds can suffer mortality by ingesting metals from contaminated sediment and vegetation.

Lead continues to be a threat for several raptor species, such as bald and golden eagles (*Aquila chrysaetos*). Lead poisoning may result in toxic results such as damage to the nervous system, paralysis, and death. At lower sub-lethal concentrations, lead can cause damage to tissues and organs, damage to the immune and reproductive systems, elevated blood pressure, and neurological impairments (Rattner et al. 2008). Species that occur in the vicinity of the SFK that may be impacted include waterbirds, waders, raptors, and some shorebird species that consume freshwater invertebrates and fish.

Other metals may be harmful to avian species, similar to those mentioned above for terrestrial wildlife, although the precise pathways for consumption and absorption may be different. An additional metal where elevated concentrations can result in toxic effects is selenium. Elevated selenium has caused adult mortality, reproductive failure, embryonic mortality, and developmental abnormalities in several aquatic bird species (Martinez 1994). Selenium is bioaccumulated in aquatic habitats, and biomagnification can occur when predators consume selenium-rich prey (such as fish and invertebrates; Martinez 1994). Selenium poisoning may persist for several generations and can be passed from parents to offspring through their eggs (Mann et al. 2011). Selenium concentrations generally accumulate in waterbodies such as ponds and lakes that are not readily flushed. Therefore, although the potential duration of impacts may extend beyond the initial period of exposure to elevated levels of selenium, the flushing of the system by rain and snow melt would reduce impacts of elevated selenium through dilution.

One final metal that is bioaccumulated and biomagnified is mercury. High body burdens of mercury are known in birds as a result of consuming aquatic invertebrates and fish. Elevated levels of mercury may result in several neurological disorders in predatory birds (Mann et al. 2011) (such as bald eagles) (see Appendix K4.24, Fish Values, for additional discussion of metals toxicity).

In summary, birds may be impacted by increased metals concentrations in the NFK. A wide variety of species may be both directly and indirectly impacted through exposure to metals. The toxicity of certain metals to avian species and their prey is related to the amount of dilution that occurs in the NFK. It is possible that some sub-lethal impact to avian species may result from consumption of high concentrations of metals in the water, and prey sources in the area immediately downstream of the spill. The duration may last for several weeks during the spill, but sub-lethal chronic impacts may last longer, depending on the amount of dilution and specific location where contaminated water extends. The extent of impacts would extend several miles downstream until metals concentrations are diluted to within water quality standards. Overall, avian species may experience localized impacts to breeding, feeding, wintering, and migrating habitat.

Fish

Potential impacts to fish from the release of untreated contact water would be similar to those described above for elevated metals impacts from the pyritic release scenario.

The spatial extent of the WQC exceedances are more limited than in the previous scenario, but the duration of exceedances are longer (months compared to weeks). The conservative nature of the WQC, species sensitivity differences, and results of the toxicity tests using mine site process water samples are discussed in greater extent under the previous scenario. Of particular importance is the assumption (under this scenario) that the metals released via the contact water spill are 100 percent bioavailable. As discussed previously, several factors are likely to limit metals bioavailability when they are released to surface water, including binding by natural ligands (such as dissolved organic matter) and binding phases on particulates. EPA's recommended aquatic life WQC for copper is based on the Biotic Ligand Model to account for various factors that modify its aquatic toxicity (EPA 2007b). Metals bioavailability in the current evaluations presents uncertainties, but site-specific toxicity tests (as discussed previously) are indicative of limited impacts on fish species. An undiluted aqueous sample from the mine site that was used in the previously described toxicity studies (Nautilus Environmental 2012; described above for the pyritic tailings release) is also understood to be representative of the untreated contact water, although there is uncertainty regarding the representativeness of the sample. The toxicity tests did not demonstrate acute and chronic toxicity to fish species, including rainbow trout and fathead minnow. No impact was observed on survival of water flea neonates, but their reproduction was adversely affected when exposed to 12.5 percent or higher aqueous sample (by volume); or 8 times dilution or less. These results indicate chronic exposures for 7 days or more to tailings fluid at lower dilutions in the streams could have sub-lethal effects on sensitive aquatic species, but likely less so on fish species.

