4.18 WATER AND SEDIMENT QUALITY

This section describes potential impacts of the project on surface water, groundwater, and sediment quality in the Environmental Impact Statement (EIS) analysis area, which includes the project footprint and outside of the project footprint where direct or indirect impacts to downstream or downgradient surface water, groundwater, and substrate or sediment quality may occur. The following potential impacts were evaluated to meet applicable Clean Water Act (CWA) Section 404(b)(1) guidelines:

- Effects of ground disturbance and potential erosion on surface water and sediment quality
- Effects of geochemical weathering of mined rock and tailings on the water quality of human-made waterbodies at the mine site
- Effects of treated water discharge on water and sediment downstream of mine site facilities
- Effects of dust deposition on water quality
- Effects of tailings, waste rock, and contact water storage on groundwater quality and downstream resources
- Effects of groundwater migration adjacent to the pit at closure
- Effects of fill placement and erosion on substrate and sediment quality
- Effects of marine construction and dredging on substrate and water quality
- Effects on drinking water sources

Information regarding impacts to surface water and groundwater occurrence and flow is provided in Section 4.16, Surface Water Hydrology, and Section 4.17, Groundwater Hydrology.

4.18.1 Methodology for Impact Analysis

Impacts to surface water and sediment quality were evaluated based on baseline data, water management plans, and predictive water quality modeling. The methodology applied to analyze and predict direct or indirect impacts is based on the range of effects for each of following factors:

- Magnitude—Effects are assessed based on the magnitude of the impact, as indicated by the degree to which water or sediment quality may be altered from documented baseline conditions, with potential changes to chemical or physical condition (e.g., changes in chemistry, temperature, or turbidity).
- Duration—The duration of effects depends on project phase, length of construction activities, and the nature of activities. Water and sediment quality effects could be temporary during construction (e.g., turbidity from construction); or they could remain after construction throughout life of mine and into closure (e.g., impacts from treated water discharge).
- Geographic Extent—Effects could be localized, or could extend to downstream areas within the same watersheds.
- Potential—Most effects on water and sediment quality at and near the mine site are predictable, and considered likely to occur. The likelihood of occurrence for other project components would be determined by the nature of activity and proximity to water and sediment resources.

The analysis of impacts to surface water and sediment quality generally considers current conditions with regard to environmental factors, including air and water temperature, precipitation type and timing, and precipitation amount. Changes in these factors over time due to climate change would be expected to alter impacts to some degree, particularly as surface water or groundwater hydrologic conditions are affected. The analysis of impacts to surface water and sediment quality detailed in this chapter are broad enough in scope to capture reasonably foreseeable changes to environmental conditions that may occur due to climate change.

Clean Water Act 404(b)(1) Evaluation Factors—Evaluation factors considered by the US Army Corps of Engineers (USACE) in making determinations under CWA Section 404(b)(1), Subpart C, include impacts on the following physical and chemical characteristics of the aquatic ecosystem. Impacts related to these characteristics are addressed in this section of the EIS as noted below:

- **Substrate—**Substrate includes sediment at the bottom of waterbodies, as well as wetlands soils. Impacts on waterbody substrate (sediment) are summarized under Substrate/Sediment Quality in each of the four project component sections. Impacts on wetlands substrate are addressed in Section 4.22, Wetlands and Other Waters/ Special Aquatic Sites.
- **Suspended Particulates/Turbidity—**Effects on turbidity and levels of suspended sediment are summarized under the "Surface Water Quality" section for each of the four project component sections below.
- **Water—**Direct effects on surface water quality and potential effects on surface water quality from migration of contaminants in groundwater are summarized under the "Surface Water Quality" and "Groundwater Quality" headings in each of the four project component sections below. Additional details are provided in Appendix K4.18.
- **Salinity Gradients—**Effects on salinity gradients are described under Surface Water Quality.

4.18.2 Summary of Key Issues

Table 4.18-1: Summary of Key Issues for Water and Sediment Quality

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Mine Site				
Mine Site Construction	**Surface Water**: Ground disturbance and fill placement would result in increased turbidity in local waterbodies and streams, to be mitigated through BMPs. **Groundwater**: Metals concentrations in shallow groundwater may increase as a result of the disruption of wetlands and fill placement. **Substrate**: Ground disturbance and fill placement would result in substrate burial[1] and	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a. *Summer-Only Ferry Operations Variant:* Increased fill placement on wetlands substrate during construction of additional storage areas.[1]	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a.	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a. *Concentrate Pipeline Variant:* Small increase in substrate burial in NFK east tributary.[1]

Table 4.18-1: Summary of Key Issues for Water and Sediment Quality

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	increased erosion and sedimentation if BMPs are inadequate and would reduce natural levels of coarse sediment transport to downstream substrates.			
Tailings and Contact Water Storage (TSFs and WMPs)	**Surface Water**: Pond water quality in TSFs and WMPs would exceed water quality standards, but would be contained within the mine site footprint and treated prior to discharge to the environment. Runoff of contact water from TSF and WMP embankments would be monitored, and diverted to WMPs or WTPs for treatment as necessary. **Groundwater**: Local impacts on shallow groundwater quality in the NFK west, east, and north drainages are likely from vertical seepage through the bulk TSF impoundment, or leakage through pyritic TSF or WMP liners. This would result in localized exceedances of water quality standards within the mine site footprint, which would be captured and treated prior to discharge to the environment. Groundwater model indicates hydraulic containment of affected groundwater by SCPs and catchment systems (underdrains, sump). No mine site effects on drinking water wells are expected. **Substrate**: Burial from fill placement in the NFK west, east, and north drainages.	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a.	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a.	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a.

Table 4.18-1: Summary of Key Issues for Water and Sediment Quality

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Fugitive Dust Effects	**Surface Water**: Minor increases in metals concentrations in surface water are predicted as a result of fugitive dust deposition, from direct fallout and runoff (in conjunction with effluent discharge), although no exceedances of water quality standards are expected. **Groundwater**: No leaching to groundwater above Alaska Department of Environmental Conservation migration-to-groundwater levels, except for arsenic, which is predicted to exceed naturally elevated baseline by 0.6 percent. **Substrate**: Metals concentrations in sediment would increase by 0.1 to 3 percent, but no exceedances of sediment quality guidelines.	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a.	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a.	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a.
Treated Water Discharge	**Surface Water**: WTPs would effectively treat metals and other constituents in WMPs and TSF pond water to meet discharge criteria; the potential exists for an increase in TDS during operations, requiring adaptive management of WTP processes. Temperature changes in the range of -1.6°C to +2.8°C are predicted in the NFK, SFK, and UTC drainages to about 0.5 mile to 2.75 miles downstream of WTP discharges.	**Surface Water:** Impacts similar to those of Alternative 1a. **Groundwater:** Impacts similar to those of Alternative 1a. **Substrate:** Impacts similar to those of Alternative 1a.	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a.	**Surface Water**: Impacts similar to those of Alternative 1a. *Concentrate Pipeline Variant*: Estimated decreased discharge volume by 1 to 2 percent would result in marginal changes in temperature effects. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a.

Table 4.18-1: Summary of Key Issues for Water and Sediment Quality

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Groundwater: WTPs would effectively treat dewatering water from open pit and shallow groundwater contamination from TSFs captured in seepage collection systems. **Substrate**: Potential erosion effects from WTP effluent would be minimal with discharge chambers to dissipate outflow energy.			
Mine Site Closure	**Surface Water**: Impacted sediment between locations of TSFs and SCPs/ WMPs, if present, would continue to release contaminants into surface water over time, but is expected to be mitigated during reclamation. Pit lake water quality would exceed water quality standards, but would be pumped to maintain operational levels, and treated prior to being discharged to the environment. **Groundwater**: Local groundwater quality in the immediate vicinity of the pit and downstream of TSFs may exceed water quality standards, but would be contained by overall gradient toward pit lake or SCP capture, and treated to meet discharge criteria. **Substrate**: Potentially contaminated sediment between TSFs and SCPs/WMPs would be monitored after closure and remediated if necessary.	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a.	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a. *Downstream Bulk TSF Variant:* Increased substrate burial beneath bulk TSF would be permanent.	**Surface Water**: Impacts similar to those of Alternative 1a. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a.

Table 4.18-1: Summary of Key Issues for Water and Sediment Quality

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Transportation Corridor				
Road Construction and Operations	**Surface Water**: Localized (affecting stream-crossing points and areas downstream) and temporary increase in turbidity at 94 stream crossings[2] during construction. Impacts are expected to be short-term and limited to the construction phase, and would be mitigated through BMPs. **Groundwater**: Impacts anticipated to be negligible. **Substrate**: Potential erosion and sedimentation during construction at stream crossings to be mitigated through BMPs. Placement of fill at bridge and culverts would bury existing substrate.[1]	**Surface Water**: Magnitude of impacts similar to those of Alternative 1a, but in different locations and marginally fewer stream crossings (91). **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a. *Kokhanok East Ferry Terminal Variant:* Impacts similar to those of Alternative 1, but affects 10 fewer stream crossings along road to East Kokhanok ferry terminal.	**Surface Water**: Localized increased turbidity, but only 46 stream crossings (approximately 50 percent fewer stream crossings along road than under Alternative 1a). **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Potential decrease in substrate impacts[1] associated with fewer stream crossings. *Newhalen River North Crossing Variant:* Impacts similar to those of Alternative 2, but in slightly different location.	**Surface Water**: Magnitude of impacts similar to those of Alternative 1a, but in different locations and at additional stream crossings (129). *Concentrate Pipeline Variant*: Marginal increase in turbidity due to wider road corridor. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 2. *Concentrate Pipeline Variant:* Marginal increase in substrate[1] due to wider road corridor.
Ferry Construction and Operations	**Surface Water**: Potential for ferry-induced increase in nearshore TSS/ turbidity during operations; expected to return to baseline levels within a short distance (less than 100 feet) from ferry. **Groundwater**: No impacts anticipated. **Substrate**: Fill placement at the ferry during construction would extend 100 to 150 feet onto the nearshore lake substrate on both sides of peninsula at Eagle Bay terminal.	**Surface Water**: Impacts similar to those of Alternative 1a with an alternate ferry location (north ferry terminal). *Summer-Only Ferry Operations Variant:* Reduced TSS/turbidity impacts in winter and increased impacts in summer. Overall impacts are the same as those for Alternative 1; however, impacts would occur with greater intensity over a shorter time. **Groundwater**: No impacts anticipated. **Substrate**: Fill placement on about half of nearshore lake	**Surface Water**: Impacts similar to those of Alternative 1a. Ferry terminal locations changed to Eagle Bay and Pile Bay. *Summer-Only Ferry Operations Variant:* Impacts similar to those of Alternative 1. **Groundwater**: No impacts anticipated. **Substrate**: Impacts similar to those of Alternative 1a. South ferry terminal location changed to Pile Bay. *Summer-Only Ferry Operations Variant:* Impacts similar to those of Alternative 1.	**Surface Water:** No impacts on lake water quality anticipated (no ferry). **Groundwater**: No impacts anticipated. **Surface Water:** No impacts on lake substrate (no ferry terminals).

Table 4.18-1: Summary of Key Issues for Water and Sediment Quality

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
		substrate[1] as that under Alternative 1a due to single north terminal ramp. North ferry terminal location changed to near mouth of UTC. *Summer-Only Ferry Operations Variant:* Increased fill placement on lake substrate during construction at terminals.[1] *Kokhanok East Ferry Terminal Variant:* Impacts similar to those of Alternative 1, but at different terminal and lake crossing location.		
Port Site				
Dock Construction	**Surface Water**: Excavation of seafloor prior to caisson placement would result in a localized increase in TSS/turbidity in Kamishak Bay for the duration of construction activities. **Groundwater**: No impacts anticipated. **Substrate**: Excavation and caisson placement during construction would result in removal and burial of substrate beneath footprint of caissons.[1]	**Surface Water**: Sheet pile installation and placement of fill during causeway construction would result in impacts similar to those of Alternative 1a. *Pile-Supported Dock Variant*: Would reduce TSS/turbidity impacts due to reduced area of disturbance.[1] Less burial of marine substrate during construction.[1] **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Placement of fill during causeway and dock construction would result in disturbance and burial of marine substrate over larger area[1] than Alternative 1a.	**Surface Water**: Greater extent of TSS/ turbidity increase due to finer-grained sediment and dredging activities; extent would range from the close vicinity of the dock to the mouth of Iliamna Bay, depending on tides and waves. *Pile-Supported Dock Variant*: Impacts similar to those of Alternative 1. **Groundwater**: Impacts similar to those of Alternative 1a; stockpile of dredged material may have local impacts on shallow groundwater quality. **Substrate**: Area of direct impact on substrate would increase[1] due to a larger causeway and access route. *Pile-Supported Dock Variant*: Impacts similar	**Surface Water**: Impacts similar to those of Alternative 1a, with increased magnitude due to additional dredging needed. **Groundwater**: Impacts similar to those of Alternative 1a. **Substrate**: Impacts similar to those of Alternative 1a, with increased magnitude as a result of additional dredging needed. *Concentrate Pipeline Variant:* The port WTP would effectively treat dewatering water to meet discharge limits prior to discharge to marine environment. *Return Water Pipeline Option*: This option would not result in any additional footprint, and would preclude the need for dewatering and the discharge of

Table 4.18-1: Summary of Key Issues for Water and Sediment Quality

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
			to those of Alternative 1.	treated water at the port site.
Natural Gas Pipeline				
Construction Effects	**Surface Water**: Impacts to freshwater similar to those for the transportation corridor under Alternative 1a, with additional trenching for pipeline installation and construction from Newhalen along the existing road to the mine access road. Slight increase in naturally high turbidity expected in Cook Inlet during construction; trenching and/or burial of the pipeline in marine substrate could result in minor short-term increases in turbidity. Small spill/ leaks from vessels expected to be dissipated by strong currents and tides. **Groundwater**: Impacts west of Cook Inlet similar to those for the transportation corridor under Alternative 1a. The risk of HDD fluid affecting drinking water supply wells during construction on Kenai Peninsula is expected to be localized and minimized; risks to the nearest private well would be avoided through further evaluation, HDD planning, and pressure monitoring during drilling; drilling fluid and cuttings would be disposed of off site. **Substrate**: Impacts to freshwater substrate similar to those for transportation corridor	**Surface Water**: Impacts similar to those for the transportation corridor under Alternative 1. **Groundwater**: Impacts west of Cook Inlet similar to those for the transportation corridor under Alternative 1. Impacts east of Cook Inlet same as those for Alternative 1a. **Substrate**: Impacts similar to those for the transportation corridor under Alternative 1.	**Surface Water**: Type of impacts similar to those for Alternative 1a, with about 35 percent more stream crossings along pipeline (including segments co-located with road). **Groundwater**: Impacts west of Cook Inlet similar to those for the transportation corridor under Alternative 2. Impacts east of Cook Inlet same as those for Alternative 1a. **Substrate**: Type of impacts similar to Alternative 1a, with about 35 percent more stream crossings.	**Surface Water**: Impacts similar to those of Alternative 2 and the transportation corridor (road construction). **Groundwater**: Impacts west of Cook Inlet similar to those for the transportation corridor under Alternative 2. Impacts east of Cook Inlet the same as those for Alternative 1a. **Substrate**: Impacts similar to those of Alternative 2 and the transportation corridor (road construction). *Concentrate Pipeline Variant:* Impacts to surface water and substrate at stream crossings similar to Alternative 3.

Table 4.18-1: Summary of Key Issues for Water and Sediment Quality

Impact-Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	under Alternative 1a, with additional trenching for pipeline installation and construction from Newhalen along the existing road to the mine access road. Trenching and/or burial of the pipeline in marine substrate of Cook Inlet could cause increased sedimentation in the vicinity of the pipeline.			

Notes:
[1] Acreages of waterbody substrate burial provided in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.
[2] Stream crossings numbers are based on number of culverts and bridges.
°C = degrees Celsius
BMPs = best management practices
NFK = North Fork Koktuli
SFK = South Fork Koktuli
TSF = tailings storage facility
UTC = Upper Talarik Creek
WTP = water treatment plant
HDD = horizontal directional drilling
SCP = seepage collection pond
TDS = total dissolved solids
TSS = total suspended solids
WMP = water management pond

4.18.3 No Action Alternative

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

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

The geologic material at the mine site would continue to naturally weather in place. Baseline water and sediment quality in the mine site vicinity would not change; certain constituents would still be present in amounts exceeding regulatory levels because of natural mineralization and geochemical weathering processes. Water quality along the transportation and pipeline corridors would continue to reflect the presence of elevated levels of some constituents, as described in Section 3.18, Water and Sediment Quality. Natural levels of sediment transport, deposition, and substrate modification would continue, and sediment would continue to contain certain constituents (e.g., metals) at elevated levels. No project-related geochemical processes or impacts on surface water, groundwater, or sediment quality would occur under this alternative.

4.18.4 Alternative 1a

This section describes the impacts of the project on surface water, groundwater, and substrate/ sediment quality for each of the four project components under Alternative 1a.

4.18.4.1 Mine Site

Surface Water Quality

Water originating in the mine site area would be managed in an environmentally responsible manner while providing an adequate water supply for operations. A primary design consideration would be to ensure the effective management of all contact water that would require treatment before release to the environment. This would include carefully assessing the layout of project facilities, process requirements, the topography, hydrometeorology, aquatic habitat and resources, and regulatory discharge requirements for managing surplus water. Water management strategies at the mine site are discussed in Section 4.16, Surface Water Hydrology. A map of the mine site layout showing water storage facilities, diversion channels, collection ponds, and flowlines is provided in Chapter 2, Alternatives, Figure 2-4 and Figure 4.16-1. A description of the water balance model is included in Appendix K4.18, and schematics showing estimated recycle flows between mine facilities are shown in Appendix K4.16.

