4.14 SOILS

This section describes potential impacts on soils resulting from each project component for all alternatives and variants. Mitigation and control measures would incorporate structural and non-structural best management practices (BMPs) to address erosion and stormwater runoff. The evaluation also assumes that activities would be performed in accordance with prepared water management and sediment control plans, and necessary Alaska Department of Environmental Conservation (ADEC) permits (if issued) and stormwater pollution prevention plans (SWPPPs). This includes typical or standard practice activities and BMPs when none are specified in project documents (see Chapter 5, Mitigation). This section also addresses impacts to soil quality from fugitive dust. The impacts of the project on resources related to soils, including impacts to marine and lake sediments, are addressed in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22, Wetlands and Other Waters/Special Aquatic Sites.

The Environmental Impact Statement (EIS) analysis area for soils includes all areas that would be disturbed as a result of the project and addresses all alternatives, components, and variants. Disturbed areas would include locations of removal or subsequent placement of soil. Because impact analyses are specific to upland soils, total soil disturbance acreages provided for alternatives and associated variants may be somewhat different from those provided in Appendix K2, Alternatives.

The impact analysis considered the following factors: magnitude, duration, geographic extent, and potential:

- Magnitude—impacts are assessed based on the quantified amount of soil resources expected to be affected (e.g., cubic feet, tons affected).
- Duration—impact duration on soil resources may be short-term, long-term, or permanent. Short-term effects are those impacts occurring only during construction and operations phases; long-term effects are considered to be those impacts extending into closure; and permanent effects are considered to be those impacts extending indefinitely into post-closure, with no restorative actions planned.
- Extent—impacts are assessed on the location and distribution of occurrence of the expected effects on soil resources (e.g., mine site footprint).
- Potential—impacts are assessed based on the potential likelihood of an effect to soil resources.

There were no scoping comments that identified specific concerns regarding the impact of the project on soils.

4.14.1 Summary of Key Issues

All alternatives would result in a similar magnitude, duration, and potential for impacts related to soils. The primary difference between the alternatives would be the amount of soils that would be affected. Table 4.14-1 presents a summary of key issues for soil resources.

Table 4.14-1: Summary of Key Issues for Soil Resources

Impact Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Mine Site[1]				
Soil disturbance	~8,390 acres (total)	~8,390 acres (total) ***Summer-Only Ferry Operations Variant:*** ~33 additional acres for concentrate laydown area, 8,423 acres (total).	~107 additional acres (downstream TSF construction). ***Summer-Only Ferry Operations Variant:*** Same as Alternative 2.	Same as Alternative 1a. ***Concentrate Pipeline Variant:*** ~1 additional acres for pump house and booster station (total).
Soil quality	Magnitude and Potential: With the exception of antimony (+3.04%), the percent increase in baseline concentrations for all HAP metals from dust deposition in surface soils would be less than 1 percent; therefore, no adverse change to surface soil chemistry is expected to occur from fugitive dust deposition. Extent: Mine site safety boundary. Duration: Throughout post-closure.	Same as Alternative 1a. ***Summer-Only Ferry Operations Variant:*** Same as Alternative 1; however, a greater (perceived) potential for soil quality impacts due to additional concentrate handling, transport, and storage.	Same as Alternative 1a. ***Summer-Only Ferry Operations Variant:*** Same as Alternative 2.	Same as Alternative 1a. ***Concentrate Pipeline Variant:*** Same as Alternative 3; however, a reduced potential for concentrate release (to soils) because of reduced concentrate transport, handling, and storage.
Erosion	Magnitude: Impacts would vary and would be mitigated by implementing the Erosion and Sediment Control Plan and following industry standard BMPs for sediment and erosion control (see Chapter 5, Mitigation). Duration: Pre-activity levels within 100 years. Extent: Project boundaries. Potential: Inherent.	Same as Alternative 1a. ***Summer-Only Ferry Operations Variant:*** Slight increase in erosion potential attributed to additional concentrate laydown area build-out (33 acres).	Potential erosion increases from TSF build-out. ***Summer-Only Ferry Operations Variant:*** Same as Alternative 2.	Same as Alternative 1a. ***Concentrate Pipeline Variant:*** Same as Alternative 3.