Based on the above considerations, acute toxicity due to metals would not occur. However, prolonged exposure (beyond months) to metals concentrations in slight exceedance of WQC may result in sub-lethal effects. See Appendix K4.24, Fish Values, for further discussion of metals toxicity. Impacts of these potential sub-lethal effects would be limited temporarily (within months) and spatially (to less than several miles). Therefore, the overall magnitude of the toxic effects of metals would be limited under this scenario.

Threatened and Endangered Species

No impacts to TES are anticipated from the scenario, because none of the released water would contact Cook Inlet, and would be within water quality standards prior to reaching areas in Bristol Bay with TES.

Marine Mammals

No direct impacts to marine mammals are anticipated, because metal concentrations would be diluted to within water quality standards prior to reaching Nushagak Bay and beyond. Although acute toxicity to fish is not predicted, sub-lethal effects may extend the duration of impacts. Loss of prey (primarily salmonid species) may indirectly impact marine mammals. The magnitude would be low, because marine mammals would have other species to feed on. The impacts of sub-lethal effects of fish may extend the duration, depending on the amount of time necessary for salmon to recover; however, it would be difficult to determine if there is a correlation between a reduction in salmon and marine mammal impacts in Nushagak Bay. As detailed previously under the bulk and pyritic tailings release scenarios, beluga whales in Nushagak Bay have an abundance of salmon, and do not appear to be constrained by a lack of salmon. The minor temporary loss of a small portion of salmon from the contact water release scenario is not expected to impact the prey base for beluga whales. Furthermore, although beluga whales swim upstream in the early spring and summer to feed on rainbow smelt and outmigrating salmon smolt (Citta et al. 2016), they do not range far enough upstream to reach areas that would have elevated levels of metals.

Needs and Welfare of the People—Socioeconomics

No employment opportunities would be created by a contact water release, because cleanup crews would be small and likely consist of PLP personnel.

Over the longer term, the impacts on employment, income, and sales would be negative if commercial and recreational fishing and/or tourism were to suffer due to the real or perceived impacts of the release. Real or perceived water contamination could also negatively impact local business and consumers.

Environmental Justice

Impacts from a tailings release would not impact socioeconomics, but subsistence and health and safety could be impacted. Taken as a whole, adverse impacts from the spill event would disproportionately impact minority and low-income communities. There would be interrelated subsistence, health, and socioeconomic impacts to the minority and low-income communities in the area.

Recreation

In the event of a contact water release, the spill and response effort would have little effect on recreational resources. There would be no displacement of recreational activities or impacts to recreational setting from cleanup equipment.

Commercial and Recreational Fishing

As noted previously, the release of contact water would result in sub-lethal effects, which would be limited to several weeks and to within about 45 river miles downstream of the mine site. Temporally and spatially limited sub-lethal effects would not be expected to affect the commercial fishery, as long as those effects do not result in a change in the number of returning adult salmon in future years. Recreational anglers fishing these waters could experience a temporary reduction in harvest rates or catch per unit effort rates if the sub-lethal effects reduced target species' ability or desire to feed/strike at anglers' lures.

Cultural Resources

Direct impacts to cultural resources from a potential water contact spill would be similar to the tailings scenarios discussed above. It would directly impact cultural resources along the NFK if ground-disturbing response efforts occurred within the bounds of a cultural resource area or known or potential historic property site. These impacts could include contamination of organic cultural materials and site sediments. Such an event would likely result in direct impacts through loss of integrity for eligibility to the National Register from cleanup activities. These impacts would likely severely damage the site, and resources would not be anticipated to return to previous levels even after actions that caused the impacts were to cease. Indirect impacts could occur to the setting (visual, noise, and olfactory impacts) of cultural resources if the spill were to occur in the vicinity. Access restrictions, noise, pollution, lack of privacy, and visual and olfactory intrusions can all negatively impact cultural landscapes, traditional cultural properties, and sites of religious or ceremonial significance, including burial grounds. Those impacts would be temporary, and would cease when response efforts are complete.

Subsistence

Some subsistence resources downstream of the release could experience toxic effects. The duration of impacts to subsistence resources is expected to occur for months or possibly years, depending on the actual toxicity levels for wildlife and fish. The extent would stretch from the location of the spill downstream in the NFK until the confluence of the Swan River, at which point all metals would be diluted enough to meet water quality standards. The contact water release would likely cause concerns over contamination for subsistence users that harvest in areas downstream from the release, and could cause users to avoid the area and alter their harvest patterns. The delayed detection and invisible nature of the release could create uncertainty and anxiety, and could undermine public confidence in the safety of the resource even after the impacts of the release have faded. A system of testing wild foods and communicating the results to local people in a timely manner could help mitigate these concerns.