All runoff water contacting the facilities at the mine site and water pumped from the open pit would be captured to protect overall downstream water quality. Prior to discharge to the environment, any water not meeting applicable discharge requirements would be treated. For example, contact water that may infiltrate into the groundwater system at the mine site would be collected at the mine site by the open pit groundwater wells or by catchment systems at tailings storage facilities (TSFs) and ponds, such as underdrains, sumps, and pumpback wells. All contact water would be treated at the two water treatment plants (WTP) and discharged as wastewater (i.e., surplus water). Non-acid-generating quarry or waste rock would be selected and used in construction of mine site roads and embankments, through techniques commonly used for grade control in open pit mines (PLP 2018-RFI 021c), such as testing for acid rock drainage (ARD) and leachable metals at specified intervals or block sizes. The project design incorporates an analysis of water collection and management, including quantity and quality estimates, water treatment options, design of water management facilities, and strategic discharge of treated water. Implementation of the water management plan would enable the process plant to operate without additional water from off-site sources. Additional details on surface water and groundwater management and controls are provided in Section 4.16, Surface Water Hydrology, and Section 4.17, Groundwater Hydrology, respectively.

The impact on surface water quality would be the discharge of treated process and runoff water that has come into direct contact with mining infrastructure. The duration and likelihood of treated discharge would be long-term and certain, if the mine is permitted and built. The following subsections describe how contact and runoff water would be treated prior to discharge.

Water Treatment during Construction—Minimal water storage capacity would be available at the mine site until the completion of initial construction activities. Therefore, before completion of the bulk TSF embankments and water management structures, all contact water not meeting water quality standards would be treated in modular WTPs and released. (Modular WTP processes are described below under "Dewatering Water Discharge in Construction" and in PLP

2018-RFI 021b and HDR [2019g].) Contact water from the following sources and activities in construction would be expected to require treatment before release:

- Dewatering of the overburden aquifer above and near the pit deposit
- Water, primarily from precipitation, that accumulates in the open pit during construction
- Runoff from construction of TSF embankments

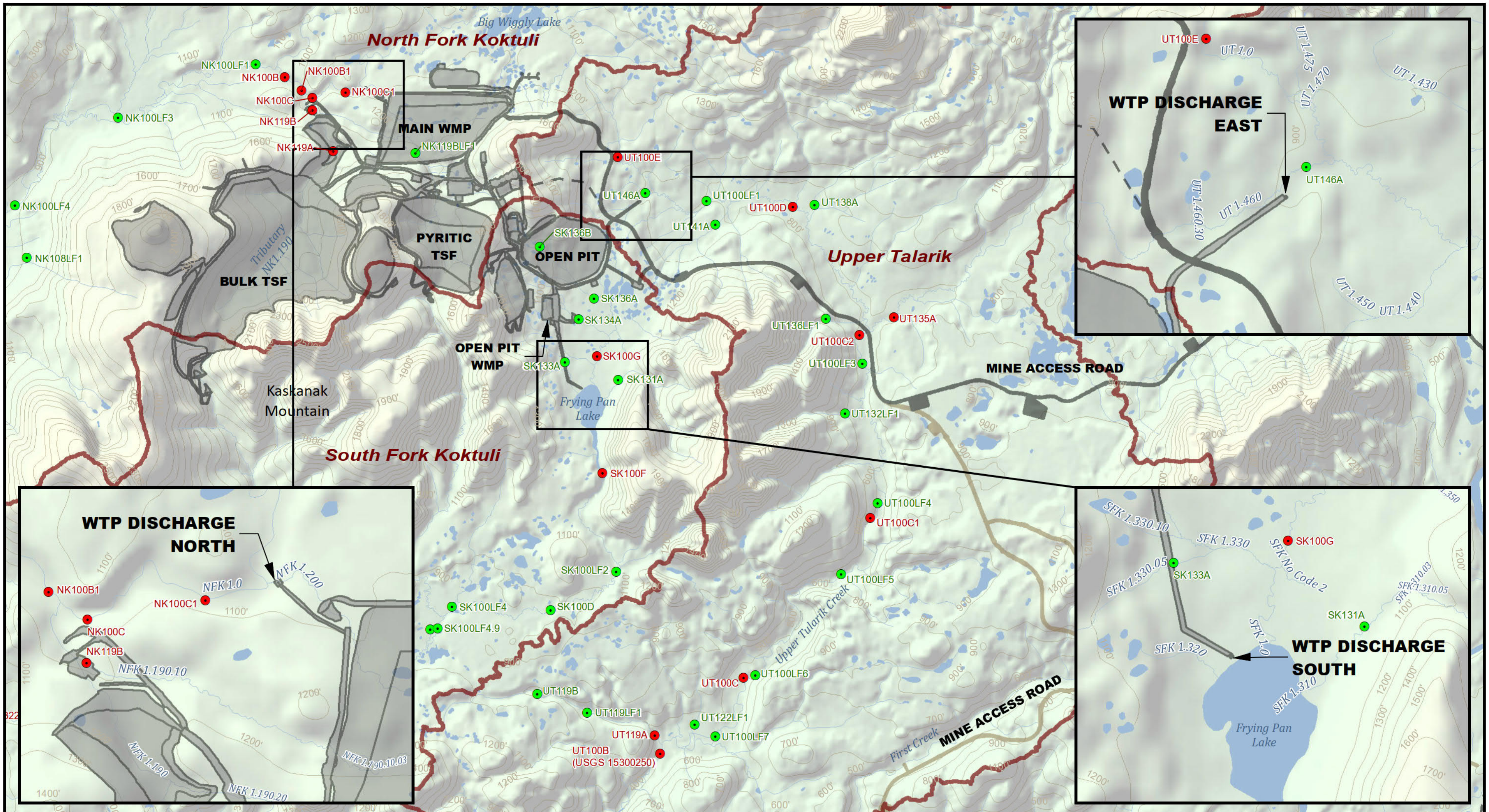
Non-contact runoff water from excavation for site infrastructure such as the process plant, camps, power plant, or storage areas would be routed to sediment settling ponds before release. Non-contact runoff water, defined as water that does not come into direct contact with mining infrastructure (e.g., open pit, waste rock, and tailings stockpiles), is considered stormwater, as defined in 40 Code of Federal Regulations (CFR) Part 122.26(b)(13). Some or all of the stormwater discharge may require authorization from the Alaska Department of Environmental Conservation (ADEC) under the Multi-Sector General Permit for Stormwater Discharges Associated with Industrial Activity, Permit Number AKR06000, and therefore could require treatment to remove sediment or meet other State of Alaska discharge criteria prior to discharge into the environment. ADEC administers the Alaska Pollutant Discharge Elimination System (APDES) Program, in compliance with the CWA, 33 US Code (USC) Section 1251 et seq., as amended by the Water Quality Act of 1987, Public Law 100-4, Alaska Statute 46.03, and the Alaska Administrative Code (AAC), as amended, and other applicable state laws and regulations, to authorize and set conditions on discharges of pollutants from facility to waters of the US (WOUS).[1] To ensure protection of water quality and human health, APDES permits place limits on the types and amounts of pollutants that can be discharged from a facility, and outlines best management practices (BMPs) to which a facility must adhere.

Water Treatment during Operations—During operations, the mine site would have two WTPs: the open pit WTP (WTP #1) and the main WTP (WTP #2). Both would be constructed with multiple, independent treatment trains, which would enable ongoing water treatment during mechanical interruption of any one train. Figure 4.18-1 provides a detailed view of WTP discharge locations and relevant nearby surface water monitoring stations and tributaries. Details of the WTP systems are provided in Appendix K4.18, and summarized below.

WTP #2 would treat water from the main water management pond (WMP), which would receive water from the bulk and pyritic TSFs and the TSF main embankment seepage collection pond (SCP). WTP #1 would treat water from the open pit WMP, which would be composed primarily of pit dewatering water. As described in Appendix K4.18, both facilities would employ treatment plant processes commonly used in mining and other industries around the world.

Key treatment steps for both WTPs would include influent heating, dissolved metals oxidization, iron co-precipitation, high rate clarification, sulfide precipitation, metals polishing, media filtration, ultrafiltration, reverse osmosis (RO), and effluent storage and equalization prior to discharge (see Chapter 2, Alternatives, Figure 2-11 and Figure 2-12). The main WTP would also include additional stages of RO and calcium sulfate (gypsum) precipitation with a lime softening process to remove sulfate. As described in Appendix K4.18, based on applying these processes to predicted influent water quality, discharge water from both WTPs is currently expected to meet ADEC criteria (Table K4.18-13). Clarifier solids-filter backwash from both WTPs would be thickened/evaporated, and transferred to the pyritic TSF (HDR 2019g; PLP 2019-RFI 021e).

[1] The regulatory definition of WOUS is given in 40 CFR Part 230.3(s). Locations in the project area in which wetlands and other waters of the US have been identified as jurisdictionally under the authority of the USACE are described in the Preliminary Jurisdictional Report in Appendix J. The project area is defined in Section 3.1, Introduction to Affected Environment, as "the exact project footprint for each action alternative."



Sources: PLP 2019-RFI153; Knight Piesold et al. 2011a; Knight Piesold 2015b

US Army Corps of Engineers

1 0 1 2
Miles

- Continuous Monitoring Gage Stations
- Early Spring Low-Flow Measurement Sites

Action Alternatives

- Natural Gas Pipelines
- Alternative 1a
- Alternative 1

Other Features

- 100' Contour (Existing)
- River/Stream
- Lake/Pond
- Major Drainage Boundary

WATER TREATMENT PLANT DISCHARGE LOCATIONS IN OPERATIONS

FIGURE 4.18-1

Independent technical reviews of the WTP design and treatment processes were initially conducted by AECOM (2018i). The conclusions of this review are discussed in Appendix K4.18, along with the results of subsequent reviews of Applicant information provided in more recent project documents. The technical content of these documents (HDR 2019g; PLP 2019-RFI 021e, 021h) was found to be generally in line with expected treatment strategies for the mining industry, including the use of chemical precipitative technologies combined with sedimentary and filtration techniques to remove constituents of concerns from the waters. However, the information provided is at a conceptual stage of development, and there is limited ability to identify potential significant technical failures of the treatment strategies. There are concerns that the approach has not been commercially demonstrated at the proposed scale; that removal efficiencies assumed for selenium are optimistic; and that salts could build up over time in the pyritic TSF, leading to increased total dissolved solids (TDS) concentrations requiring treatment. Additional discussion is provided in Appendix K4.18 regarding these concerns and the additional studies needed to identify the types and concentrations of salts species might reach their solubility limits in the pyritic TSF. Recommendations are also provided in Appendix M1.0, Mitigation Assessment, to address these concerns, which have largely been adopted by PLP. The technical viability of the WTPs would require further evaluation during the permitting phase with the State of Alaska to demonstrate that the configuration can achieve the suggested water quality.

As described in HDR (2019g) and PLP (2019-RFI 021h), the WTPs would undergo further investigation as design progresses, and would employ long-term adaptive management strategies. These would include detailed process water and mass balance modeling, pilot plant testing, backup treatment trains, influent flow monitoring, and the addition of RO membranes if necessary (HDR 2019g). If hydraulic capacity of the WTPs is not adequate to meet the influent flow, additional trains would be installed as needed (PLP 2019-RFI 106). The operational capacity of the main WMP provides flexibility (equivalent to 3 average years of water discharge time) to allow time for addressing process interruptions (PLP 2019-RFI 021h).

Assuming these protections are adopted, direct and indirect impacts of treated contact waters to off-site surface water are not expected to occur. However, over the life of the mine, it is possible that APDES permit conditions may be exceeded for various reasons (e.g., treatment process upset, record-keeping errors) as has happened at other Alaska mines. In these types of events, corrective action is typically applied in response to ADEC oversight to bring the WTP discharges into compliance.

In terms of magnitude and extent, all WTP #1 treated water and most WTP #2 treated water would be discharged to the environment downstream of the mine site. A small portion of the WTP #2 treated water would be used for process and power plant needs. Water discharge points would be in the North Fork Koktuli (NFK) River, South Fork Koktuli (SFK) River, and Upper Talarik Creek (UTC) drainages (Figure 4.18-1). Water from both treatment plants would be strategically discharged in a manner that would optimize downstream aquatic habitat, based on modeling and monitoring during discharge (PLP 2020d). Monitoring of surface water flow and quality would be conducted downstream of discharge points as shown in PLP 2019g and PLP 2019-RFI 135). WTP discharges as mitigation for streamflow reduction are further discussed in Section 4.16, Surface Water Hydrology, and Section 4.24, Fish Values. The duration and likelihood of impacts would be long-term, lasting for the life of the project and into closure.

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

- APDES Individual Permit for point source discharge into wetlands and other WOUS
- Integrated Waste Management Permit for solid waste disposal and wastewater discharge not into wetlands and other waters
- APDES Multi-sector General Permit for Stormwater Discharges Associated with Industrial Activity (Permit Number AKR06000)
- State Wastewater Discharge Permit for discharge other than into WOUS

An APDES permit is necessary unless discharge is not to wetlands and other waters, in which case a State wastewater discharge permit would be required. State of Alaska regulations require that the conditions of these permits comply with State water quality standards that are based on the use classification for the waterbody receiving discharge, and on the State's anti-degradation policy. For constituents that exceed criteria in baseline surface water and groundwater (see Table K3.18-1), there are currently no plans to incorporate site-specific baseline levels of constituents into discharge limits (ADEC 2018-RFI 064a). However, a potential permittee may choose to seek site-specific criteria per 18 AAC 70 rather than implement the required water quality treatment technology to meet existing criteria.

Water Treatment during Closure—Water treatment during closure/post-closure would use the operations WTP #1 and WTP #2 as needed, with WTP #1 upstream of Frying Pan Lake reconfigured as WTP #3 (Knight Piésold 2018d), and separate WTP systems developed in later closure phases to treat SCP and pit water. Closure water treatment would occur as follows (HDR 2019b):

- Closure Phase 1 (years 0 to 15)—WTP #2 would treat water from the main WMP, and WTP #3 would treat water from the open pit during placement of pyritic tailings prior to filling of the pit lake. The treatment processes from WTP #2 in operations would continue to be used, with chemical feed rates adjusted and the first stage of RO replaced by a nanofiltration step. WTP #3 would use the same steps as WTP #2, with the addition of a brine evaporation and crystallization system to remove salts. As described in Appendix K4.18 and Appendix M1.0, Mitigation Assessment, further analysis would be required during the engineering phase prior to closure to determine the waste characteristics of the final salt, and whether it would be disposed of on site or off site.
- Closure Phase 2 (years 16 to 23)—No water treatment is anticipated during closure phase 2 as the pit lake fills. WTP #2 would be decommissioned and WTP #3 would be on standby status.
- Closure Phases 3 and 4 (years 23 to 50, and beyond year 50)—Water from the open pit would be pumped and treated to maintain the pit lake level at or below the maximum management (MM) level of 890 feet above mean sea level (amsl). Surplus water from the open pit, as well as the bulk TSF main SCP, would be treated as two stand-alone water treatment streams, both of which would be housed in the same WTP building. Treatment for the SCP stream would include processes similar to WTP #2 in operations, but with fewer RO and calcium sulfate stages. Treatment for the open pit stream would include processes similar to WTP #1 in operations, but without ultrafiltration (UF)/RO (HDR 2019b, 2019g, 2019h).

In terms of magnitude and extent, treated water would be discharged in the NFK, SFK, and UTC drainages at the locations shown on Figure 4.18-1. Details of the WTP processes and waste streams in closure phases are described in HDR (2019g, h) and summarized in Appendix K4.18. Water quality would be monitored and treatment processes adjusted as needed. If hydraulic capacity of the WTPs is not adequate to meet the influent flow, additional trains would be installed as needed (PLP 2019-RFI 106). Table K4.18-14 through Table K4.18-16 provide estimates of treated discharge water quality from the closure WTPs, which is predicted to be within water quality standards. Post-closure discharges from the open pit WTP would be subject to an APDES permit. Reclamation and closure plan and financial assurance mechanisms required by the State of Alaska would include financial provisions for operating water treatment facilities and conducting ongoing monitoring indefinitely in the post-closure period.

Effects of Ground Disturbance and Erosion—Ground disturbance during construction has the potential to lead to erosion and introduce suspended sediment and increased turbidity into waterbodies downstream of the mine site, potentially resulting in direct and indirect impacts to water quality. These effects are likely to occur, and the magnitude and extent of direct impacts would include increased turbidity, temperature changes, or changes in water chemistry in downstream waterbodies. Indirect impacts would also be expected to occur. The magnitude and extent of indirect impacts could include changes to dissolved oxygen (DO) content, or an increase or decrease in biologic activity in waterbodies resulting from the mine project. The duration and likelihood of impacts would be long-term, and certain to occur if the mine is permitted and constructed. Implementation of the water management plan during the construction phase would include the following features:

- Water diversion, collection, and treatment systems would be installed to reduce the effects of ground disturbance and erosion on water quality during construction. The locations of these features would be determined based on minimizing sedimentation effects, and would be in compliance with applicable State permit requirements. Major features currently planned are shown on Figure 2-4 and Figure 4.16-1.
- BMPs for water management and sediment control structures, including temporary settling basins, sediment traps, and silt fences, would be installed to accommodate initial construction at the mine site.
- Among the first facilities to be constructed would be water management structures that would be maintained for use in adaptive management during operations. These structures would include diversion and runoff collection ditches to minimize water contact with disturbed surfaces, and sediment control measures such as settling ponds to prevent or minimize sediment from reaching downstream waterbodies.
- Stormwater runoff from facilities that does not come in direct contact with mining infrastructure would be treated for sediment and discharged under applicable general APDES stormwater permits (Knight Piésold 2018a).