Table 4.14-1: Summary of Key Issues for Soil Resources

Impact Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Transportation Corridor[1]				
Soil disturbance	~1,793 acres (includes port and mine access roads, ferry terminals, material sites, spur road, and shared pipeline corridor).	~1,778 acres (includes port and mine access roads, ferry terminals, material sites, spur roads and shared pipeline corridor). ***Summer-Only Ferry Operations Variant:*** Same as Alternative 1. ***Kokhanok East Ferry Terminal Variant:*** ~Comparable to Alternative 1; however, 13 more acres would be affected primarily due to material site acreage.	~1,349 acres (includes port and mine access roads, ferry terminals, material sites, spur roads, and shared pipeline corridor). Fewer acres disturbed compared to Alternative 1a and Alternative 1, with ~20 fewer miles of roadway. More material sites under Alternative 2. ***Summer-Only Ferry Operations Variant:*** ~23 additional acres for concentrate storage than Alternative 2. ***Newhalen River North Crossing Variant:*** Approximately 19 more acres than Alternative 2; primarily due to material site acreage.	~2,347 acres (includes the north access road, material sites, spur roads, and shared pipeline corridor) 25% greater than Alternative 1a. ***Concentrate Pipeline Variant:*** Increased width of road corridor to accommodate pipeline, but likely less than or equal to 10 percent.
Soil quality	Magnitude and Potential: No adverse change to surface soil chemistry from fugitive dust deposition. No potentially acid-generating material from locally sourced material sites, seasonal emission mitigation/ suppression through watering, and concentrate transport in sealed containers. Duration: Indefinite, based on continued post-closure transportation corridor access. Potential: Low	Same as Alternative 1a. ***Summer-Only Ferry Operations Variant:*** Same as Alternative 1. Kokhanok East Ferry Terminal Variant: Same as Alternative 1.	Same as Alternative 1a. ***Summer-Only Ferry Operations Variant:*** Same as Alternative 2; however, a greater (perceived) potential for soil quality impacts due to additional acreage for concentrate storage on transportation corridor, handling, and transport steps. ***Newhalen River North Crossing Variant:*** Same as Alternative 2.	Same as Alternative 1a. ***Concentrate Pipeline Variant:*** Same as Alternative 3; however, less potential for concentrate release (to soils) because of reduced concentrate transport, handling, and storage.

Table 4.14-1: Summary of Key Issues for Soil Resources

Impact Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Erosion	Magnitude: Approximately 27 miles of road corridor in moderate to rough terrain. May require some enhanced design and mitigation measures. Duration: Temporary to indefinite. Extent: Project footprint. Potential: Inherent. Greatest potential for erosion would be along port access road; lower potential for other transportation components.	Magnitude, Extent, and Duration: Comparable to Alternative 1a. Potential: Appreciably greater due to terrain and greater length (~3 additional miles). Approximately 30 miles of road corridor in moderate to rough terrain. ***Summer-Only Ferry Operations Variant:*** Potential erosion increases due to greater road usage during ice-free months. Kokhanok East Ferry Terminal Variant: Comparable, but potentially less erosion based on shorter road length.	Magnitude and Extent: Reduced, based on smaller acreage of ground disturbance and increased presence of coarser soil types and gentler terrain. Duration: Similar to Alternative 1a. Potential: Increased along 2.5-mile coastline segment of port access road, where unique road design and mitigation measures would prevent or minimize erosion potential; however, erosion potential would likely persist (e.g., topography and maritime conditions). ***Summer-Only Ferry Operations Variant:*** Potential erosion increases due to greater road usage during ice-free months, but less than the Alternative 1 Summer-Only Ferry Operations Variant, based on shorter road length. ***Newhalen River North Crossing Variant:*** Minimal potential erosion increases corresponding with slightly increased total acreage of disturbance.	Magnitude, Extent, and Potential: Greater than Alternative 1a, Alternative 1, and Alternative 2, based on greatest footprint acreage and waterbody crossing frequency. However, magnitude and potential may be comparable to Alternative 1 (at a minimum), based on less moderate to rough terrain that coincides with shallow fine-grained soil types. Duration: Similar to Alternative 1a. ***Concentrate Pipeline Variant:*** Magnitude and Potential: Greatest among all alternatives and variants due to increase (~10 percent) in transportation corridor width. Duration: Similar to Alternative 1a. Extent: Similar to Alternative 3.