Health and Safety

No overbank flooding would occur due to this scenario. There are no nearby downstream human habitations. The closest village downstream is New Stuyahok, 105 miles downstream by way of the NFK. Therefore, there would be no safety risk due to flooding from this scenario.

Modeling results show that surface water quality would be impacted for a maximum of 45 miles downstream of the mine site. Downstream communities rely on groundwater wells for drinking water. No measurable impacts to groundwater would be expected from this scenario, although groundwater contamination could be perceived. Perceived contamination of the environment and subsistence foods may affect community concerns about access to, and quantity and quality of subsistence foods (e.g., salmon), which can affect the socioeconomic status, emotional well-being, food security, and dietary patterns of local communities; this concern may extend throughout the extended spills analysis area. Restricted access to the environment (e.g., due to real or perceived contamination) may result in decreased mental health and increased psychosocial and family stress, substance use, suicidal tendencies, and cardiovascular disease (Dillard et al. 2012; Gibson and Klinck 2005).

There are potential adverse impacts to social determinants of health (HEC 1), with psychosocial stress resulting from community anxiety over a release of untreated contact water, particularly in areas of valued subsistence and fishing activities. Subsistence and food security may be impacted, with potential perceptions of subsistence food contamination that could extend throughout the area (HEC 4). Reliable and prompt communications about environmental and subsistence food impacts, or lack thereof, would alleviate psychosocial stress, reduce impacts to subsistence and food security, and allay other public health concerns. Impacts would vary in duration and be limited to the area of the spill. Table 4.27-1 summarizes variations in spill risk by alternative for each spill scenario.

4.27.10 Cumulative Effects

The geographic extent of potential impacts of the spill scenarios extends beyond the EIS analysis area for other potential impacts analyzed in the EIS. The “Spills Impact Analysis Areas—Affected Environment” at the beginning of this section describes the extended analysis areas addressed throughout.

The same methodology assumptions used to evaluate impacts associated with potential spill risk also applies to the cumulative effects analysis of spill risk. This includes assumptions about tailings dam failure and the fate and behavior of tailings should there be an accidental release. Similarly, diesel fuel is being offloaded, stored, and transferred under the alternatives evaluated in this EIS. In both cases, the reasonably foreseeable future action associated with Pebble Project expansion would extend the operating life of the mine and the volume of material with a potential for spill risk over a period of time.

4.27.10.1Past and Present Actions

Given the limited nature of community, infrastructure, and project development in the area of analysis, past and present spills would primarily be related to the storage and transportation of petroleum products; would be relatively small in volume; and have effects that are limited to the area of the spill. These would include onshore and offshore pipeline leaks, marine spills in Cook Inlet, small spills in Iliamna Lake, fuel tank spills in existing communities, and vehicle rollover spills on community roads. Any past or present spills that have had an impact on the physical, biological, and social environment have been addressed in Chapter 3, Affected Environment, for specific resources that have been affected.

4.27.10.2 Reasonably Foreseeable Future Actions

Because spills (unintended releases) associated with project construction and operation are not a planned or routine event, they are not typically analyzed for cumulative effects as an element of a specific Reasonably Foreseeable Future Action (RFFA); where they are analyzed, quantitative information on the mode of failure, probability, and volume of potential spills has not been available or is based on assumptions that are not relevant or have not been substantiated. This section provides a qualitative analysis of potential spills associated with RFFAs.

RFFAs that could contribute cumulatively to effects on spill risk in the cumulative effects analysis area include those activities that would occur in the Nushagak River or Kvichak River watersheds, or in other waterbodies intersected by the transportation and pipeline corridors in both Bristol Bay and Cook Inlet watersheds and marine waters of Cook Inlet. RFFAs that could contribute cumulatively to effects on spill risk, and are considered in this analysis include: Pebble Project expansion scenario; mining exploration activities for Pebble South/PEB, Big Chunk South, Big Chunk North, Fog Lake, and Groundhog mineral prospects; offshore oil and gas development; and road improvements and the continued development of the Diamond Point Rock Quarry.