During the operations phase, implementation of the water management and sediment control plan would focus on reducing the accumulation of contact water through diversion structures. Runoff and associated sediment control measures would be managed with BMPs and adaptive management control strategies. BMPs are described further in Section 4.14, Soils. Where water could not be diverted, it would be collected for use in the mining process, or treated and discharged.

Effects of Dewatering Water Discharge in Construction—Dewatering of the open pit is likely to have both direct and indirect impacts on surface water quality, resulting from changes to hydrologic flow regimes between groundwater and surface water, and discharge of pumped groundwater to surface waterbodies.

The construction phase would involve dewatering of the pit area beginning approximately 1 year before the start of operations. During construction, water collected from pit dewatering wells would be discharged to the open pit WMP, which is expected to be in place before preproduction (e.g., removal of overburden in the pit area) mining commences in Year 1. In the event that the open pit WMP is not available, water from dewatering wells would be treated prior to discharge by WTP #1 if it is in place; or by a modular WTP if WTP #1 is not in place. WTP processes for construction wastewater would include modules for the following processes as necessary: a temporary sedimentation pond; a sedimentation tank and/or sand separator; chemical addition and rapid-mix module; a filtration module; and associated modules containing water feed/transfer pumps, chemical storage/feed systems, electricity generation, a workshop, and parts storage (PLP 2018-RFI 021b). WTP discharge locations are depicted on Figure 4.18-1. In terms of magnitude and extent, following module WTP processing, water from pit dewatering wells would be discharged to the SFK catchment (PLP 2018-RFI 021b). The duration of impact would be until the open pit WMP is in place. Under either the WTP #1 scenario or the modular WTP scenario, discharge would require an APDES permit, and must meet prescribed discharge limits and monitoring and reporting requirements.

Effects of Waste Rock/Tailings Storage and Water Management Ponds—Waste rock, TSFs, and WMPs would impact surface water or groundwater quality if not properly managed. Contact water that accumulates in on-site tailings and waste rock storage facilities and WMPs would be managed through containment and recycling/reuse so that it would not be released to surface water downstream of these facilities until intended for treatment and discharge. Water in these containments would not be considered WOUS prior to discharge; therefore, such water would not be subject to regulation under the CWA, or subject to APDES permitting requirements while retained in on-site water management facilities.

Bulk and pyritic tailings slurries from the mill would be directed to the bulk TSF and the pyritic TSF, respectively. Potentially acid-generating (PAG) waste rock from the pit would also be stored in the pyritic TSF. Section 3.18, Water and Sediment Quality, provides a description of these materials. Precipitation and runoff water would also collect in these facilities. The bulk TSF would maintain a small operating (supernatant) pond, while the pyritic tailings would remain fully submerged in the lined pyritic TSF to minimize ARD and metal leaching (ML) by eliminating contact with air, and thereby greatly reducing the potential for oxidation, the process by which acid is generated from PAG rock. Submersion of pyritic tailings would minimize resuspension of tailings by wind-induced waves and oxidation of the tailings through exposure to air. Excess water from the pyritic TSF would be pumped to the main WMP (see Section 4.16, Surface Water Hydrology, Figure 4.16-2).

The main embankment at the bulk TSF would operate as an unlined flow-through facility. Water collecting in the bulk TSF would flow through the embankment to the main embankment's SCP and would be pumped directly from the supernatant pond to the main WMP as necessary. From the SCP, water would be directed to the main WMP, and then to the mill for use or to WTP #2 for treatment and discharge. Excess surface water in the pyritic TSF would be managed by pumping to directly to the main WMP. Water treatment byproduct sludge and reject water (water resulting from the treatment process) would be directed to the process plant and added to the pyritic TSF via the pyritic tailings slurry line. A portion of the treated water from WTP #2 would be returned for use in the process plant and power plant cooling towers. The magnitude and extent of impacts to surface waters would be that treated water from WTP #2 not needed for mine operations would be discharged downstream of the mine. The effects of seepage and leakage from these facilities on groundwater are described below under "Groundwater Quality."

The predicted chemistry of geochemical sources contributing to the main and pyritic TSF ponds, the main SCP, and main WMP is discussed in Appendix K4.18 and shown in Table K4.18-2. Table K4.18-4 shows the predicted water quality in the ponds. Water in these ponds is predicted to contain levels of TDS, sulfate, and a number of metals in excess of water quality criteria (Appendix K3.18, Table K3.18-1). These data have been used in the development of WTP processes described in Appendix K4.18.

The size of the ponds and the design criteria intended to prevent overtopping of pond water are described in Section 4.16, Surface Water Hydrology. Upset conditions that could lead to unexpected release of pond water to the environment are addressed in Section 4.27, Spill Risk.

A water surplus is anticipated during operations under all climatic conditions (Knight Piésold 2018a). The magnitude, duration, and extent of impacts to surface water would be that treated surplus water would be discharged throughout the year. Section 4.16, Surface Water Hydrology, provides further details on the volume of water available for discharge, compared to baseline (i.e., pre-mine) flows in surrounding drainages.

Effects from Embankment Rockfill Runoff—Runoff from rockfill would impact surface water quality if not properly managed. Based on the geochemical analysis of source rock, the chemistry of runoff from rockfill in embankments is expected to be comparable to that of natural surface water and groundwater with respect to ARD and ML, because only non-PAG rock would be used in construction (SRK 2018d).The embankment rockfill could contain explosive residues from blasting; however, explosives used during mining would consist of ammonium nitrate/fuel oil (ANFO) mixtures manufactured on site (PLP 2020d). A small amount of these materials may not be fully consumed, and residue may remain on rock used in embankment construction. In terms of magnitude of impact, these materials could impact surface waters through runoff. Runoff from embankments quarried with explosives would be captured and managed as contact water (PLP 2018-RFI 021c). Explosives residue is considered in the prediction of surface water quality from mine site sources in Table K4.18-2 (SRK 2018a, 2019e), and is accounted for in planned treatment processes.

Effects from Small Spills of Hydrocarbons or other Toxins—Inadvertent release of hydrocarbons or other potentially toxic compounds would result in a direct impact to surface water quality if spilled materials come into contact with surface water. The likelihood of these small spills from mine-related sources (e.g., mine machinery, product or waste storage facilities, or transfer operations) would be reduced through the application of BMPs, including the use of certified containers to transfer and store fuels and lubricants; secondary lined containment around bulk storage facilities; and managed storage, reuse, and/or disposal of used fuel products and other potentially toxic materials. Should a small spill occur, controls would be implemented, including automatic shutoff devices, and in-place spill response equipment and procedures (PLP 2020d). Section 4.27, Spill Risk, describes the potential for and effects of large-volume spills, which would have the potential for greater magnitude and extent of direct effects on surface water and sediment quality.

Effects of Discharge Water Temperature—For efficiency and effectiveness of the water treatment process, influent water temperature must be at least 5 degrees Celsius (°C). In portions of the year where water temperatures are anticipated to be below 5°C, it would be necessary to heat influent water to support water treatment processes. A dual-looped heat exchanger system would be used to increase influent water to the WTPs using a glycol heat exchanger and cool effluent via a recycle heat exchanger prior to discharge into the environment. The glycol heat exchanger would use hot glycol from the power plant, and the recycle heat exchanger would cool effluent with the influent wastewater stream. In the coldest predicted operating conditions, influent water to the WTPs is anticipated to reach a minimum temperature of about 3°C. Influent water would be heated to approximately 6°C for treatment, and under the coldest expected conditions, effluent would be cooled to about 4.5°C prior to discharge into the environment (HDR 2019g).

Modeling of temperature impacts using documented baseline temperatures, flow data, and predicted WTP discharge temperature and flow rates indicates the magnitude of expected effects on temperature (R2 Resource Consultants 2019b). In terms of extent of impacts to surface waters, the modeled temperature effects are based on a limited set of measured water temperatures and flow scenarios collected at specific locations; the calculated discharge impacts reflect those conditions and locations. The duration and likelihood of impacts would be long-term, and certain to occur if the mine is permitted and constructed as designed. The calculated temperature effects provide a reasonable estimate of typical temperature effects from operational WTP discharges, summarized as follows:

- Temperature changes in the NFK watershed approximately 0.5 mile downstream of the WTP discharge point would be expected to be in the range of about -1.60 to +1.60ºC; (average of about +0.02ºC) in summer months, and from about +1.2 to +2.8ºC (average of about +1.94ºC) in winter months.
- Thermodynamic analysis indicates that the thermal effects of Frying Pan Lake causes a cooling effect during summer months and a warming effect in winter months. Temperature changes in the SFK watershed approximately 1.4 miles downstream of the WTP discharge point at the outfall of Frying Pan Lake would be expected to be in the range of about -0.20 to +0.40ºC (average of about -0.038ºC) in summer months. Modeling indicated that during winter months, there is no anticipated downstream change in temperature for most winter months, and only a predicted change in downstream temperature of +0.85ºC for the month of April.
- Temperature changes in the UTC watershed approximately 2.75 miles downstream of the WTP discharge point would be expected to be in the range of about +0.10 to +0.60ºC (average of about 0.26ºC) in summer months, and from about +0.20 to +0.50ºC (average of about +0.36ºC) in winter months.

Monitoring of surface water temperature would be conducted downstream of WTP discharge points as shown in PLP 2019g and PLP 2019-RFI 135.

Effects of Treated Water Discharge on Spatial Trends—Discharge of treated water from WTPs during operations would also have an effect on water conditions other than temperature in receiving waters (e.g., DO levels, turbidity, nutrient levels). As with temperature in terms of extent, these effects would be expected to be spatially limited to the area at and immediately downstream of discharge points, and would be managed by the planned strategic discharge of treated water between the three planned discharge points, with discharges alternated based on flow conditions in receiving waters (PLP 2020d). The magnitude of changes in water conditions that occur at each discharge point due to effluent below water quality standards but greater than baseline would also be expected to be diluted through natural flow over a relatively short distance, and to return to baseline or near-baseline conditions. The magnitude, duration, and extent of the effects of discharges on natural stream conditions would vary by location and seasonally, depending on baseline flow and other variable factors (e.g., fluctuations in water clarity, nutrient levels, or DO content). Additionally, installing engineered discharge chambers at discharge points would reduce effects on certain water conditions such as turbidity and DO by baffling the discharge and allowing for more equilibration of water condition at the discharge point (Knight Piésold 2018f).

Effect of Treated Water Discharge on Environmental Mass Load—Variations in treated effluent water quality and reduced streamflow relative to baseline conditions would alter the total mass of individual metals, nutrients, and ions flowing through the environment. The average mass of these constituents flowing through the mine site study area (NFK, SFK, and UTC) was examined to assess overall changes in the environmental mass load of water quality constituents on an average annual basis. The annual mass load during operations is dependent on anticipated streamflow reduction to each main-stem stream of the mine site area, as well as the average annual discharge from project WTPs into the environment. A more detailed discussion of methods used for analyzing mass loading is included in Appendix K4.18.

Table K4.18-21 presents estimates for the change in mass load for the total hydrologic environment flowing downstream of the mine site, as well as the change in mass flowing through each main-stem stream. Results indicate that changes in the average mass of metals flowing through the system are typically within ±10 percent of baseline in the SFK and UTC. The NFK is anticipated to experience greater variability, with changes in most metals within ±25 percent of baseline, with the greatest change being for molybdenum (29 kg/year, a 127 percent increase above baseline). Some major ions, including chloride, sulfate, and potassium, are anticipated to experience a more significant increase in mass load as a result of mining operations. Annual mass load of chloride is anticipated to show the greatest increase, with a 1,620 percent increase in the NFK and a 685 percent increase across all three watersheds combined.

Dissolved constituents in WTP effluent could be carried downstream from the mine site in streamflow and/or transported into hydraulically connected wetlands. Generally, alterations to water chemistry as a result mass loading from effluent discharge are expected to be higher near the discharge points and taper downstream as effluent is mixed and diluted with water of baseline quality in receiving streams. A simple dilution analysis was performed comparing the average annual flow of treated effluent discharged into each watershed to the reduced average annual streamflow as described in Knight Piésold (2019r). A detailed description of this analysis is provided in Appendix K4.18. Figure K4.18-15 depicts the results of the effluent dilution calculations and linear regression analyses for effluent discharged into the NFK, SFK, and UTC. Results indicate that downstream of the WTP discharge points, effluent would be diluted in baseline water approximately nine times in NFK and 65 times in the SFK as they near the Koktuli River confluence, and about 275 times in the UTC by the time the stream reaches Iliamna Lake. Further dilution would occur as the NFK and SFK merge and flow towards Bristol Bay. For example, average streamflow in the lower Nushagak River near Ekwok is about 100 times greater than flows near the Koktuli confluence (Knight Piésold 2019r; USGS 2020f). Near the mine site, dilution of effluent would be least pronounced in NFK, because the NFK watershed is anticipated to have the greatest streamflow reduction from mine site water use and facility stream blockages, and would receive the greatest volume of treated effluent.

The mass load of metals, ions, and nutrients has the potential to be transported into wetlands and accumulate locally. Transport of loaded streamflow into wetlands could occur in those that are hydrologically connected to the NFK, SFK, or UTC. As described in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, the length of the main-stem streams that are bordered by wetlands ranges from about 30 to 80 percent of their total. Wetlands vegetation and soils function to physically slow the flow of water, and thereby increase the residence time of constituents and allow water to warm slightly via an albedo effect. Potential effects would be greater for bogs where soil types and peat are more likely to create an acidic and anoxic environment, than for marsh and shrub-type wetlands fringing river channels where pH and DO are likely to be similar to that of river water. Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, discusses potential impacts associated with mass loading transport into wetlands in greater detail.

As a result of stream connectivity to wetlands, there may be an increased potential for chemical reactions of certain constituents. In general, inorganic anions (i.e., chlorides, nitrates, and sulfates) and cations (i.e., calcium, magnesium, potassium, and sodium) typically form complex compounds in aquatic environments with metals and metal compounds. The formation of complex compounds is influenced by multiple factors, including but not limited to valence state, oxidation state, availability of counter ion, pH, and temperature. These compounds may be dissolved in water or adsorb to sediments, especially those with higher organic content or those containing other compounds available for binding (e.g., arsenic may adsorb to sediments with iron oxides, aluminum hydroxides, or manganese compounds). The individual chemical components of a complex compound can be subsequently released and form different compounds under various scenarios (e.g., reducing conditions in sediment, dissolution via microbial action, and volatilization and biotransformation of mercury). These compounds have varying levels of bioavailability and toxicity. Potential impacts to aquatic habitat from changes in environmental mass loading are described in Appendix K4.24, Fish Values.

The potential for the methylation of mercury as a result of the anticipated mass of sulfate to be released from WTPs was examined. Overall, sulfate loading was estimated to increase 119 percent above baseline due to effluent discharge in the three watersheds (see Table K4.18-21). Water quality samples indicate that baseline levels of mercury are low, with most laboratory samples yielding mercury concentrations below detection limits. Section 3.18, Water and Sediment Quality, provides a discussion of baseline mercury sample numbers, detection limits, percent of detections, and detected concentrations. While the presence of inorganic mercury in water is expected to be low, methylmercury has been detected in area fish tissue samples. The potential for environmental loading of sulfates to result in an increase in methylmercury production in the environment is further described in Appendix K4.24, Fish Values, along with a discussion of related uncertainties. Additional information pertaining to the toxicity of other trace elements is also provided in Appendix K4.24, Fish Values.

Effects from Deposition of Fugitive Dust—Fugitive dust from various mine site sources with elevated levels of certain metals would be deposited on soils surrounding the mine site. Impacts on surface water quality would be through erosion or leaching of these metals into runoff leading to downgradient waterbodies, or through deposition directly on waterbodies. In terms of impact extent, the modeled areal extent of dust deposition in construction and operation phases of the mine site is depicted in Figure 4.14-1 and PLP (PLP 2018-RFI 009a, PLP 2019-RFI 009b). Section 4.14, Soils, presents the incremental concentrations of metals that would be expected in the top inch of soil at the end of operations. Appendix K4.18 describes the methodologies used to calculate the incremental increase in surface water, and Table K4.18-18 and Table K4.18-19 show the results of deposition modeling to surface water. In terms of impact magnitude, the calculations indicate that the dust deposition would not result in exceedances of the most stringent water quality criteria (see Table K3.18-1) when added to baseline conditions or WTP outflow conditions (AECOM 2019h).

PLP has developed a draft fugitive dust control plan for mitigation and control of fugitive dust and wind erosion related to project activities. The final plan would be developed as design advances and would use BMPs and best available control technology (PLP 2018-RFI 071a). Dust suppression water would be used at the mine site and along the transportation corridor as described below (PLP 2018-RFI 021c). These impacts would be long term, lasting for the life of the mine, and would be expected to occur if the project is permitted and constructed. Within the limits of its regulatory authority, ADEC can require an assessment of ambient air quality to verify whether fugitive dust is causing or significantly contributing to concentrations of particulate matter above ambient air standards.

Effects from Dust Suppression Water—During operations, dust suppression at the mine site would use untreated contact water from the open pit WMP. This water source would be applied only to areas of the mine site where runoff is collected and treated. The impact on surface waters would be that this water is discharged as described above for treated water discharge. Outside of these areas, dust suppression would use non-contact water from other unaffected water sources outside of the mine site footprint (PLP 2018-RFI 021c).