Table 4.14-1: Summary of Key Issues for Soil Resources

Impact Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Port Site[1, 2]				
Soil disturbance	~29 acres disturbed (includes the port terminal, airstrip, and water extraction site).	Same onshore port footprint as Alternative 1a). ***Summer-Only Ferry Operations Variant:*** 28 additional acres required at Amakdedori port. ***Pile-Supported Dock Variant:*** Same onshore port footprint as Alternative 1a and Alternative 1.	~50 acres (includes the port terminal, and dredge material storage areas). ***Summer-Only Ferry Operations Variant:*** Same as Alternative 2 (the additional acres for seasonal storage of concentrate containers would be along transportation corridor). ***Pile-Supported Dock Variant:*** Same onshore port footprint as Alternative 2.	~36 acres (includes the port terminal, and dredge material storage areas). ***Concentrate Pipeline Variant:*** Same onshore port footprint as Alternative 3.
Soil quality	Magnitude: No adverse change to surface soil chemistry from fugitive dust deposition. No PAG material from locally sourced material sites; seasonal emission mitigation/suppression through watering. Concentrate transfer from sealed bins to bulk carriers conducted offshore below deck. Calculated concentrate emissions total approximately 4 pounds per year. Duration: Indefinite, based on continued post-closure port needs. Potential: Low; however, greatest during the operational period during concentrate storage and handling.	Same as Alternative 1a. ***Summer-Only Ferry Operations Variant:*** Same as Alternative 1; however, a greater (perceived) potential for soil quality impacts due to additional concentrate handling and transport steps. ***Pile-Supported Dock Variant:*** Same as Alternative 1.	Same as Alternative 1a. ***Summer-Only Ferry Operations Variant:*** Same as Alternative 2. ***Pile-Supported Dock Variant:*** Same as Alternative 2.	Same as Alternative 1a. Some additional potential for impacts to soil quality as a result of upland storage of dredged material. ***Concentrate Pipeline Variant:*** Same as Alternative 3; however, a reduced potential for concentrate release (to soils) because of reduced concentrate transport, handling, and storage.

Table 4.14-1: Summary of Key Issues for Soil Resources

Impact Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Erosion	Magnitude: Low. Duration: Indefinite; and up to several years into post-closure. Extent: Project footprint. Potential: Low.	Magnitude: Similar to Alternative 1a. Duration, extent, and Potential: same as Alternative 1a. ***Summer-Only Ferry Operations Variant:*** Increased erosion due to additional storage area (29 acres) at Amakdedori port. ***Pile-Supported Dock Variant:*** Lower erosion potential – similar to caisson dock under Alternative 1a.	Magnitude and Extent: Increased, compared to Alternative 1a, based on larger acreage of ground disturbance/ infrastructure, terrain, and dredge material stockpile. Duration: Same as Alternative 1a. Potential: Increases compared to Alternative 1a, based on larger acreage of ground disturbance, terrain, and dredge material stockpile. ***Summer-Only Ferry Operations Variant:*** Increased erosion magnitude and potential along transportation corridor due to storage sites. No additional effect at the port. ***Pile-Supported Dock Variant:*** Reduced erosion potential similar to caisson dock under Alternative 1a.	Similar to Alternative 1a. Some additional erosional potential as a result of increased storage of dredged material. ***Concentrate Pipeline Variant:*** Same as Alternative 3. Additional acreage (0.3) is considered negligible for increased erosion potential.
Natural Gas Pipeline Corridor[1,3]				
Soil disturbance	~222 acres (includes onshore pipeline-only segments, compressor station, and HDD pullback work area)	~63 acres (includes onshore pipeline-only segments, compressor station, and HDD pullback work area). ***Summer-Only Ferry Operations Variant:*** Same as Alternative 1. ***Kokhanok East Ferry Variant:*** ~88 acres.	~ 1,106 acres (includes onshore pipeline-only segments, compressor station, HDD pullback work area, material sites, and construction access roads). ***Summer-Only Ferry Operations Variant:*** Same as Alternative 2. ***Newhalen River North Crossing Variant:*** Same as Alternative 2.	~138 acres (includes onshore pipeline-only segments, compressor station, HDD pullback work area, and material sites). ***Concentrate Pipeline Variant:*** Proportional increase of disturbance along pipeline-only segments to accommodate shared natural gas pipeline alignment with road. Also, see Alternative 3, Transportation Corridor key issues, for commonly aligned/ shared transportation corridor.