The No Action Alternative would not contribute to cumulative effects related to spill risk.

The RFFA contributions to cumulative effects on spill risk are summarized by alternative in Table 4.27-3.

Table 4.27-3: Contribution to Cumulative Effects on Spill Risk

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Pebble Project Expansion Scenario	**Mine Site**. The Pebble Project expansion would have an additional larger bulk TSF, an additional larger pyritic TSF, larger/additional fuel storage facilities, and other expanded storage facilities that would contribute to cumulative effects on spill risk through higher volumes of storage for a longer period of time. Longer-term tailings storage could allow for increased acid generation and metals leaching from stored tailings, depending on storage conditions, resulting in deteriorating water quality of supernatant ponds. The main WMP would be used beyond its original 20-year operational life, and may be at an increased risk of failure as it ages. Portions of the north WRF and north WRF collection pond would be in the UTC watershed. Waste rock storage facilities are stabilized structures, and drainage is collected, treated, and released; spill risk would be similar to that discussed previously under TSF seepage collection ponds, with the exception that there is the potential for an unintentional release in the UTC watershed under Pebble Project expansion. The Pebble Project expansion and associated development would be similar for all alternatives. The Pebble Project expansion scenario could involve the use of cyanide at the mine site, introducing new spill risk. Any cyanide used would be destroyed on site. **Other Facilities**: A north access road and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment, and extended to a new deepwater port site at Iniskin Bay. The spill risk of large spills of concentrate and diesel from the ferry into Iliamna Lake would be	**Mine Site**: Identical to Alternative 1a. **Other Facilities**: Similar to Alternative 1a, except that the mine access road would extend south to the north ferry terminal instead of the Eagle Bay ferry terminal. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. **Magnitude**: Similar to the magnitude of Alternative 1a. **Duration/Extent**: Similar to duration and extent of Alternative 1a. **Contribution**: The contribution to cumulative effects would be similar to Alternative 1a.	**Mine Site**: Similar to Alternative 1a. **Other Facilities**: The spill risk of a natural gas release from the gas pipeline into Iliamna Lake would be eliminated, because the pipeline would not traverse the lake. The north access road would be extended east from the Eagle Bay ferry terminal to Iniskin Bay. Concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. **Magnitude**: Similar to the magnitude of Alternative 1a, except that there would be no spill risk of natural gas release to Iliamna Lake. **Duration/Extent**: Similar to duration and extent of Alternative 1a. **Contribution**: The contribution of spill risk to cumulative impacts for Alternative 2 would be similar to Alternative 1a, except for elimination of	**Mine Site**: Similar to Alternative 1a. **Other Facilities:** The spill risk of large spills from the ferry and releases from the natural gas pipeline into Iliamna Lake would be eliminated, because materials would be transported by road and/or pipeline instead of ferry. Overall expansion would use the existing north access road; Concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay. **Magnitude**: Similar to the magnitude of Alternative 1a, except for reduced spill risk to Iliamna Lake. **Duration/Extent**: Similar to duration and extent of Alternative 1a. **Contribution**: Alternative 3 would eliminate the spill risk of a large spill from the ferry into Iliamna Lake; other spill risk contributions to cumulative impacts would be similar to Alternative 1a.

Table 4.27-3: Contribution to Cumulative Effects on Spill Risk

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	eliminated once those materials are transported by pipeline instead of ferry. Potential diesel and concentrate spills from the pipelines could result from leaks, involving small quantities of spilled material; or from a pipeline rupture, which would be a low-probability event involving a higher spill volume. The consequences of potential diesel spills as a result of truck transportation have been discussed previously in this section, and the environmental impacts from a diesel pipeline spill would be similar in terms of resources and geographic areas that are affected. The probability and consequences of a concentrate pipeline spill have been previously addressed in this section, and would likely be similar in terms of resources and geographic areas that are affected. If the Pebble Project expansion scenario includes a larger-diameter concentrate pipeline, then spilled volumes could be larger. Risk of spills from diesel and concentrate pipelines could increase over the additional decades of operation due to deterioration of the pipelines, such as from corrosion, if pipelines are not maintained/replaced as needed. There would continue to be a spill risk for transport of molybdenum concentrate, reagents, and other materials transported by road, as described above. The Pebble Project expansion scenario would require increased storage of diesel at the port site. In the Pebble Project expansion scenario, there is a potential spill risk of cyanide spills at the mine site or on the transportation corridor.		the risk of a natural gas release into Iliamna Lake.	