Effects during Closure/Post-Closure—Once mining ceases, partial dewatering would be maintained within the open pit to allow the PAG waste rock to be moved from the pyritic TSF to the pit, and to maintain pit wall stability until the PAG waste rock buttresses potentially unstable lower walls of the open pit (see Section 4.15, Geohazards and Seismic Conditions, and

Appendix K4.15). An initial layer of PAG waste rock would be placed 1 year prior to deposition of pyritic tailings (Knight Piésold 2018d). The remaining PAG waste rock would be deposited in the open pit concurrently with the pyritic tailings as it is exposed during reclamation of the pyritic TSF (Knight Piésold 2018b, 2018d). The pyritic tailings would be re-slurried using water in the pyritic tailings, and the tailings slurry pumped to the open pit for subaqueous disposal. The water level in the open pit would be maintained to allow controlled placement and management of the PAG waste rock in dry areas of the pit, while keeping a water cover over the submerged pyritic tailings to prevent or minimize oxidation and acid generation or metal leaching. Backhauling of the PAG waste rock would end approximately 14 years into closure, and the transfer of pyritic tailings would end about 15 years into closure. Dewatering of the open pit would cease at the end of Closure Phase 1 once the transfer of these materials is complete. PAG waste rock would be submerged within 2 years of placement as the water level in the pit rises (PLP 2018-RFI 092). Once dewatering ceases, groundwater behind the pit walls would begin to rise to create a pit lake. The open pit would then be allowed to fill with direct precipitation, surface water runoff, and groundwater, but would be kept at a maximum management level so that groundwater would continue to flow into the open pit from all directions; and it would remain as a hydraulic sink to minimize the potential for subsurface releases to the environment (see Section 4.17, Groundwater Hydrology). The maximum managed elevation of the pit lake in closure is expected to be 890 feet amsl (Appendix K4.18, Figure K4.18-6). Additional general details of the pit lake are included in Table K4.18-12.

Surface runoff from reclaimed areas of the mine site would be collected, and if water quality meets water quality criteria it would be allowed to free drain to the environment. Otherwise, surface runoff water would be treated in the WTPs or directed to the open pit lake. The bulk TSF would be graded and revegetated to direct surface runoff toward the closure spillway at approximately closure Year 10. This would reduce infiltration and direct runoff water to the eastern end of the bulk TSF, where it would be collected in seepage collection and recycle ponds. In terms of magnitude, duration, and extent of impacts, surplus free water on the surface of the bulk TSF would be pumped to the main WMP through approximately Year 15 post-closure, then to the open pit through approximately Year 50 post-closure. Seepage water from the embankment seepage collection systems would be collected, and either treated in the WTPs, or directed to the pit lake until determined to be suitable for discharge, anticipated after approximately closure Year 50 (Knight Piésold 2018d).

Surface runoff into the pit lake would carry any metals leached from the pit walls. In addition, potentially contaminated groundwater would flow into the pit as described below under "Groundwater Quality." The groundwater capture zone is the area in which all groundwater would flow into the pit in closure. The extent of these zones in operations (end of mining) and closure are discussed in Section 4.17, Groundwater Hydrology.

Water quality in the pit lake would be expected to be initially acidic, becoming slightly alkaline over time, with elevated concentrations of TDS, hardness, sulfate, and some metals (aluminum, antimony, arsenic, cadmium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, and zinc) exceeding water quality standards as a result of the oxidation of sulfide minerals in the pit walls, and the natural concentrations of metals found in the unmined mineralized rock. Appendix K4.18 describes pit lake water quality modeling further. Table K4.18-7 through Table K4.18-10 summarize predicted lake water quality for a fully mixed pit lake during the four closure phases. The evolution of pit lake water quality during closure was further evaluated using a one-dimensional hydrodynamic model to determine if thermal and/or chemical stratification is expected to develop within the pit lake. The hydrodynamic pit lake model approach and water quality results are also summarized in Appendix K4.18, and Figure K4.18-9 through Figure K4.18-14.

Once the level of the pit lake has risen to about 890 feet amsl, anticipated to occur at approximately Year 23 post-closure (Knight Piésold 2019s), water would be pumped from the pit to maintain the lake level at the maximum management level, and treated as required at WTP #3 (redesigned for post-closure from WTP #1). In terms of magnitude and extent, the treated water would be discharged to the environment downstream of the mine site at the upstream end of Frying Pan Lake in the SFK drainage (Figure 4.18-1). The duration of impact would be permanent, and it would occur only if mine closure is approved as described.

Summary of Mine Site Effects on Surface Water Quality—As described above, direct and indirect impacts to water quality are likely to occur as a result of permitted discharges of treated water to drainages downstream of the mine site. The duration of these discharges would range from long term, lasting from construction throughout the life of the mine; and in some cases, throughout post-closure. Process-related (contact) water would not be considered WOUS or subject to APDES permitting while such water is retained in on-site water management facilities and recycled/reused on site. Contact water collected in mine facilities (e.g., bulk TSF, pyritic TSF) is not expected to meet Alaska water quality criteria for discharge (AAC Title 18, Section 70, ADEC 2018b) and would not be released directly to the environment without prior treatment to meet specific discharge requirements. WTP processes are expected to be effective in treating water to meet discharge criteria, although concerns regarding potential long-term increased TDS levels may require further investigation as design progresses, and/or adaptive management strategies are implemented during operations (see Chapter 5, Mitigation). State of Alaska water quality criteria, described in this section and Appendix K3.18 and Appendix K4.18, would be the basis of discharge limits set forth in an APDES permit, which would have monitoring requirements to ensure that discharged water meets applicable water quality criteria. The geographic extent of impacts on surface water chemical quality attributable to contact water would be limited to areas used for on-site storage of contact water before treatment. The magnitude of temperature effects ranging from about -1.6 to 2.8°C would occur up to 0.5 to 2.75 miles downstream of the mine site. Additional information pertaining planned monitoring and mitigation is included in Chapter 5, Mitigation. Water quality monitoring locations in operations and post closure are depicted in PLP (2019g).

Groundwater Quality

Section 3.17, Groundwater Hydrology, and Section 3.18, Water and Sediment Quality, address the affected environment with respect to groundwater flow and quality, respectively. The principal mechanisms responsible for potential effects on groundwater quality at the mine site are summarized below.

Effects from TSF Seepage—The main embankment of the bulk TSF would be designed to promote seepage to the bulk TSF main SCP, thereby minimizing the volume of water contained within the tailings impoundment, and promoting embankment stability (see Section 4.15, Geohazards and Seismic Conditions). In terms of magnitude and extent, groundwater that would be affected by vertical seepage from the unlined bulk TSF would primarily flow north down the NFK west drainage and be captured by the main SCP. The primary design criterion for management of this and other seepage collection systems at the mine site is defined as "no detectable seepage downgradient of the collection and pumpback systems" (PLP 2018j). Hydraulic containment of seepage flow from the bulk TSF would be achieved and maintained using a series of control measures, including:

- North-flowing underdrains beneath the bulk TSF impoundment and beneath the main embankment that flow towards the central underdrain
- Tailings beaches that would promote a north-sloping phreatic surface in the bulk tails

- Upstream liners, low-permeability core zones, and grout cutoff walls at the south embankment of the bulk TSF
- Monitoring and seepage pumpback wells downgradient of three topographic saddles on the northwestern and eastern sides of the impoundment and SCPs (Knight Piésold 2018a; PLP 2020d, 2019g; PLP 2018-RFIs 006, 006a, 008f; PLP 2019-RFI 135)

Hydraulic containment (described in Section 4.17, Groundwater Hydrology) would minimize the likelihood of seepage/leakage of contact water beyond the mine site:

- Seepage from the bulk TSF would flow toward the main SCP and be captured there.
- Potential leakage at lined facilities (i.e., pyritic TSF, main WMP, open pit WMP) would be captured in underdrains, collection points, and pumpback wells.
- The pit lake level in post-closure would be pumped and treated so all groundwater in the capture zone would flow toward and into the pit lake.

The drainage and hydraulic containment systems described above are currently only conceptual and would be further developed in final design. Drainage materials that would be placed beneath the bulk TSF impoundment and embankment would help minimize the amount of vertical seepage to groundwater (see PLP 2018-RFI 006, Figure 1).

In terms of magnitude and extent of impacts, groundwater modeling estimates that the bulk TSF would contribute approximately 1.7 to 5.5 cubic feet per second (cfs) of seepage to the underlying groundwater system during and at the end of mining (BGC 2019d). The extent of effects on shallow groundwater would be expected to be limited to the area beneath and between the bulk TSF and the SCP, with collection systems capturing and directing water. The extent could extend to deeper fracture-flow groundwater, depending on geologic and hydrogeologic conditions beneath the bulk TSF, but these flow paths are also predicted by the groundwater model to report to the main SCP (see Section 4.17, Groundwater Hydrology).

In terms of magnitude and duration of impacts, the seepage rate would decrease over time after closure as the tailings consolidate and pore waters are squeezed out. The duration of effects would be long-term, lasting for the life of the project, and certain to occur if the mine is permitted and constructed. Affected groundwater migrating beneath the bulk TSF and downgradient to the main SCP would flow through the overburden and underlying weathered bedrock units shown on cross-section M-1 in Section 3.17, Groundwater Hydrology, Figure 3.17-9, and described in Appendix K3.17, Table K3.17-1. Additional discussion of the potential for contaminated groundwater to migrate in units beneath the bulk TSF and SCP, and uncertainties in the groundwater model, is provided in Section 4.17, Groundwater Hydrology.

Containment of affected groundwater would be monitored using monitoring/pumpback wells to assess groundwater levels and quality (Knight Piésold 2018a). Any impacted groundwater that bypasses the SCP capture system is expected to be detected in these wells. Additional seepage collection, cutoff walls, and/or pumpback systems may be installed downstream if necessary, as determined by monitored water quality (PLP 2018-RFI 006a).

The predicted concentration of constituents in groundwater beneath the bulk TSF, and between the TSF and the main SCP, would be similar to those listed in Appendix K4.18, Table K4.18-4 for the main SCP. In terms of magnitude, several metals (antimony, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, molybdenum, nickel, selenium, silver, and zinc), TDS, and sulfate in the main SCP are predicted to exceed baseline concentrations and regulatory criteria at the end of mining and the end of closure phase 3, and therefore would require continued treatment at WTP #3 in post-closure to meet discharge criteria (Knight Piésold 2018d).

The pyritic TSF would be fully lined. Construction of the embankment foundation of the pyritic TSF would likely require dewatering (estimated to be approximately 1.7 cfs [BGC 2019c]). This water would be treated as necessary prior to discharge. The potential for liner damage (e.g., from ice or placement of waste rock) leading to leakage of tailings pore water was evaluated in the EIS-Phase Failure Modes Effects Analysis (FMEA), and the likelihood of occurrence was considered to be low to moderate (AECOM 2018l). In terms of magnitude and extent of impact, potential leakage through the liner would be diluted by unaffected groundwater. Mitigation measures such as underdrains and seepage pumpback wells would intercept seepage water and minimize potential impacts. Liner leakage, at a rate of 1 liter per second (L/s), was modeled by BGC (2019a), and indicates that leakage reaching the sub-drains and shallow groundwater beneath the pyritic TSF would migrate northward and be effectively captured in the SCP.

Based on the seepage collection systems and contingencies, the vertical extent of impacts on downgradient groundwater quality outside of the mine would be expected to be limited to shallow groundwater in overburden deposits, and the bedrock contact zone between the TSFs and seepage collection facilities. The magnitude and duration of impacts on local groundwater in the mine site are expected to exceed water quality regulatory criteria, and those effects would persist through the life of the mine, and well into post-closure phase 4. In terms of duration, groundwater impacted by limited seepage from the bulk TSF is predicted to improve over time after closure (Table K4.18-11) but would not meet criteria yet in closure year 105 (Knight Piésold 2019s). Collection and treatment of water at the main SCP would continue as long as required based on post-closure water quality monitoring (Knight Piésold 2018n). Should monitoring at seepage collection systems in post-closure indicate that water quality meets approved criteria for discharge without treatment, direct discharge would occur (Knight Piésold 2018d).

Effects from WMP Leakage—Table K4.18-4 shows the predicted concentration of mine-related constituents in water in the main and open pit WMPs. Water in these ponds is anticipated to contain TDS, sulfate, and a number of metals at levels exceeding discharge water quality criteria. Pond water leaking through the pond liners would be intercepted by underdrain systems included in the design of those facilities, and subsequently pumped back to the respective WMP (PLP 2018-RFI 019a). Groundwater model particle tracking suggest that the WMP underdrain systems and pumpback wells would effectively capture leakage of contact water through the liner in base case scenarios and all sensitivity scenarios evaluated (BGC 2019c) (see Section 4.17, Groundwater Hydrology).

In the case of the main WMP, in terms of magnitude of impacts to groundwater, the estimated maximum leakage rate through the liner of 1 L/s (Piteau Associates 2018a; BGC 2019a; PLP 2018-RFI 019c) or 0.035 cfs would potentially impact underlying shallow groundwater if it were to bypass the underdrain system. In terms of extent of impacts, without intervention, this water would be expected to mix with shallow groundwater and discharge into the NFK watershed. To prevent this, a sump and pumping system would be installed at the downgradient toe of the underdrain system, and monitoring/pumpback wells would be installed along the northern and western sides of the main WMP. Should monitoring of these wells show impacts from liner leakage, the wells would be used to intercept and recycle shallow groundwater back to the main WMP. As indicated in Knight Piésold (2019s) and PLP (2019g), the final location and spacing of pumpback wells would be determined, based on additional hydrogeologic investigation as design progresses, to minimize the likelihood of this occurrence.

Because the main WMP would be removed at the end of mining closure phase 2 (Knight Piésold 2018d), the duration of potential effects on groundwater quality would be through this closure phase, and would not occur during subsequent post-closure periods. After decommissioning of the main WMP, shallow groundwater would be monitored to detect any contact water that may have leaked through the liner. If a leak is detected, contact water would be collected via pumpback wells and transferred to the pit lake as needed (Knight Piésold 2018b). Based on data collected during construction and operations, the seepage collection/monitoring network would be expanded and adjusted as required (Knight Piésold 2018n).

Effects from Pit Overburden Stockpile Seepage—Seepage from pit overburden materials that would be excavated and stockpiled would be expected to affect surface water or groundwater quality. Potential effects would be limited by segregating mineralized overburden from non-mineralized overburden, and stockpiling mineralized materials that exhibit a high potential for leaching in the pyritic TSF. Prior to excavation, overburden materials would be characterized by drilling and sampling, thereby allowing materials to be segregated visually during excavation. This technique is common in open pit mining for grade control (PLP 2018-RFI 021c). As a secondary control to address placement of potential PAG material in the non-mineralized overburden stockpile, multiple lines of monitoring wells would be installed downgradient from the stockpile and monitored for exceedances of applicable water quality standards. If exceedances were observed, the wells would be converted to pumping wells to intercept and redirect impacted water to the open pit WMP for treatment and permitted discharge (PLP 2018-RFI 021c).

Effects on Seeps—Most overburden with seeps overlying the open pit would be removed, and seeps present in the footprints of the TSFs and mine facilities would be covered. However, should seeps occur downgradient of mine facilities, surface water runoff controls would be used to capture and route it to the appropriate collection ponds for treatment and subsequent discharge. Monitoring would also be conducted to recognize new seeps that may form, measure their water quality, and ensure that the seepage is captured and routed to the appropriate seepage control pond; or if water quality is satisfactory, discharged to the environment.

Dust Leaching to Groundwater—Fugitive dust deposited on soils surrounding the mine site has the potential to leach into groundwater. Section 4.14, Soils, presents the baseline and incremental concentrations of metals in soil at the end of mining. These results were compared to ADEC migration-to-groundwater levels to estimate the magnitude of this effect on groundwater. Appendix K4.18, Table K4.18-20 presents the metals concentrations in soil after dust deposition, as well as ADEC comparative action levels for the migration to groundwater criteria for soils. In terms of magnitude, the predicted percent increase in metals concentration in groundwater attributable to dust deposition was less than 0.8 percent for all metals, with the exception of antimony and copper, which are predicted to increase in concentration by approximately 3 and 6 percent, respectively. Modeling and calculations of dust deposition do not indicate that any new exceedances of the ADEC levels would result from dust effects. Arsenic was the only metal that would be expected to exceed these criteria; however, that exceedance would result from naturally elevated baseline soil conditions, and dust deposition would be expected to increase arsenic concentrations in soil by only about 0.6 percent. The duration of impact to groundwater would be long-term, lasting though the life of the mine, and would be expected to occur at this magnitude if the mine is permitted and built.

Effects from Pit Lake in Closure—Surface water in the pit would continue to be pumped out during the first 15 years of closure while pyritic tailings and PAG waste rock are placed in the pit. Pumping of groundwater may initially be maintained in an area of the open pit at the end of mining to facilitate safe placement of the waste while maintaining pit wall stability in the lower portion of the pit where faults are present (see Section 4.15, Geohazards and Seismic Conditions) (PLP 2018-RFI 023a). In terms of magnitude and extent, pumping of water from the pit during early closure, and cessation of most groundwater pumping while waste is being placed, would result in the groundwater level adjacent to the pit rising faster than the pit lake level rise, so that contact water in the pit is not likely to extend beyond the pit walls, except in the localized area of temporary wall stability depressurization. As discussed in Section 4.17, Groundwater Hydrology, hydraulic containment would be maintained during all closure phases because overall flow gradients would be toward the pit lake radially from all directions, thereby limiting the extent of migration and capturing any pit-contaminated groundwater (BGC 2019b; PLP 2018-RFI 019d).