Table 4.14-1: Summary of Key Issues for Soil Resources

Impact Causing Project Component	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Erosion	Magnitude: Low, based on limited ground disturbance and shared transportation corridor. Duration: Indefinite. Extent: Project footprint. Potential: Low.	Decreased potential for erosion on a temporary basis during construction and post-construction compared to Alternative 1a due to a smaller area of surface disturbance (acreage). More of the pipeline corridor is common with access roads and less is stand alone, as compared to Alternative 1a. ***Summer-Only Ferry Operations Variant:*** Same as Alternative 1. ***Kokhanok East Ferry Terminal Variant:*** Increased erosion potential as compared to Alternative 1.	Magnitude, Extent, and Potential: Increased during construction and operations based on larger acreage of ground disturbance, length, and reduced accessibility. Potential: Increased during post-closure based on extents. Duration: Comparable, based on shared transportation corridor segments. ***Summer-Only Ferry Operations Variant:*** Same as Alternative 2. ***Newhalen River North Crossing Variant:*** Same as Alternative 2.	Although the pipeline under this alternative is considered part of the commonly aligned transportation corridor for evaluation, the following key issue is considered: The potential for increased erosion susceptibility of shallow, fine-grained soils in moderate to rough terrain from the port road to Canyon Creek west of Pedro Bay under Alternative 2 would be reduced under Alternative 3 immediately after construction and throughout operations. This is due to continuous road access for monitoring and maintenance of surface stabilization and restoration measures. ***Concentrate Pipeline Variant:*** Increased erosion potential along co-located pipeline segments due to greater ground disturbances.

Note:
[1] Footprints include the total impacted area, including both permanent and temporary.
[2] Includes the footprints for the onshore components of the port. Impacts to marine and lake sediments are addressed in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.
[3] Includes impacts from the pipeline-only sections of the natural gas pipeline where the pipeline is not co-located with the transportation corridor, as well as other onshore natural gas pipeline components (e.g., compressor station, material sites). The sections of the natural gas pipeline that are co-located with the road are included under the transportation corridor analysis. Impacts to marine and lake sediments are addressed in Section 4.16, Surface Water Hydrology; Section 4.18, Water and Sediment Quality; and Section 4.22 Wetlands and Other Waters/Special Aquatic Sites.
~ = approximately
BMPs = best management practices
HAP = hazardous air pollutant
HDD = horizontal directional drilling
PAG = potentially acid-generating
TSF = tailings storage facility

4.14.2 No Action Alternative

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

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

PLP would reclaim any remaining sites at the conclusion of their exploration program. The State has authority to grant reclamation approval after the cessation of reclamation activities and may request continued authorization for ongoing monitoring and reclamation work as deemed necessary. Soils along the transportation corridor, natural gas pipeline corridor, and at the port sites would remain in their current state. There would be no effects on existing soils in the areas of these components. In summary, there would be no direct or indirect impacts on baseline soil conditions from implementation of the No Action Alternative.