Table 4.27-3: Contribution to Cumulative Effects on Spill Risk

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Magnitude. The Pebble Project expansion scenario would impact spill risk by increased volume of storage of tailings, waste rock, and untreated contact water across a wider footprint for an operational life that extends an additional 78 to 98 years longer than the 20-year project. Additional bulk and pyritic TSFs would be constructed with the same design features as the original TSFs. Bulk tailings storage footprint would increase from 2,797 to 7,045 acres; pyritic tailings storage footprint would increase from 1,000 to 2,560 acres. In the event of a release of pyritic tailings, the increased volume of storage could result in a larger volume of release, increasing the chance of contamination in the UTC, as described above. **Duration/Extent**: The duration and extent of cumulative impacts to spill risk would vary from temporary spill risks during construction to long-term risk during operation in the footprint of mine and other project facilities. **Contribution:** The probabilities and potential impacts of spills associated with PLP's alternatives and alternative variants have been addressed previously in this section for the following substances: diesel fuel, natural gas, copper-gold concentrate, chemical reagents, bulk and pyritic tailings, and untreated contact water. For project features and elements previously discussed in this section, it is assumed that design, construction, and operational parameters associated with expansion would be the same (such as for tailings dams, water treatment, and concentrate pipeline). However, they would be handling larger volumes of material and represent expansion of facilities over an operational life that extends an additional 78 to 98 years through			

Table 4.27-3: Contribution to Cumulative Effects on Spill Risk

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	post-mining milling, which could increase the volume and geographic extent of an unintentional release. Some project features that create spill risk, such as transport of copper-gold concentrate by truck and ferry traffic, would cease after 20 years, and be replaced by construction of additional roads and the concentrate and diesel pipelines.			
Other Mineral Exploration Projects	**Magnitude**: Mining exploration activities, including additional borehole drilling, road and pad construction, and development of temporary camp facilities, would contribute a small amount of soil disturbance at discrete locations, depending on landowner permitting and restoration requirements. For example, the 2018 drilling program by PLP consisted of 61 geotechnical boreholes and 19 diamond-drilled core boreholes with diameters ranging from 2 to 8 inches. **Duration/Extent**: Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. Table 4.1-1 in Section 4.1, Introduction to Environmental Consequences, identifies seven mineral prospects in the EIS analysis area where exploratory drilling is anticipated (four of which are in relatively close proximity of the Pebble Project). **Contribution**: There would be limited seasonal contribution from alternatives to the cumulative effects related to spill risk associated with mineral exploration.	Similar to Alternative 1a.	Similar to Alternative 1a.	Similar to Alternative 1a.
Oil and Gas Exploration and Development	**Magnitude:** Onshore and offshore oil and gas exploration activities in the western Cook Inlet area could involve seismic and other forms of	Similar to Alternative 1a.	Similar to Alternative 1a.	Similar to Alternative 1a.

Table 4.27-3: Contribution to Cumulative Effects on Spill Risk

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	geophysical exploration; and in limited cases, exploratory drilling. A large oil spill in Cook Inlet associated with oil and gas exploration could affect the project area (BOEM 2016a). **Duration/Extent:** Seismic exploration and exploratory drilling are typically temporary, seasonal activities. A large oil spill in Cook Inlet associated with oil and gas exploration could affect the shoreline of western Cook Inlet in the vicinity of the proposed port (BOEM 2016a). **Contribution:** If there were concurrent oil spills in Cook Inlet from project activities and oil and gas exploration, the spills would contribute to the cumulative effects related to spill risk.			
Road Improvement and Community Development Projects	**Contribution:** There would be no contribution from alternatives to the cumulative effects related to spill risk associated with road improvement, and community development projects.	Same as Alternative 1a.	Same as Alternative 1a.	Same as Alternative 1a.

Notes:
EIS = Environmental Impact Statement
PLP = Pebble Limited Partnership
TSF = Tailings Storage Facility
UTC = Upper Talarik Creek
WRF = waste rock facility