In terms of duration of the impacts, all pit dewatering would cease once placement of the PAG waste rock and pyritic tailings is complete to allow the pit lake to rise and cover the waste. Inputs of contaminated water into the pit lake from the waste and walls are predicted to exceed regulatory limits for water quality for a number of constituents, including TDS, sulfate, and metals (see Table K4.18-7 through Table K4.18-10).

After lake level rise, groundwater gradients toward the pit would be maintained by managing the pit lake level through long-term pumping and treating of the lake water. With the pit water level maintained at the MM level of 890 feet amsl, groundwater flow is expected to be directed radially toward the pit from all directions, although there are uncertainties in the groundwater model, as described in Section 4.17, Groundwater Hydrology. At the MM level, the pit water would be expected to be retained in the pit, and would not contribute (flow out) to affect the quality of groundwater outside of the radius of influence of the pit. To maintain the lake level, the anticipated annual average pit water surplus is approximately 3 cfs (Knight Piésold 2018d). This rate is well below the WTP #3 open pit stream capacity of 44 cfs in later closure phases (HDR 2019g). Section 4.17 and Appendix K4.17, Groundwater Hydrology, provide additional information on the analysis of groundwater flow in closure.

Modeling of post-closure pit water quality indicates that the open pit water would need to be treated long-term (Knight Piésold 2018d, 2019s). To ensure that impacted groundwater is contained as planned, groundwater monitoring would be conducted at selected wells surrounding the pit lake to confirm that groundwater flow is toward the pit, and that impacted groundwater is not migrating outside of the pit (PLP 2019g, PLP 2019-RFI 135). Should the monitoring find that groundwater does not flow toward the pit, or that groundwater quality outside the pit is degraded during the post-closure period, the MM level (890 feet amsl) would be reconsidered, and the pit lake level would be lowered to maintain hydraulic containment. Once the groundwater and lake levels rise to the MM level, the water cover over pyritic wastes in the open pit would be maintained at all times to minimize oxidation. The depth of the final pit lake would be approximately 420 feet above the backfilled pyritic waste (Knight Piésold 2019s).

Pit lake modeling indicates that the lake would become thermally and chemically stratified (Lorax Environmental 2018), as discussed in Appendix K4.18. In terms of magnitude and extent, pit lake water quality predictions for various closure and post-closure time periods indicate that hardness and trace metals (aluminum, antimony, arsenic, cadmium, copper, iron, mercury, manganese, molybdenum, nickel, lead, selenium, and zinc) in near-surface (upper 30 feet) pit lake water would exceed discharge limits. Pit lake pH values are predicted to be slightly alkaline (7.6 to 8.2). At these pH values, the concentrations of some of the metals (aluminum, cadmium, copper, iron, mercury, manganese, nickel, lead, and zinc) may be reduced via precipitation, adsorption, or complexation (which was not accounted for in the model). However, several metals form oxyanions (arsenic, molybdenum, antimony, and selenium) are likely mobile at these pH values. Therefore, it would be important to continue to maintain the pit lake as a hydraulic sink long-term to control releases of these (and possibly other) metals to the environment.

Effects of possible pit wall failure during post-closure are described in Section 4.15, Geohazards and Seismic Conditions; and Section 4.17, Groundwater Hydrology. A pit wall failure could cause thermal or chemical destratification of the pit lake, changes in intake water quality to the WTP #3 open pit water treatment system, and changes to water treatment operations to maintain compliance with ADPES discharge permits and hydraulic containment of pit lake water.

Effects on Drinking Water Wells and Drinking Water Sources—Groundwater is abundant in the project area, and would be used as a source of potable water for the mine facilities. The water supply wells would be sited on a groundwater high upgradient and on the northern (i.e., opposite) side of the NFK east and north drainages that contain seepage collection systems for the pyritic TSF and main WMP (see Figure 4.16-1). Therefore, groundwater that would be potentially affected by mine site facilities would not be expected to affect drinking water sources used by on-site workers. Similarly, no effect would be expected on drinking water sources outside of the mine site area. The nearest water systems used by communities outside of the mine site are about 15 to 20 miles away from the groundwater capture zones at the mine site facilities. Impacts to surface water that serves as potential drinking water sources to local communities in the Bristol Bay region would not be expected due to capture, containment, and treatment of groundwater at the mine site.

Effects of Wetlands Reduction—Disruption, infilling, and removal of wetlands would be likely to influence groundwater recharge and discharge patterns, which would affect groundwater quality in the vicinity of the mine site. Currently, although sulfides appear to be naturally oxidizing in the deposit (pit) area, the groundwater is not acidic except in localized weathered bedrock zones in the pit area (see Section 3.18 and Appendix K3.18, Water and Sediment Quality). Reducing conditions in near-surface groundwater are prevalent, partly because of deposition of organic carbon from wetlands and infiltration of organic carbon during spring thaw. The redox (reduction-oxidation reaction) state of the overburden may change during mine operations as the water table is lowered, and previously saturated soils and sediments are exposed to oxygen. In terms of magnitude of impact, this change in redox conditions would be expected to result in the release of metals to groundwater as oxidation occurs, and possibly precipitate reduced metals within sediment pores. Concentrations of metals in shallow groundwater may also increase because of the disruption of wetlands and increased sedimentation, resulting in an increase in suspended particulates with adsorbed metals. If these effects on groundwater conditions were to occur, the effects would be in the groundwater capture zone of the open pit, and all impacted water would be treated prior to discharge to the environment.

Summary of Effects on Mine Site Groundwater Quality—The geographic extent of impacts on groundwater quality from mine site activities would be limited to effects on local groundwater in the near vicinity of mine facilities, within the footprint of the mine site. Section 4.17, Groundwater Hydrology, provides the results of groundwater model sensitivity analyses that describe the range of uncertainties in the extent of affected groundwater. The magnitude of impacts would be such that groundwater would not meet regulatory criteria at certain discrete locations in the mine site (e.g., groundwater beneath the bulk TSF and groundwater in the open pit as the lake level rises). Groundwater entering the pit, where it would mix with pit lake water, would be pumped and treated long-term to maintain the open pit as a hydraulic sink.

In terms of duration, groundwater quality beneath the NFK west and NFK east drainages in the immediate vicinity of the mine site would be impacted during operations, but would be expected to improve over time after mine closure. In the NFK east drainage, where contamination is expected to occur from leaks through the liners of the pyritic TSF and WMPs, removal of the sources of contamination during closure would allow natural attenuation processes such as flushing with recharged rainwater and snowmelt to eventually act to reduce contaminant levels in groundwater. In the NFK west drainage, consolidation of the bulk tailings from their own weight over time would be expected to reduce their permeability and the amount of leachate that would blend with upgradient background groundwater in the underdrains, and thereby reduce the concentration of contaminants reporting to the north SCP. Monitoring would be conducted at the SCPs after the end of mining and during the closure and post-closure periods, to determine whether groundwater quality in these localized areas improves after mining ceases. If monitoring shows that water quality is not improving during the post-closure period, additional remedies would be implemented to treat the impacted groundwater, as needed. These impacts are expected to occur through post-closure if the mine is permitted and constructed. Additional information pertaining to planned monitoring and mitigation is included in Chapter 5, Mitigation. Potential water quality monitoring locations in operations and post-closure are depicted in PLP 2019g (Figures 1 and 2).

Substrate/Sediment Quality

This section describes impacts on waterbody substrates. Impacts on wetlands substrates are addressed in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.

Effects of Fill Placement on Physical Substrate—The magnitude and extent of impacts of physical substrate would be that placement of fill for construction of TSFs, WMPs, stockpiles, seepage and sediment ponds, and other facilities at the mine site would bury substrate in a number of streams and ponds. Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, lists the acreages of fill placement in both waterbodies and wetlands.

Another impact of placement of fill would be changes in sediment supply to downgradient streams. In terms of extent of the impact, at mine site locations where streams would be filled, such as at the bulk TSF and associated seepage and sediment ponds, a portion of the downstream sediment supply to the NFK River originating from those source areas would be cut off, depleting the natural supply of sediment to downstream gravels, and potentially affecting aquatic habitats (see Section 4.24, Fish Values). A decrease in water flow velocities resulting from fill placement would also lower the natural level of coarse sediment transport. These impacts of placement of fill would be permanent, and certain to occur if the project is permitted and constructed.

Effects of Erosion on Physical Substrate—Sediment release from erosion during construction and operations would be likely to impact water quality. BMPs (described above under Surface Water Quality) would be followed, and sediment control measures would be applied during construction, including the use of temporary settling basins and silt fences. Sediment control measures during operations through closure would include a number of diversion channels that would direct surface runoff away from project facilities, and sediment ponds that would allow material to settle out of the water column, inhibiting the extent of downstream sediment transport. Surface runoff and seepage from stockpiles would be captured by drainage ditches and routed into sedimentation ponds to allow settling before water is released downstream. The potential exists for erosion during periods of high precipitation and runoff, resulting in an influx of fine sediment and increased turbidity into gravel-dominated streambeds. BMPs would be designed to manage and mitigate the effects of large precipitation events. In terms of magnitude and extent of impacts, suspended fine particles would be expected to settle, and fill in interstitial spaces among the gravel, potentially affecting the streambed ecosystem (see Section 4.24, Fish Values).

Construction of the mine site facilities would block some streamflow, reducing natural erosion during high-precipitation events. However, in terms of magnitude and extent of impacts, increased streamflow where WTP effluent is discharged would increase the quantity of sediment that would be eroded, transported, and deposited downstream, thereby modifying substrate. Current designs for WTP discharge indicate that each outfall pipeline would be equipped with a discharge chamber to mitigate the potential for erosion at discharge points. Discharge chambers would be buried at sufficient depth for thermal insulation against freezing. Each outfall pipeline would be designed first to drain into the discharge chambers to reduce the energy of water outflow, then to release the water into the drainage (Knight Piésold 2018f). The duration of impacts would be long-term, and possible if control measures are inadequate or fail.

Impacts on Sediment Quality during Construction and Operations—Mining and exposing rock to chemical and physical weathering and erosion may increase the natural (pre-mine) rates of these processes and release constituents into surrounding surface water and substrate, thereby resulting in direct impacts to sediment quality. The impact would be that substrate may be inundated with newly eroded materials, or undergo changes in chemistry due to the presence of weathering by-products. The evaluation of impacts on sediment quality depends largely on water quality and the other direct sedimentation impacts described above (e.g., erosion, dust). In terms of magnitude and extent, the chemical quality of sediment in some sections of streams at the mine site would be altered by fill placement, sediment accumulation upstream of embankments, and migration of contact water to downstream collection facilities. As described below, potentially contaminated sediment beneath TSFs and SCPs/WMPs would be monitored after closure and remediated if necessary (Knight Piésold 2018b).

In terms of the extent of impacts on sediment quality, containment structures, and implementation of BMPs would limit impacts on sediment quality from surface disturbances to the project footprint. Water would be treated before discharge, and the potentially affected sediment would be contained by seepage and sediment ponds upstream of the discharge points. Likewise, although sediment in fully lined or contained facilities such as the pyritic TSF, WMPs, and pit lake would contain PAG materials and metals from the mining process, these would not affect native sediment in downstream waterbodies if properly managed.

Impacts on Sediment Quality from Fugitive Dust—Fugitive dust from various mine site sources and activities has the potential to affect sediment chemistry, particularly the concentration of metals. Appendix K4.18 provides the methodology used to calculate the predicted incremental increase in metals concentrations in sediment, and Table K4.18-17 shows the results. In terms of magnitude, total increases in metals concentration in sediment due to dust deposition are predicted to be less than 1 percent for all metals except antimony, which would be expected to increase by about 3 percent. Dust deposition would not be expected to result in any exceedances of the most stringent sediment quality criteria (Table K3.18-1).

Effects on Sediment Quality during Closure—Residual impacts from mine operations could remain beneath operational facilities. During closure and reclamation, soil and sediment beneath the facilities slated for removal (such as the pyritic TSF and WMPs) would be tested for contaminants, and any impacted materials exceeding applicable regulatory levels would be either treated or removed, and placed in the open pit (Knight Piésold 2018b). Surface runoff and groundwater that may be hydraulically connected to on-site sediment would be monitored downstream of the TSFs and WMPs at selected locations during post-closure to verify that potentially contaminated sediment is not affecting downstream water quality.

It is possible that mine-impacted sediment would remain between the reclaimed pyritic TSF and WMP footprints that are tested at closure. In these locations, the duration of impacts would be such that sediment can retain chemical constituents and slowly release them into overlying water, for decades or longer. Contaminants can be flushed out of coarse sediments such as gravels relatively quickly; by contrast, fine sediments like silts, muds, and clays found in some of the glacial lake deposits at the mine site could retain contaminants in porewater, and could store them for long periods of time because of their higher surface area. Even in areas where downstream water quality would be monitored, contaminants held in sediment would be expected to continue to be slowly released into waterbodies over the long-term through runoff.

4.18.4.2 Transportation Corridor

Surface Water Quality

Road Corridor—In terms of magnitude, duration, extent, and likelihood, long-term impacts on surface water quality along the road corridor resulting from erosion at construction sites, material sites, and stream crossings would be expected, potentially causing increased suspended solids and turbidity in downstream waterbodies. Increased turbidity is expected to return to baseline levels within the short-term (e.g., days or weeks) following completion of construction and BMP placement. Baseline levels of turbidity and suspended solids at stream crossings along the road corridors are discussed in Section 3.18, Water and Sediment Quality. Erosion and sedimentation would be managed by implementing BMPs as described in Section 4.14, Soils and Chapter 5, Mitigation.

Based on a field review of geology at material sites, PAG material has not been identified at any site along the transportation corridor, and the rock types present are not typical of PAG rock. Rock types would be investigated further during site evaluation before construction. If PAG material is identified, it would not be used for construction, and the material site would be relocated to an alternate location with non-PAG rock (PLP 2018-RFI 035).

Inadvertent release of hydrocarbons or other toxins to surface waterbodies would result in a direct impact to surface water quality. The likelihood of small hydrocarbon spills (related to vehicles or the ferry) from transportation-related sources would be reduced through the application of BMPs and fuel handling requirements. Should a small spill occur, controls would be implemented, including an in-place spill response plan. In addition, based on the fate and transport of hydrocarbons, it would be expected that lighter-weight hydrocarbons would volatilize from the surface water, while heavier hydrocarbons would partition to sediment. Additional discussion regarding the potential for small amounts of vehicle- or ferry-related pollutants to affect streams along the transportation corridor is discussed below under "Substrate/Sediment Quality." Section 4.27, Spill Risk, discusses the potential for containers filled with concentrate to affect water quality. The potential for fugitive dust transport into streams at bridges and stream crossings along the transportation corridor is expected to be minimal, because concentrate containers and trucks would be spray-washed prior to departing from the mine site.

Snow removal along the transportation corridor would be required and would generate snow piles adjacent to the roadway and potentially in snow storage areas. Although the volume of snow would be unchanged from natural conditions, piled snow would generally melt at a slower rate than undisturbed snowpack, and would therefore result in runoff effects lasting later into the spring breakup season than might otherwise be seen. The effect of this runoff would be similar to runoff from natural snowpack.

Ferry Construction and Operations—In terms of duration and magnitude, short-term but recurring impacts on surface water quality would result if ferry-induced suspended sediment in Iliamna Lake near the terminals were to exceed baseline levels (see Appendix K3.18, Table K3.18-13). However, because the ferry would approach the dock perpendicularly at low power, and the propeller base plane would be 4 feet above the keel, the potential for propeller-induced erosion of the lakebed would be limited (PLP 2018-RFI 013). In terms of magnitude and duration, if fine bottom sediments were resuspended by ferry operations, it is expected that TSS concentrations would be expected to return to baseline levels within a short distance from the ferry, depending on the amount of sediment disturbance, sediment characteristics, and water conditions. Lake bottom substrate size, water depth, and ferry operations would affect the magnitude and extent of ferry-related impacts on surface water quality.

Stormwater runoff at the ferry terminals would be a potential source of impacts on surface water quality, potentially carrying suspended material and contributing to increased turbidity. Releases from ferry terminal facilities (e.g., generators, maintenance shops, or parking areas) would have the potential to affect surface water quality through stormwater runoff. Releases at the ferry terminals would be reduced through implementation of engineering controls (e.g., secondary containment, planned material management, and the presence of spill response equipment). In addition, stormwater capture and treatment systems would be in place at both ferry terminal locations to capture potential contaminants (PLP 2018-RFI 093). The duration and likelihood of impacts from construction and operation of ferry terminals would be long-term, and possible if control measures are inadequate or fail.

Groundwater Quality

Road construction, material site development, and ferry operations are not expected to affect groundwater quality.

Substrate/Sediment Quality

Erosion Effects—Project-induced erosion and increased sedimentation on waterbody substrates would be expected to occur during construction activities such as vegetation removal, excavation, and grading of road beds and material sites. In terms of duration and magnitude, long-term impacts ranging from direct inundation of substrate to minor changes to substrate characteristics and chemistry would result. Withdrawal of water from permitted waterbodies during construction and operations also has the potential to disturb fine sediment on streambeds and lakebeds. BMPs such as dust control and erosion and sedimentation control measures, and compliance with permit stipulations for water extraction methods would be followed to reduce potential impacts. The extent of effects during road construction would be limited to stream crossing locations within the construction right-of-way, and downstream. The duration and potential for erosion and sedimentation is expected to be seasonal (reduced in winter by frozen conditions), and to continue for the life of the unpaved roads, which would be permanent, because they would be needed to support water treatment at the mine site post-closure.