4.14.3 Alternative 1a

Impacts to soil resources from Alternative 1a would include those related to soil disturbance and erosion. Soil quality is also evaluated for the mine site due to potential fugitive dust impacts from sources of concern. Factors used to evaluate soil impacts include soil type and area of disturbance; erosion based on BMPs, and foreseeable control measures using common industry practices; planned reclamation and objectives; and anticipated effects on soil quality based on planned project activities. Chapter 5, Mitigation, describes PLP's mitigation measures that have been incorporated into the project.

Evaluation of soil impacts assumes that sediment control measures, BMPs, and adaptive control strategies would be established in a water management and sediment control plan prepared prior to construction and operation. The Alaska Pollutant Discharge Elimination System program (APDES) Construction General Permit (CGP) addresses discharge of pollutants from construction for disturbances of at least 1 acre of land, including authorized and unauthorized stormwater and non-stormwater discharges. A permittee is required to contain runoff from exposed soils to minimize erosion and sediment transport. The CGP also requires established conditions that meet water quality standards through operator control measures. The CGP includes filing a signed Notice of Intent and SWPPP with the ADEC. The SWPPP is required to be prepared by an ADEC-qualified person, and establishes sources of pollutants and how control measures would be implemented to meet permit standards. The SWPPP also establishes inspection-related criteria; how corrective actions are addressed; and permit eligibility related to endangered species. Additional information and references to applicable requirements are provided in the ADEC APDES CGP-Final, Permit No. AKR100000 (ADEC 2016); Alaska Storm Water Guide (ADEC 2011); and Alaska Department of Transportation and Public Facilities (ADOT&PF) Best

Management Practices for Erosion and Sediment Control (ADOT&PF 2016). To be issued, the requirements of these permits must be met.

Other agencies that may require additional considerations related to upland soils include the Alaska Department of Natural Resources (ADNR) for an approved Pipeline Right-of-Way (ROW) Lease; the ADOT&PF for a Utility Permit on ROW; Kenai Peninsula Borough; and US Army Corps of Engineers (USACE) Section 404 Permit.

The following subsections describe the potential impacts on soils and soil quality of project components under Alternative 1a (mine site, including material sites, Amakdedori port, transportation corridor, and natural gas pipeline corridor).

4.14.3.1 Mine Site

This section describes potential effects of Alternative 1a on soils at the mine site from construction through closure and post-closure management. These effects include soil disturbance, changes to soil quality due to fugitive dust, and erosion.

Soil Disturbance

The magnitude and extent of impact would be the disturbance of approximately 8,390 acres of soil at the mine site. Most of the extent of the impact would be soils associated with soil map unit D36MTG (5,796 acres), followed by disturbances of 2,093 acres and 501 acres to soil map units D36HIL and D36HIJ, respectively. The total acreage of soil disturbances includes major earthworks; the duration of the impact would be long-term, over the 4-year construction period, and mine site operations up to closure. The total acreage estimate does not include reclamation of various mine site infrastructure that would be partially restored, or reduced soil disturbances during the closure period. These impacts to soil at the mine site would be certain to occur if the project is permitted and built as described for Alternative 1a.

Temporary impacts to soils at the mine site are limited to less than 1 acre for installation of chambers at the three effluent discharge points. PLP has prepared a Restoration Plan (Owl Ridge 2019a; PLP 2019-RFI 123) outlining their proposed approach for restoring temporarily impacted natural habitats, including aquatic habitats, to a condition that resembles the pre-construction condition, or that of adjacent lands undisturbed by the project (see Appendix M3.0, Restoration Plan).

Mine site facilities not required for post-closure activities would be reclaimed in accordance with an ADNR-approved reclamation plan per Alaska Reclamation Act requirements; and mining reclamation regulations per Alaska Statute (AS) 27.19 and 11 Alaska Administrative Code (AAC) 97. The reclamation performance standard is the adequate reclamation of disturbed areas from mining operations, and to leave the site in a stable condition; or reestablishment of renewable resources on the site within a reasonable period of time by natural processes.