Should BMPs be inadequate or overwhelmed by high-precipitation events, eroded soils and sediments would be transported by water and wind, potentially causing sedimentation into nearby waterbodies. Section 4.24, Fish Values, describe effects on fish habitat and aquatic resources. Streams intersecting the transportation corridor vary in grain size and substrate composition, with some crossings composed mainly of sand, silt, and organic material; and others having a higher concentration of gravel, cobbles, and boulders (Section 3.18, Water and Sediment Quality) (PLP 2018-RFI 036). The Gibraltar River bridge crossing location is largely dominated by gravel and cobbles. Stream crossings in areas where substrate is predominantly fine-grained would likely be subject to greater erosional effects and impacts on substrate than those with predominantly coarser substrates (see Section 4.16, Surface Water Hydrology, for discussion of erosion and sedimentation at stream crossings).

Placement of Fill Material—Road construction would include the placement of fill that may potentially affect waterbody substrates at stream crossings, lakes, and ponds along the transportation corridor, resulting in a direct long-term to permanent impact to sediment. Fill and riprap would be placed at certain bridge abutments and at the ends of culverts larger than 3 feet in diameter to protect the bridge structures and substrate from erosion (PLP 2019e, f). Fill would also be placed inside larger culverts requiring fish passage to simulate streambed material for aquatic habitat. The areas and lengths of streams affected are quantified in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, Table 4.22-2, and shown in Appendix K4.22 on Figure K4.22-1. The magnitude of the direct effect of fill placement would be to permanently bury existing sediment, because the road would remain during post-closure. In terms of extent and duration, fill placement at the ferry landings would extend about 105 to 155 feet onto the nearshore lake sediment (PLP 2018-RFI 093), and would remain in place at closure. Potential indirect effects under CWA Section 404(b)(1) include temporary localized sediment suspension and redeposition downstream during construction.

Sediment Contamination—Fuel, oil, and lubricants would be used during the normal course of operations; and if not properly managed, these materials could be inadvertently released onto the roadbed, and run off to stream or pond substrates, or could be released into Iliamna Lake and incorporated into lakebed substrate, resulting in direct impacts to sediment quality. These potential impacts related to sediment contamination would be reduced by following BMPs and fuel handling requirements, and would extend throughout the life of the mine and into post-closure. Section 4.27, Spill Risk, addresses impacts from potential major spills along the transportation corridor.

4.18.4.3 Amakdedori Port

Surface Water Quality

Surface Water Runoff—Amakdedori port would be the shoreline hub for shipping, receiving, and storage of concentrate containers, fuel, reagents, and other freight for the project; and as a result, would experience impacts from those activities. In terms of magnitude and extent, the primary potential direct impact from surface water runoff would be the transport of contaminants from the port facilities into adjacent marine waters. These direct impacts would be reduced through engineering controls. For example, the outside of concentrate containers would be vacuumed or spray-washed at the port site, mitigating the transport and impacts associated with concentrate dust (PLP 2018-RFI 45). In addition, the secondary containment (container barrier wall) built around the fuel tanks, and a perimeter containment curb constructed around the terminal would prevent or minimize surface water runoff from these facilities and activities from reaching off-site surface water. Container wash water would be recirculated through the wash equipment following filtration and the removal of solids. Removed solids would be collected and transported back to the mine site for storage in the pyritic TSF (PLP 2019-RFI 159).

The WTP at Amakdedori port would treat surface runoff from the port facilities, truck wash bays, and concentrate container wash water, which could potentially contain constituents from the above sources. Treated and filtered water would be discharged into marine waters via an outfall pipeline and dispersion chamber. Any residual solid waste from the port site WTP would be removed and hauled to the mine site for storage in the pyritic TSF (HDR 2019g). Additional details regarding port site water treatment processes are described in Appendix K4.18.

In terms of magnitude and extent of impact to water quality, runoff water from the port facilities would have some similarities to mine contact water in terms of solids, but would not be expected to have the same levels of TDS, given the lack of material processing. Prior to discharge, the treatment process would include dissolved metal oxidation using potassium permanganate, followed by co-precipitation with ferric chloride. Water from the co-precipitated solids would flow into flocculators/clarifiers to separate out the solids. The clarified water would then be treated with sodium hydrogen sulfide, sodium hydroxide, and ferrous sulfate to further co-precipitate the remaining metals under reducing conditions. The solids removed would be thickened and disposed of appropriately, either at the mine site in the pyritic TSF, or at an approved off-site disposal facility via barge. As discussed in Appendix K4.18, water treatment would also address any hydrocarbons (petroleum, oil, lubricants) in the runoff (PLP 2018-RFI 087). The treated water would be suitable for discharge, with a discharge point in marine waters at the end of the dock structure. A potable WTP and a sewage treatment plant would also be at the port site. The duration of potential impacts would be for the life of the project, if the mine is permitted and the Amakdedori port is constructed and operated.

Dust Impacts on Marine Water Quality—In terms of impact potential, dust generation during bulk carrier loading operations would be mitigated by implementing BMPs to prevent or minimize the dust from entering the water. The copper and gold concentrate containers would be lowered into the hold of the bulk carrier prior to being emptied, deep enough to prevent or minimize crosswinds from generating dust. The containers would be emptied within 10 feet of the concentrate pile, minimizing dust generation, and the hold would be filled to only approximately 50 percent of capacity. Based on the typical dimensions of a bulk carrier, the inverting and discharge of containers would occur at least 20 feet below the hatch. The concentrate is expected to still be moist from processing, but a water fog system could be installed to minimize dust if required (PLP 2018-RFI 009; PLP 2018-RFI 045). Section 4.27, Spill Risk, addresses impacts on water quality under potential upset conditions. Additional information pertaining to mitigation of impacts associated with fugitive dust is included in Chapter 5, Mitigation, as well as the conceptual Fugitive Dust Control Plan (PLP 2019-RFI 134).

Impacts on Salinity Gradients—Salinity gradients that might occur naturally at the locations of freshwater discharges into the port areas would assimilate quickly into adjacent marine waters due to natural mixing by wind-driven currents and waves, and therefore would not be affected by port operations.

Suspended Particulates/Turbidity from Caisson Placement—In terms of magnitude and duration of potential impacts on marine waters, increased concentrations of suspended sediment and redeposition would occur in Kamishak Bay during the preparation of the seabed and placement of caissons for the dock structure. Such conditions could persist for up to several hours after the completion of construction. However, one advantage of a caisson-supported dock is a reduced impact on the seabed compared to an earthfill causeway and sheet pile dock under other alternatives. The duration and extent of the increase in suspended sediment concentrations would depend on the amount of fine sediment in the fill material and disturbed seafloor material, as well as weather conditions (i.e., tides and wind-driven currents and waves would disperse suspended sediment even as it settles to the seabed). Section 4.16, Surface Water Hydrology, also describes impact of in-water structures.

Groundwater Quality

Impacts on groundwater quality at the port site are not expected. No excavation or placement of fill would occur at depths that intersect the water table. Using groundwater for drinking water supplies at the port would not adversely affect groundwater quality. A single groundwater well is planned for the port site for potable water supply (location to be identified during detailed design). The well would be sited on uplands far enough from shore to mitigate the risk of potential saltwater intrusion, and water would be piped to the port site from the wellhead (PLP 2018-RFI 022a).

Substrate/Sediment Quality

Effects on Freshwater Substrate—In terms of magnitude, extent, and duration, direct impacts to sediment in Amakdedori Creek on the southwestern side of the terminal and in ponds to the north may occur as a result of erosion and overland runoff, especially during construction. However, BMPs would be in place to avoid or reduce erosion and runoff. The port terminal would be built at an elevation of 35 feet, about 15 feet above the floodplain of Amakdedori Creek. As described above, runoff from the terminal would be contained and treated before discharge to Amakdedori Creek. Section 4.14, Soils, and Section 4.16, Surface Water Hydrology, provide further descriptions of BMPs and potential flooding effects, respectively.

Effects on Marine Substrate—The caisson-supported causeway and dock structure under Alternative 1a would excavate and cover approximately 2.1 acres of marine substrate where caissons would be placed to support the dock structure. The duration and likelihood of effects would be permanent and certain to occur if the project is permitted and Alternative 1a is selected.

Fuel, oil, lubricants, or other liquids such as bilge water or rinse water may leak from vessels into Kamishak Bay and Cook Inlet waters, and potentially become incorporated into seafloor sediments. However, strong currents, shallow water, and high tidal exchange in Cook Inlet create an ongoing flushing of seawater in the inlet (USACE 2013). Potential contaminants from marine vessels accessing Amakdedori port would likely be diluted and flushed into the North Pacific Ocean (Section 3.18, Water and Sediment Quality). Section 4.27, Spill Risk, discusses impacts from upset conditions.

4.18.4.4 Natural Gas Pipeline Corridor

Surface Water Quality

As discussed above, small leaks from vessels could occur in Cook Inlet waters during pipeline construction, and would likely be dissipated by strong currents and tides. Trenching and pipe-laying activities, including the construction and placement of permanent berms in both Cook Inlet and Iliamna Lake, would result in increased turbidity in the near vicinity of these activities. Differences in construction methodology used in Cook Inlet may result in variations in the amount of suspended sediments and increased water turbidity; however, these variations are not anticipated to be significant. These effects are expected to be temporary, reaching baseline levels within hours or days after construction, independent of trenching method. Additional discussion of construction impacts during pipeline installation is provided in Section 4.16, Surface Water Hydrology.

The magnitude, duration, extent, and likelihood of impacts to onshore surface water quality in the natural gas pipeline corridor would be associated with installation of the pipeline at water crossings and the use of local water sources for hydrostatic testing. Impacts at stream crossings would be the similar to those described above for the transportation corridor, and could include interception of overland surface flows by the pipeline ditch, erosion and sedimentation from exposed trench spoils and frost heaving, and release of hydrostatic test waters. Stream crossing impacts would be different for the stand-alone section of pipeline between Iliamna and the mine access road (i.e., where the pipeline would not be co-located with and buried in the road prism) and could include runoff from open cut trenching and overland access. Discharges to freshwater or the land surface from activities associated with construction and operation of the natural gas pipeline (including horizontal directional drilling [HDD], hydrostatic testing, or other potential discharge sources) would be regulated under ADEC Wastewater Discharge Authorization Program, General Permit AKG320000, Statewide Oil and Gas Pipelines.

In terms of magnitude of effects, surface water quality at pipeline stream crossings is expected to be within water quality standards for turbidity during construction. Natural turbidity measurements at stream crossings along the transportation corridor were mostly below the instrument's minimum detection level of 7 to 11 nephelometric turbidity units (NTUs) during 2018 field studies (see Section 3.18, Water and Sediment Quality) (PLP 2018-RFI 036). ADEC water quality standards specify that turbidity levels may not exceed 5 NTUs above these conditions (when the natural turbidity level is 50 NTUs or less). It is possible that isolated occurrences of impacts above this standard could occur temporarily during construction (e.g., during high-precipitation periods along summer construction segments); however, planned redundancies in BMPs, erosion and sediment control measures, and reclamation/cleanup crew functions would reduce potential impacts. Exceedances of turbidity standards would not be expected during operations if appropriate pipeline cover material is applied, consistent with the US Department of Transportation Pipeline and Hazardous Materials Safety Administration code and BMPs, including water bars, sediment traps, or diversion features.

Impacts to surface water quality in excess of allowable standards from erosion of HDD sites during and after construction would not be anticipated if proper procedures and BMPs are applied (PLP 2018-RFI 011). The composition of drilling fluid typically includes water and bentonite. Other additives may be added as required, and would be selected and used in compliance with the ADEC General Permit AKG320000, Statewide Oil and Gas Pipelines. HDD operations into Cook Inlet, in which one end begins above ground and terminates underwater, is a trenchless crossing approach that minimizes effects on surface water. Design parameters, such as the geometry of the drillhole, would be selected to minimize fluid loss (PLP 2019-RFI 011a).

The removal of water from rivers and small lakes along the route for hydrostatic pipeline pressure testing would be required. The annual water volume removed for testing and road construction combined would range from 1 to 8 million gallons per water extraction site over a 3-year period (see Table K2-7). Water withdrawals would be conducted under stipulations of applicable State permits intended to minimize impacts to source waters; therefore, impacts on surface water quality from hydrostatic testing are not expected. Discharges of hydrostatic test water would meet the requirements of the applicable APDES general permit, or other State-issued permit as applicable, depending on whether discharges are to land or water.

Groundwater Quality

Trenching Effects—The pipeline trench would likely intersect shallow groundwater intermittently along the overland portion of the route, causing potential impacts on groundwater quality similar to those of the transportation corridor. In areas of shallow groundwater, there would be local alterations to groundwater flow patterns (Section 4.17, Groundwater Hydrology), and small changes in the composition of groundwater that would likely not exceed applicable regulatory criteria. The extent of groundwater impacts would be limited to particular areas, primarily in the vicinity of stream crossings.

Horizontal Directional Drilling Effects on Drinking Water Wells—HDD operations would be required for the natural gas pipeline at the Kenai shore approach near Anchor Point, and potentially at other locations as permits require. Drilling fluid would likely be composed of bentonite and water. The potential risk exists for drilling fluids, injected under pressure, to propagate away from the borehole and escape into the local aquifer (PLP 2018-RFI 051). On the Kenai Peninsula, 12 private water wells exist within 0.5 mile of the planned HDD route, with the closest well approximately 100 feet from the proposed HDD route. As described in greater detail in Section 4.17, Groundwater Hydrology, the closest private water well is directly downgradient of construction activities and compressor stations. As a result, there is potential for well contamination as a result of leaked fluid, fuel spills, or diffusion of natural gas into the aquifer.

Recommendations are provided in Appendix M1.0, Mitigation Assessment, to conduct further evaluation and planning to avoid impacts to the closest drinking water well in Anchor Point; these measures have been adopted by the Applicant. Drilling fluid returns would be closely monitored during operations to ensure no excessive fluid loss. Dewatering would not be required for HDD operations, precluding the risk of changes in local groundwater flow patterns (see Section 4.17, Groundwater Hydrogeology). Drilling fluid returns would be treated via a separation system, and the cleaned fluid would be reinjected into the borehole for use during drilling, or stored in tanks at the surface for later disposal off site (PLP 2018-RFI 051).

Substrate/Sediment Quality

Potential impacts on waterbody substrate from trenching, erosion and sedimentation, fill placement, and contamination would be similar to those described above for the transportation corridor. No waterbody substrates would be crossed by the pipeline segment east of Cook Inlet.

Construction and installation of the pipeline crossing Cook Inlet would require trenching and disturbance of bottom substrates. This would result in increased sedimentation in the vicinity of the pipeline. These impacts are anticipated to be minimal in extent compared to the size of overall substrate in Cook Inlet; and are likely to be temporary, with sediment characteristics expected to return to near baseline conditions shortly after pipeline installation is complete, given the high-energy tidal environment in Cook Inlet. Differences in the trenching methodologies used may result in variations in sedimentation and the amount of seafloor bottom disturbed. An overview of potential construction technologies to be used is included in PLP 2019-RFI BSEE 1. Although all methods would create sedimentation effects, those proposed for the shallower depths (clamshell, long-reach backhoe) are likely to disturb a larger area of substrate, but create less overall sedimentation distant from the excavation, than those proposed for deeper water (jetting, mechanical trenching), which use high pressures and fluidize the dredged material.

West of Cook Inlet, trench excavation and placement of cover material at stream crossings would be within the acreages documented for the road fill prism in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites. BMPs would be in place to control runoff and erosion during trenching, backfilling, and other ground-disturbing activities; therefore, impacts would be avoided or minimized.

Placement of fill at pipeline landfalls in Cook Inlet and Iliamna Lake would entail trenching into the existing bottom sediment and covering the pipeline with at least 3 feet of fill to a water depth of 12 feet (PLP 2018-RFI 013). Additionally, pipeline installation in Iliamna Lake would require the construction of permanent berms using clean, graded, engineered fill and rock to support pipeline spans (PLP 2020-RFI 164). Construction of berms would result in the burial and compaction of lake bottom sediments beneath berms. Typical berm segments would be approximately 100 feet in length and about 1.5 feet high (PLP 2020-RFI 164). Section 4.16, Surface Water Hydrology, further addresses the potential for sediment suspension, plume transport, and redeposition to occur during construction in the marine environment.

4.18.5 Alternative 1

This section describes the impacts associated with Alternative 1. Alternative 1 is similar to Alternative 1a, with a modified transportation and natural gas pipeline corridor in and north of Iliamna Lake.

4.18.5.1 Mine Site

Under Alternative 1, impacts to the mine site would be the same as under Alternative 1a.

Summer-Only Ferry Operations Variant—The magnitude of impact of potential operational scenarios under the Summer-Only Ferry Operations Variant would be an additional effect on substrate because of the increased operational footprint at the mine site (Ausenco Engineering 2018). In terms of extent, ore concentrates and additional diesel fuel would be stockpiled at the mine site, requiring additional container and fuel storage areas that would total approximately 38 acres. These storage areas would be constructed partially or wholly on wetland areas, thereby directly affecting substrate. The impacts would be long-term, and would occur if the Summer-Only Ferry Operations Variant is chosen, and the mine is permitted and built.

4.18.5.2 Transportation Corridor

The transportation corridor for Alternative 1 is the same as for Alternative 1a south of Iliamna Lake, with the port access road connecting Amakdedori port to the south ferry terminal. The ferry would traverse Iliamna Lake from the south ferry terminal to a north ferry terminal near the mouth of UTC. Potential impacts of ferry operations would be similar to those described for Alternative 1a, with potential variation in the location and magnitude of impacts due to the alternate and shorter ferry route.

North of Iliamna Lake the transportation corridor extends from the north ferry terminal to the mine site, and includes the Iliamna spur road to the airport. The Alternative 1 road system results in approximately 3 percent fewer stream crossings than Alternative 1a. Water quality and substrate impacts associated with the road segments and material sites would therefore be expected to be incrementally less than Alternative 1a. As in Alternative 1a, the impacts that would be expected would be potential direct and temporary effects on water quality due to sedimentation and turbidity generated through construction activities, which would be limited by use of BMPs and engineering controls (PLP 2018-RFI 086).

Summer-Only Ferry Operations Variant—Under the Summer-Only Ferry Operations Variant, the magnitude and duration of impacts from activities at the Iliamna Lake ferry terminals would be reduced for approximately 6 months per year, during the winter (Ausenco Engineering 2018). As a result, roadway use would also be greatly reduced, particularly on the southern side of Iliamna Lake. During the period of no use, the potential for impacts on substrate and sediment quality would also be reduced because of the lower activity levels. However, the potential for impacts would not be eliminated entirely, because fuel, lubricants, or other potential contaminants would still be stored at local ferry terminal facilities, and because some roadway use would still be expected. During the periods of ferry operation, the magnitude of activity would approximately double to account for the reduced length of the operational season.

Kokhanok East Ferry Terminal Variant—The transportation corridor under this variant would have similar effects to those of Alternative 1, with a slight variation in the location of the ferry crossing and stream crossings south of Iliamna Lake. The type of impacts to surface water and substrate at stream crossings would be similar to those described under Alternative 1a, but would affect 10 fewer stream crossings than the Alternative 1 base case. Increased turbidity from road construction activities at stream crossings is expected to return to baseline levels within the short-term (e.g., days or weeks) following completion of construction and BMP placement. While no turbidity measurements were collected along the road associated with the Kokhanok East ferry terminal variant (Section 3.18), baseline conditions at stream crossings in this area are expected to be similar to those collected along the main port access road due to the similar nature of the terrain.

4.18.5.3 Amakdedori Port Site

Impacts associated with the port site for Alternative 1 would be greater than described for Alternative 1a due to more invasive construction of a fill causeway and dock structure, as opposed to the caisson-supported dock under Alternative 1a.

In terms of magnitude and extent of impacts on marine substrate, the causeway under Alternative 1 would be approximately 1,200 feet long with an average base width of 250 feet, and the wharf would extend another 700 feet, with a width of 120 feet (PLP 2018-RFI 093); the footprint on the floor of Kamishak Bay would be approximately 11 acres (see Chapter 2, Alternatives, Table 2-2). The duration and likelihood of effects would be permanent and certain to occur if the project is permitted and the causeway is constructed. Placement of fill and riprap on top of the seabed during causeway construction and installation of sheet pile for wharf construction would result in direct impacts, including the burial of substrate beneath the footprint, disturbance of seafloor sediment during fill placement and sheet pile driving, and settling of suspended solids away from the footprint, as described above under Surface Water Quality. Dredging of offshore sediment would not be required at the Amakdedori port site. Section 4.24, Fish Values, discusses impacts on the primarily soft sediment habitat types in this area.

Fill material would consist of either blasted granitic bedrock trucked along the road from the closest material site, MS-A08, or imported by barge from existing commercial sources (PLP 2018-RFI 005; PLP 2018-RFI 035) such as the granite quarry at Diamond Point (ADNR 2014a). The existing marine substrate at the port site consists of subtidal sands and gravels (GeoEngineers 2018a; PLP 2018-RFI 039). Although sediments in the area are generally coarse-grained (Section 3.18, Water and Sediment Quality), project-related activity would contribute to the magnitude, duration, extent, and potential of increased suspended sediment levels in marine water around the port site.

Summer-Only Ferry Operations Variant—In terms of magnitude and extent, the Summer-Only Ferry Operations Variant would result in an increased operational footprint at the port site, which would cause increased effects on substrate (Ausenco Engineering 2018). The additional concentrate storage under this variant would require placement of fill along the eastern bank of Amakdedori Creek (PLP 2018-RFI 065). Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, provides the acreage of wetland substrate loss under this variant. The impact of additional fill placement would be permanent, and certain to occur if the Summer-Only Ferry Operations Variant is chosen, the project is permitted, and the port is built.

Pile-Supported Dock Variant—Compared to the causeway alternative, this dock variant would not deflect longshore currents in the same manner as a solid-fill causeway. In terms of magnitude and extent, wake effects would be limited to a few pile diameters' distance from each pile (on the leeward side). No alteration of water movements or sedimentation processes would occur. Other than the piles displacing small areas of seafloor sediment, there would be no fill placement and burial of marine substrate. Vibrations caused by pile driving during construction could affect sediment substrate; however, these effects would be limited in duration to the actual pile-driving period.

4.18.5.4 Natural Gas Pipeline Corridor

Impacts under Alternative 1 associated with the portion of the natural gas pipeline south of Iliamna Lake and crossing Cook Inlet would be the same as described for Alternative 1a. The pipeline would cross along the bottom of the lake from the south ferry terminal and extend to the north ferry terminal. Impacts to lake water and substrate would be the same as described for Alternative 1a, with potential variations in impacts and magnitude of impacts due to the alternate location and decreased length of lake crossing. Impacts to water and substrate quality for the lake crossing would be similar to impacts described for Alternative 1a, with decreased footprint as a result of a shorter lake crossing. Along the north access road, extending from the north ferry terminal to the mine site, impacts associated with the natural gas pipeline would be similar to those described by the transportation corridor because the pipeline would be buried in the road bed during construction.

4.18.6 Alternative 2—North Road and Ferry with Downstream Dams

4.18.6.1 Mine Site

Buttressed Downstream Bulk TSF Main Embankment—Due to similar seepage design and downstream capture under Alternative 1a and Alternative 2, the downstream dam alternative for the bulk TSF main embankment under Alternative 2 would likely have similar impacts on surface water and groundwater quality as centerline construction under Alternative 1a. However, impacts to substrate (freshwater sediment) would be greater under Alternative 2 than under Alternative 1a due to increased fill and larger embankment footprint necessary for downstream dam construction. Using a buttressed downstream design, which would be required to achieve the same static factor of safety (FoS) of 1.9 to 2.0 as Alternative 1a, the downstream dam would result in an approximately 60 percent increase in fill volume, and increase the dam footprint by 115 acres (PLP 2018-RFI 075). This would result in a corresponding increase in direct impacts on substrate in the NFK west drainage through permanent burial by fill, and a potential increase in erosion and redeposition impacts (described under Alternative 1a).

4.18.6.2 Transportation Corridor

Mine Site to Eagle Bay, and Pile Bay to Diamond Point Roads—Under Alternative 2, two road segments would cross approximately half as many waterbodies requiring bridges or culverts as the transportation corridor under Alternative 1a. Water quality and substrate impacts associated with the road segments and material sites would therefore be expected to be incrementally less than Alternative 1a. As in Alternative 1a, the impacts that would be expected would be potential direct and temporary effects on water quality due to sedimentation and turbidity generated through construction activities, which would be limited by use of BMPs and engineering controls (PLP 2018-RFI 086).

Eagle Bay to Pile Bay Ferry—Ferry operations from Eagle Bay to Pile Bay would have similar impacts on water and substrate quality as ferry operations in Alternative 1a.

Summer-Only Ferry Operations Variant—Although the Summer-Only Ferry Operations Variant would reduce water quality impacts on the lake during the 6-month winter season, ferry operations and activity would be increased during the 6 months of ferry operations. Placement of additional fill at the mine site and the port site would be required to support additional storage areas for concentrate and diesel (PLP 2018-RFI 065), resulting in corresponding increases in burial of existing lake substrate and in suspended solids and turbidity during fill placement. Additional concentrate storage at the port site under this variant would also require an increase in fill placement along the western side of Iliamna Bay near Williamsport (see Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, for the acreage of wetland and waterbody substrate coverage under this variant). The likelihood of small spills and contaminated runoff would increase because of the extra container and fuel storage under this variant, although this is expected to be mitigated by water treatment of runoff.

Newhalen River North Crossing Variant—Impacts under this variant are expected to be similar to those of the south crossing under the other alternatives, but would occur in a slightly different location. River bank and substrate materials that would be disturbed by bridge pile installation are expected to be similar at both locations (PLP 2019f).

4.18.6.3 Diamond Point Port

Terminal Runoff and Lightering Locations—Impacts from surface water runoff and water treatment at the terminal, and from dust at the lightering locations, would be the same as described for Alternative 1a.

Surface Water and Groundwater Quality at Dredge Disposal Area—Because of the differences in the approaches to the dock facilities between Amakdedori port and Diamond Point port, dredging of marine substrate at the Diamond Point location would be required to achieve a minimum 20-foot water depth. This dredging would generate approximately 650,000 cubic yards of material, of which a minimum of 50 percent would be used in dock construction. The remaining dredged material would be transported and disposed of onshore in two bermed storage areas west and upland of the dock site, about 200 feet from the shoreline (PLP 2018-RFI 063) (see Figure 2-71 and Figure 2-72). Most interstitial water (e.g., water contained in the dredged sediment) would be expected to drain back into Cook Inlet during placement of the dredged material onto a barge prior to transport. However, a limited amount of water would remain in the dredge spoils, and would be placed in the upland disposal site with the solids. Uncontrolled surface runoff from the bermed containment areas is not expected to occur. However, saline pore water in the dredged material would be expected to seep into underlying soils, and would mix with any shallow groundwater present. Drainage from the bermed area would discharge via an engineered system, which would include collection of seepage and stormwater runoff, and treatment in settling ponds prior to discharge (PLP 2018–RFI 099).

The overall area of the potential surface water and groundwater impact would be somewhat limited by the proximity of the disposal sites to the shoreline and the width of the engineered drainage/collection system. Depending on the process, periodic maintenance dredging could generate additional material that would be contained in the upland containment. In this case, similar effects on surface water and groundwater would be expected, but the volume of dredged material would be expected to be less than that generated during initial dredging activities.

Impacts on Salinity Gradients—Salinity gradients that might occur naturally at the locations of freshwater discharges into the port area would assimilate quickly into adjacent marine waters due to natural mixing by wind-driven currents and waves, and therefore would not likely be affected by port operations.

Earthen Fill Dock: Suspended Particulates/Turbidity and Substrate Effects—Construction of dock facilities at Diamond Point would have greater direct impacts on marine substrate than either the caisson dock under Alternative 1a or the earthen fill causeway and dock under Alternative 1. The footprint of the earthen fill structures at Diamond Point would cover roughly 3 more acres of marine substrate with fill than the similar design at Amakdedori port under Alternative 1. Placement of the fill causeway and wharf structure at Diamond Point would contribute suspended sediment to the water column, leading to temporary turbidity and redeposition in the vicinity of construction. These effects are expected to be greater than those of Alternative 1a and Alternative 1 causeway construction because of the greater amount of fill placement, and because the finer seabed material in Iliamna Bay is expected to travel farther before settling. This would cause an increase in the extent of turbidity effects and redeposition compared to both Alternative 1a and Alternative 1, and an increase compared to the Pile-Supported Dock Variant under this alternative.

Some dredging of shallow offshore sediments would be required for construction of a marine vessel channel at the Diamond Point port. Initial dredging and maintenance dredging over 2 decades of production at the mine would cover an area of approximately 58 acres. These activities would temporarily increase suspended solids in the water column, which would be redeposited on marine substrate; effects that would not occur under Alternative 1a or Alternative 1. The extent of these effects could range from localized, to potentially beyond the mouth of Iliamna Bay, depending on tides and wave conditions.

Pile-Supported Dock Variant: Suspended Particulates/Turbidity and Substrate Effects—Construction of a pile-supported dock at Diamond Point would result in fewer direct impacts on substrate than a fill causeway, because the piles would be driven through vibratory and hammer methods and would require no fill (PLP 2018-RFI 072). Effects would be slightly greater than the effects of constructing a pile-supported dock under Alternative 1 because the footprint of the piles would be about twice as large. Temporary and limited impacts from increased suspended sediment in marine waters would be expected to occur during construction of the pile structure.

4.18.6.4 Natural Gas Pipeline Corridor

For the portion of the natural pipeline corridor crossing Cook Inlet from the Kenai Peninsula, the types and scale of impacts on water and sediment quality would be the same as described under Alternative 1a, despite the shorter pipeline alignment. From the point the pipeline would come ashore at Ursus Cove to the mine site, the Alternative 2 pipeline corridor would cross approximately 20 percent more waterbodies than Alternative 1a route, but would eliminate the crossing of Iliamna Lake. The increase in waterbody crossings would suggest an incremental increase in the potential for impacts to water and sediment quality, primarily through the local and temporary direct effects of sedimentation during construction. Sedimentation would be minimized through the use of engineering controls and BMPs such as silt fences and bale check dams. In addition, the pipeline trench would have the potential to intersect shallow groundwater in the area between Ursus Cove and Diamond Point; however, impacts to groundwater would be expected to be limited and temporary.

4.18.7 Alternative 3—North Road Only

A continuous overland access road would connect the Diamond Point port to the mine site under Alternative 3. The natural gas pipeline would be commonly aligned with the transportation corridor under this alternative, and would align with the same route as the natural gas pipeline under Alternative 2. Impacts to water and sediment quality on the pipeline corridor would be very similar to those described for the Alternative 2 transportation corridor. The following section describes impacts for the mine site, transportation corridor, and port that would be unique under Alternative 3.

4.18.7.1 Mine Site

Under Alternative 3, impacts on the mine site would be similar to Alternative 1a, with minor differences in effects under the Concentrate Pipeline Variant. Impacts of this variant are described below.

Concentrate Pipeline Variant—The concentrate pipeline from the mine to the port under this variant would require an electric pump station at the mine site, which would require a small increase in fill placement over stream substrate in an NFK east tributary (PLP 2018-RFI 066). This would slightly increase the long-term direct impact at the mine site through burial of natural sediment. This variant would also reduce the amount of WTP water released at discharge locations at the mine site by approximately 1 to 2 percent (PLP 2018-RFI 066). This would result in slight reductions in temperature effects, impacts on substrate, and turbidity or erosional effects at the locations of treated water discharges. Inclusion of the concentrate pipeline would result in a slight increase in the potential for minor spills at the mine site. Section 4.27, Spill Risk, examines major spill scenarios.

4.18.7.2 Transportation Corridor

Alternative 3 would increase the project footprint, but would eliminate surface water quality impacts associated with the ferry crossing of Iliamna Lake. The northern access all-road route would result in an increase of about 35 percent in the number of stream crossings relative to

Alternative 1a, with a corresponding increase in direct but temporary water quality and substrate impacts (described under Alternative 1a). Additionally, portions of the access road under Alternative 3 approaching the port facility and caisson dock may reside in the intertidal reaches of Iliamna Bay. As a result, construction of the mine access road would result in the burial and compaction of some intertidal substrates.

Concentrate Pipeline Variant—Inclusion of a concentrate pipeline under this alternative would result in slightly greater direct impacts on water and substrate/sediment quality than the all-road route alternative without the concentrate pipeline. The concentrate pipeline would be buried during road construction, and the road corridor would be widened by less than 10 percent to accommodate the pipeline, which would marginally increase the turbidity effects on water quality and fill placement over substrate. An electric pump station would be required along the transportation corridor under this variant (PLP 2018-RFI 066), resulting in a small increase in the footprint in an upland area that is unlikely to affect water quality or substrate. Inclusion and operation of the concentrate pipeline would also result in an increased potential for impacts on substrate and surface water quality due to potential minor spills/leaks, although the likelihood of occurrence would be low with the use of a leak-detection system (major spill scenarios for concentrate are discussed in Section 4.27, Spill Risk). Because only the molybdenum concentrate (2.5 percent of the total concentrate production) would be trucked from the mine site to the port, a large reduction in road traffic would be anticipated, thereby reducing some potential direct and indirect impacts from dust, erosion, and runoff.

Concentrate Return Water Pipeline Option—Under this option, the return water pipeline would be buried in the same trench as the slurry and natural gas pipeline, requiring the trench to be widened by a few feet, and resulting in an increased footprint of the transportation corridor and a slight increase in direct impacts (PLP 2018-RFI 066). Therefore, the return water pipeline would result in a minimal increase in the same water quality and substrate/sediment quality effects as described above. Under this option, there would be a potential for minor spills of contact water from the pipeline affecting water and sediment quality that would not exist under the other options.

4.18.7.3 Port North of Diamond Point

Caisson Dock Construction and Dredged Material Storage—Alternative 3 would use a caisson dock constructed similarly to the caisson dock described under Alternative 1a. Impacts associated with construction and installation of the Alternative 3 caisson dock would be similar to those described under Alternative 1a. Under this alternative, the footprint of the port marine facilities would cover approximately 3 acres of marine substrate, approximately 1 acre more than for Alternative 1a (see Table 2-2).

The Alternative 3 dock would be constructed in shallower water than the Diamond Point dock location under Alternative 2, requiring additional dredging above that required for the turning basin and access channel under Alternative 2. The Alternative 3 channel would be approximately 1.2 miles long and 300 feet wide. Approximately 1,100,000 cubic yards of material are anticipated to be initially removed for construction of the channel and turning basin, and an additional 700,000 cubic yards of material would be removed during maintenance dredging over the 20-year life of the mine. As a result of the increased dredging required, associated impacts, including marine water turbidity and volume of displaced substrate, would be increased in magnitude and duration during construction and maintenance dredging compared to Alternative 2.

Material dredged during construction would be stored inside a bermed stockpile in an upland area adjacent to the port access road west of Williamsport (PLP 2020d). During operations, maintenance dredged material would be placed in the closest material site to Williamsport. Impacts related to the storage of dredged material (initial and maintenance dredging) would be similar in type as described under Alternative 2, although they would be somewhat greater in magnitude as a result of the increased volume of dredged material required for this design. As with the Alternative 2 dredged material storage areas, runoff from the dredge storage stockpiles under Alternative 3 would be channeled into a sediment pond to allow suspended particulates to settle prior to discharging runoff water into Iliamna Bay (PLP 2020d). Due to the location of the dredge storage stockpiles in uplands away from marine waters, there is increased potential for high-salinity runoff and seepage water to adversely impact water and sediment quality along Williams Creek.

To prepare for caisson placement, an additional 5 feet would be excavated below the turning basin using a barge-mounted excavator. Once set in place, the caissons would be filled with a coarse fraction of dredged material and additional fill from onshore material sites as necessary to achieve proper caisson seating and compaction within the caisson. Water that may accumulate in the top of the caissons would be pumped out to minimize saturation in the top layers, and if necessary, run through sediment settlement tanks on the barge prior to discharge to the marine environment (PLP 2020d).

Concentrate Container Storage—Concentrate would be shipped to the Alternative 3 port site in washed containers on trucks along the north mine access road from the mine site to the port facility. Impacts to water and sediment quality associated with concentrate trucking would be similar to those described for Alternative 2. Concentrate would be stored at the port site in the trucked containers until loading of concentrate into bulk carriers, which would use the same process described under Alternative 1a. The Alternative 3 port facilities with trucked container storage would be located along steep bluffs just south of Williamsport (see Figure 2-80).

4.18.7.4 Concentrate Pipeline Variant

Concentrate Bulk Storage and Handling—The concentrate pipeline variant for Alternative 3 would reduce the need for truck hauling of copper and gold concentrate. Molybdenum concentrate would still be dewatered at the mine site and transported to the port site along the north access road; however, the amount of haul truck traffic would be greatly reduced, because copper and gold concentrate would be transported via the concentrate pipeline and dewatered at the port site. Dewatered concentrate would be stored in a large building at the Alternative 3 port site until the loading of concentrate onto bulk carriers for transport.

The Alternative 3 port facilities with concentrate storage and bulk handling equipment would be sited in the same location and have the same footprint as under Alternative 3, and therefore, would have the same direct impacts from substrate burial as Alternative 3 (see Figure 2-86).

Bulk handling of the concentrate would use controls to reduce dust emissions, such as covered conveyors that are used at Red Dog Mine dock facilities (PLP 2018-RFI 066). If not properly managed, the storage and handling of bulk concentrate would result in an increased potential for direct effects on water and sediment quality.

This variant would require a different WTP configuration at the port site for the treatment of concentrate water than the Alternative 3 non-concentrate pipeline case. The water removed from the concentrate would be treated in a WTP to meet marine water quality standards, and discharged through an outfall pipeline and diffuser to the marine environment. Treatment would consist of adding chemicals for pH adjustment and metals precipitation, followed by the use of clarifiers for solids removal, additional metals precipitation with sodium hydrogen sulfide, and filtration. Solids and/or brine captured in the clarification and filtration steps would be trucked to the mine site or barged to an off-site disposal facility (PLP 2018-RFI 066).

Return Water Pipeline Option—The concentrate pipeline variant using a return-water pipeline option would result in no additional project footprint at the Alternative 3 port facilities, and would preclude the need for the discharge of treated water into marine waters at the Cook Inlet terminus. This option would eliminate the need for a dewatering WTP at the port, instead requiring a return-water pump station of appropriate capacity (PLP 2018-RFI 066). This option would result in no change in the footprint at the port site, and no changes in impacts on substrate, compared to Alternative 3 without the return water pipeline.

4.18.8 Cumulative Effects

Direct and indirect impacts to water and sediment quality that could contribute to cumulative effects include those caused by ground disturbance and potential erosion; geochemical weathering of mined rock and tailings on the water quality of human-made waterbodies at the mine site; treated water discharge on water and sediment downstream of mine site facilities; dust deposition; effects of tailings, waste rock, and contact water storage on groundwater quality and downstream resources; groundwater migration adjacent to the pit at closure; fill placement and erosion on substrate and sediment quality; marine construction and dredging on substrate and water quality; and effects on drinking water sources.

Information regarding impacts to water and sediment quality is provided in this section. Information regarding impacts to surface water and groundwater occurrence and flow is provided in Section 4.16, Surface Water Hydrology, and Section 4.17, Groundwater Hydrology. Impacts to water and sediment quality associated with low-probability, high-volume spills are addressed in Section 4.27, Spill Risk.

The cumulative effects analysis area for water and sediment quality includes all watersheds in which project-related activity would occur, where direct and indirect effects on surface water, groundwater, or substrate (encompassing the footprint of the project, including alternatives and variants, and areas downgradient) could reasonably be expected to contribute to cumulative effects. In this area, a nexus may exist between the project and other past, present, and reasonably foreseeable future actions (RFFAs) that could contribute to a cumulative effect on water and sediment quality. Section 4.1, Introduction to Environmental Consequences, details the comprehensive set of past, present, and RFFAs considered for evaluation as applicable. A number of the actions identified are considered to have no potential of contributing to cumulative effects on water and sediment quality in the analysis area. These include activities that may occur in the EIS analysis area but are unlikely to result in any appreciable impact on water or sediment quality, or actions outside of the cumulative effects analysis area.

4.18.8.1 Past and Present Actions

Past and present activities that may have affected water and sediment quality in the analysis area include boat operations in Iliamna Lake and Cook Inlet used for fishing and tourism; annual maintenance dredging in Iliamna Bay; communities that generate sewage and solid waste, and use fossil fuels for energy and heat generation; past mining exploration; and dust generation and small fuel leaks/spills along existing roads (see Section 4.1, Introduction to Environmental Consequences). Some regional organizations have expressed concerns regarding permit violations and environmental degradation associated with past Pebble Project exploration activities. ADNR conducts annual inspections during exploration activities and has generally found that exploration activities are in compliance with standard practices. In some instances, additional reclamation at exploration sites has been required. In general, past and present actions have had some localized, and in most cases, short-term effects on water and sediment quality.

4.18.8.2 Reasonably Foreseeable Future Actions

RFFAs that could contribute cumulatively to surface water quality and sediment impacts, and that are therefore considered in this analysis, are limited to those activities that would occur in the Nushagak River or Kvichak River drainages, or in other waterbodies intersected by the transportation corridor in the Cook Inlet drainage. RFFAs that could contribute cumulatively to impacts on groundwater quality are more limited, consisting only of activities in the mine site area, or immediately in or adjacent to the transportation corridor.

Past, present, and RFFAs that could contribute cumulatively to water and sediment quality effects, and are therefore considered in this analysis, include: Pebble Project expansion scenario; mining exploration activities at Pebble South, Big Chunk South, and Groundhog mineral prospects; onshore and offshore oil and gas development; road improvements, and the continued development of the Diamond Point Rock Quarry.

The No Action Alternative would not contribute to cumulative effects on water and sediment quality.

The RFFA contribution to cumulative effects on water and sediment quality is summarized by alternative in Table 4.18-2.

Table 4.18-2: Contribution of Cumulative Effects on Water and Sediment Quality

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Pebble Project Expansion Scenario	**Mine Site:** The mine site footprint would have a larger open pit and new facilities to store tailings and waste rock, which would contribute to cumulative effects on water and sediment quality due to an increase in footprint by about 3.5 times[1]; an increase in tailings, waste rock, wastewater discharge volume; and substantially longer duration of mining activity. The projected buildout would correspond to an increase in the magnitude and local extent of cumulative ground disturbance impacts[1] potentially contributing to sedimentation and fill placement on substrate, and the extent of stream blockages by major new storage facilities, further reducing stream flows in SFK and UTC drainages. The potential for cumulative impacts on surface water, groundwater, and sediment quality in the mine site would increase proportionally. The potential for cumulative effects on water and sediment quality from dust deposition would also increase with increased footprint. Additional design features to capture, manage, and treat impacted water and waste streams would be necessary to manage mine site impacts. Additional water treatment plan (WTP) capacity would be required to handle the increased treatment needs from contact water captured in SCPs downstream of expanded storage facilities. Treated water would likely be discharged back into the UTC and SFK drainages if not needed for expanded processing. Discharges would undergo State permitting and are expected to meet water quality criteria. The expanded storage areas and pit lake would be required to maintain hydraulic containment so that affected groundwater does not flow away from the site. **Other Facilities:** A north access road, and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment at year 20. The road would be extended east from the Eagle Bay ferry terminal to Iniskin Bay. Concentrate and diesel pipelines would be	**Mine Site:** Same as Alternative 1a. **Other Facilities:** Similar to Alternative 1a, except that the portion of mine access road from about 10 miles west of Newhalen River to the Eagle Bay area would not already be in place, resulting in slightly more stream crossings impacted. **Magnitude/Extent:** The Pebble Project expansion scenario would be similar to Alternative 1a. **Duration:** The duration of cumulative impacts to water and sediment quality would be similar to that of Alternative 1a. **Contribution:** The contribution to cumulative effects would be similar to Alternative 1a.	**Mine Site:** Same as Alternative 1a. **Other Facilities:** The north access road would be extended east from the Eagle Bay Ferry Terminal to 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/Extent:** Overall expansion would affect less acreage[1] than Alternative 1a, given that a portion of the north road and all of the gas pipeline would already be constructed. Impacts to water and sediment quality from the Pebble Project expansion would be less than that of Alternative 1a. **Duration:** The duration of cumulative impacts to water and sediment quality would be similar to that of Alternative 1a. **Contribution:** Similar to Alternative 1a.	**Mine Site:** Same as Alternative 1a. **Other Facilities:** Overall expansion would use the existing north access road; concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay. **Magnitude/Extent:** Overall expansion would affect less acreage[1] than Alternative 1a, given that the north road and gas pipeline would already be constructed. Impacts to water and sediment quality from the Pebble Project expansion would be less than that of Alternative 1a, Alternative 1, or Alternative 2. **Duration:** The duration of cumulative impacts to water and sediment quality would be similar to that of Alternative 1a. **Contribution:** Similar to Alternative 1a.

Table 4.18-2: Contribution of Cumulative Effects on Water and Sediment Quality

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. These would have potential impacts on water and sediment quality at stream crossings and at the Iniskin port site due to trenching activities, potentially increased erosion, port water treatment needs, and dock construction activities in marine waters. The increase in diesel fuel use over an extended period of time would increase the likelihood of hydrocarbon spills and contribute to increased potential cumulative impacts; however, installation of a pipeline would reduce the overall cumulative impacts from spills compared with truck transport of fuel from the port site to the mine site. **Magnitude/Extent:** Cumulative impacts at the expanded mine site would affect runoff and substrate over a footprint area of approximately 30,000 acres[1] and potentially cover about 300 stream miles. The magnitude of WTP discharges would partly mitigate blocked flow downstream of the mine site, and would be expected to meet water quality criteria. The extent of effects along the expanded transportation corridor and pipelines would impact about twice as many stream crossings as Alternative 3, where the north access road would already be constructed. **Duration:** The duration of cumulative impacts to water and sediment quality would vary from temporary (e.g., erosion impacts during construction) to long-term (e.g., operations WTP discharges for 98 years) to permanent (e.g., pumping and treating of expanded pit lake). **Contribution:** The expanded mine scenario contributes to cumulative effects on water and sediment quality. However, the area in the Kvichak and Nushagak River watersheds is relatively undeveloped, and effects would be limited to the project footprint and several miles downstream of the footprint, which is a relatively small area within the overall watersheds.			

Table 4.18-2: Contribution of Cumulative Effects on Water and Sediment Quality

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Other Mineral Exploration Projects	**Magnitude:** Mining exploration activities, including additional borehole drilling, road and pad construction, and development of temporary camp facilities, would contribute to potential cumulative effects on water and sediment quality, although impacts would be expected to be limited in extent and low in magnitude. **Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the duration and geographic area affected in a specific mineral prospect. Three of the mineral prospects where exploratory drilling is anticipated (listed in Table 4.1-1, in Section 4.1, Introduction to Affected Environment) are directly adjacent to the Pebble lease area, and exploration activities could be in areas that drain towards the same mainstem streams impacted by the Pebble mine site (North Fork Koktuli [NFK] South Fork Koktuli [SFK], Upper Talarik Creek [UTC]). **Contribution:** This RFFA contributes limited impacts (e.g., from drill pads, camps) to cumulative effects on water and sediment quality in watersheds common to the Pebble Project, although the areal extent of disturbance is a relatively small portion of the Kvichak/Nushagak watersheds. Assuming compliance with permit requirements, contributions to surface water and sediment quality would be minimal.	Similar to Alternative 1a.	Similar to Alternative 1a.	Similar to Alternative 1a.
Oil and Gas Exploration and Development	**Magnitude:** Oil and gas exploration activities in the Lake and Peninsula Borough (LPB) and lower Cook Inlet federal lease area could involve geophysical exploration, and in limited cases, exploratory drilling. Onshore geophysical exploration would involve temporary overland activities, with permit conditions that avoid or minimize water and sediment quality impacts. Should it occur, onshore exploratory drilling would involve the construction of temporary pads and support facilities, with permit	Similar to Alternative 1a.	Similar to Alternative 1a.	Similar to Alternative 1a.

Table 4.18-2: Contribution of Cumulative Effects on Water and Sediment Quality

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	conditions to minimize soil disturbance and restore drill sites after exploration activities have ceased. Offshore exploration activities that occur in the area of the Pebble pipeline could cause a slight increase in marine substrate disturbance or turbidity from anchor dragging with increased boat traffic, or small fuel leaks/spills from vessels. Given the naturally elevated turbidity and strong current flushing in Cook Inlet, however, effects on water and sediment quality are not expected to be noticeable. **Duration/Extent:** Seismic exploration and exploratory drilling are typically single-season temporary activities. The 2013 Bristol Bay Plan Amendment shows 13 oil and gas wells drilled on the western Alaska Peninsula, and a cluster of three wells near Iniskin Bay. Historic and active offshore leases in lower Cook Inlet overlap the Pebble pipeline route in the center and eastern side of the inlet. It is possible that additional geophysical testing and exploratory drilling could occur in the analysis area, but based on historic activity, is not expected to be intensive. **Contribution:** Oil and gas exploration activities would be required to minimize surface and seafloor disturbance and protect sediment and water quality. Onshore activities would occur in the analysis area, but distant from the project. Offshore activities would be required by the Bureau of Safety and Environmental Enforcement to have plans in place for spill prevention and avoidance of existing infrastructure such as underwater pipelines. The project would have minimal contribution to cumulative effects from these activities.			
Road Improvement and Community Development Projects	**Magnitude:** Road improvement projects would take place in the vicinity of communities and have impacts through grading, filling, and potential increased erosion. Communities in the immediate vicinity of project facilities, such as Iliamna, Newhalen, and Kokhanok, would have a potential nexus with the Pebble Project, and therefore, the greatest contribution to cumulative effects. Some limited	Similar to Alternative 1a, but less than Alternative 2 and Alternative 3, due to less community infrastructure shared with the project (e.g., there would be no nexus for	LPB and State of Alaska transportation, infrastructure, and energy projects include possible upgrades to Williamsport-Pile Bay Road, the same alignment that would be	Similar to Alternative 2. The increase in cumulative effects from substrate disturbance and erosion impacts would be similar to Alternative 2; however, because the footprint of the

Table 4.18-2: Contribution of Cumulative Effects on Water and Sediment Quality

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	road upgrades could also occur in the vicinity of the natural gas pipeline starting point near Stariski Creek, or in support of mineral exploration previously discussed. The continued use and expansion of Diamond Point Rock Quarry would include the excavation of rock, which would require removal of soil overburden materials, potentially resulting in increased sedimentation in local surface water or effects on sediment quality. The estimated area that would be affected is approximately 140 acres (ADNR 2014a). **Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. Geographic extent would be limited to the vicinity of communities and Diamond Point **Contribution**: Road construction would be required and surface disturbances would occur in the analysis area. The project would have minimal contribution to cumulative effects.	communities at the eastern end of Iliamna Lake).	used under Alternative 2. The magnitude and extent of effects on water and sediment quality at stream crossings would be relatively low, because the north access road may already be rerouted and upgraded under Alternative 2. The footprint of the Diamond Point Rock Quarry overlaps with the Diamond Point port footprint in Alternative 2. The increase in substrate disturbance and erosion impacts would result in cumulative effects on water and sediment quality. Cumulative impacts would likely be less than Alternative 1a or Alternative 1 due to commonly shared project footprints with the quarry site.	Diamond Point Rock Quarry does not overlap with the Diamond Point port footprint in Alternative 3, the reduction in cumulative impacts from commonly shared footprints would not be realized.
Summary of Project Contribution to Cumulative Effects	The primary factors contributing to cumulative effects on water and sediment quality would include: • Increased impacts to surface water, groundwater, and substrate/sediment quality under the Pebble Project expansion scenario from new storage areas, larger pit lake, increased dust deposition from larger area of surface disturbance, increased WTP capacity and discharge, and extension of roads and pipelines across an increased number of stream crossings.	Similar to Alternative 1a.	Similar to Alternative 1a.	Similar to Alternative 1a.

Table 4.18-2: Contribution of Cumulative Effects on Water and Sediment Quality

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	• Minor effects from the project combined with mineral and oil/gas exploration projects, road improvements, and continued quarry development. Overall, the contribution of Alternative 1a to cumulative effects to water and sediment quality, when taking other past, present, and RFFAs into account, would be minor outside of the controlled mine site in terms of magnitude, duration, and extent, given the limited acreage affected in the overall Kvichak/Nushagak watersheds, and permit requirements for limiting stormwater discharges, maintaining hydraulic containment beneath mine site facilities, and meeting water quality criteria in WTP discharges.			

Notes:

[1] Acreages of waterbody substrate burial provided in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.
WTP = water treatment plant