Interim reclamation may be required as needed during mine site operation to stabilize ground surfaces. Where needed, stabilization may include surface roughening, revegetation, mulch, or erosion control fabric. Final reclamation during closure would use a phased approach once mine site operations have ceased. Facilities that would be reclaimed include the pyritic tailings storage facility (TSF), bulk TSF, overburden stockpiles, milling and processing facilities, non-essential roads, and most water management/treatment infrastructure (see Figure 2-4). Mine site infrastructure that would not undergo reclamation includes the open pit (approximately 609 acres); mine water treatment plant (WTP #3) (approximately 3 acres); bulk TSF main seepage collection pond and embankment (approximately 99 acres); south and east seepage collection and recycle ponds (SCRPs) and embankments (approximately 11 acres); power generation facilities (approximately 22 acres); inert monofill (approximately 9 acres) in the disturbed footprint; and limited camp, storage facilities, and access roads (see Figure 2-4). Two surface water runoff diversion channels associated with the bulk TSF would foreseeably remain for the post-closure phase. Reclamation of quarry sites B and C (approximately 860 acres) would include the diversion of surface water runoff and placement of a 3-foot lift of growth medium over the bottoms and sloped areas steeper than 2H:1V; however, steep slopes and benches would remain as they are in some areas of the highwalls. The magnitude and duration of post-closure impacts would be that a total of approximately 1,500 acres would not be reclaimed, and would result in permanent disturbances to existing soil conditions.

Although soil conditions underlying the TSF footprints would result in permanent soil disturbances, each would be reclaimed to conform to designated post-mining land use, as administered by the ADNR. The liner below the pyritic TSF would be removed, and bermed structures would be recontoured. This would be followed by application of salvaged growth media and surface restoration. The bulk TSF would remain in place after controlled dewatering and dry closure, resulting in a permanent landform. The bulk TSF surface would be graded and contoured as needed for drainage control. Growth media would be added for seeding and revegetation, including the embankments.

Indirect soil disturbance impacts are most likely to be associated with erosion and stormwater sediment transport processes, and are evaluated under erosion.

Soil Quality

The magnitude and extent of project effects on soil quality would be the wet and dry deposition of fugitive dust derived from mine site sources, including mining operations in the pit (e.g., drilling and blasting); material transport, storage, processing, and handling (including ore, waste rock, concentrate, and aggregate); and wind erosion of exposed bulk tailings. This deposition would be long-term, lasting from construction through the life of the project, and would be certain to occur if the project is permitted and built. The cumulative deposition (i.e., loading) of dust throughout construction and operation was evaluated for the potential to impart an adverse change to surface soil chemistry. Dust deposition effects on water quality are discussed in Section 4.18, Water and Sediment Quality.

Fugitive Dust Constituents of Concern

Total potential criteria pollutant and hazardous air pollutant (HAP) emissions were calculated for the mine site and other project components, assuming that each emission unit was operated continuously unless otherwise noted (PLP 2018-RFI 007). Annual fugitive particulate matter (PM) emissions were calculated based on conservative scenarios that assumed worst-case conditions for each activity or source component, such as peak ore-crushing capacity, maximum ore-hauling distance from final pit, and maximum waste rock hauling. Hourly surface meteorological data were obtained from January 2009 to December 2011; processed in accordance with US Environmental Protection Agency (EPA) and ADEC guidance using AERMET; and reviewed and approved by ADEC. Upper air meteorological data were derived from the King Salmon observation station operated by the National Weather Service. Wind directions over the duration of the 3-year period were predominantly from the southeast and northwest, and sustained wind velocities greater than 25 miles per hour were not uncommon (PLP 2018-RFI 009).

Of the 189 HAPs listed in the 1990 Clean Air Act Amendment and 40 Code of Federal Regulations (CFR) Part 63, applicable metals from fugitive sources were further evaluated for incremental increase over the 20-year operations period (Table 4.14-2). Hydrocarbons, anions, and cations are not considered compounds of concern from fugitive dust emissions.

Table 4.14-2: Calculated Mine Site Post-Dust Deposition Metal Concentrations in Soil

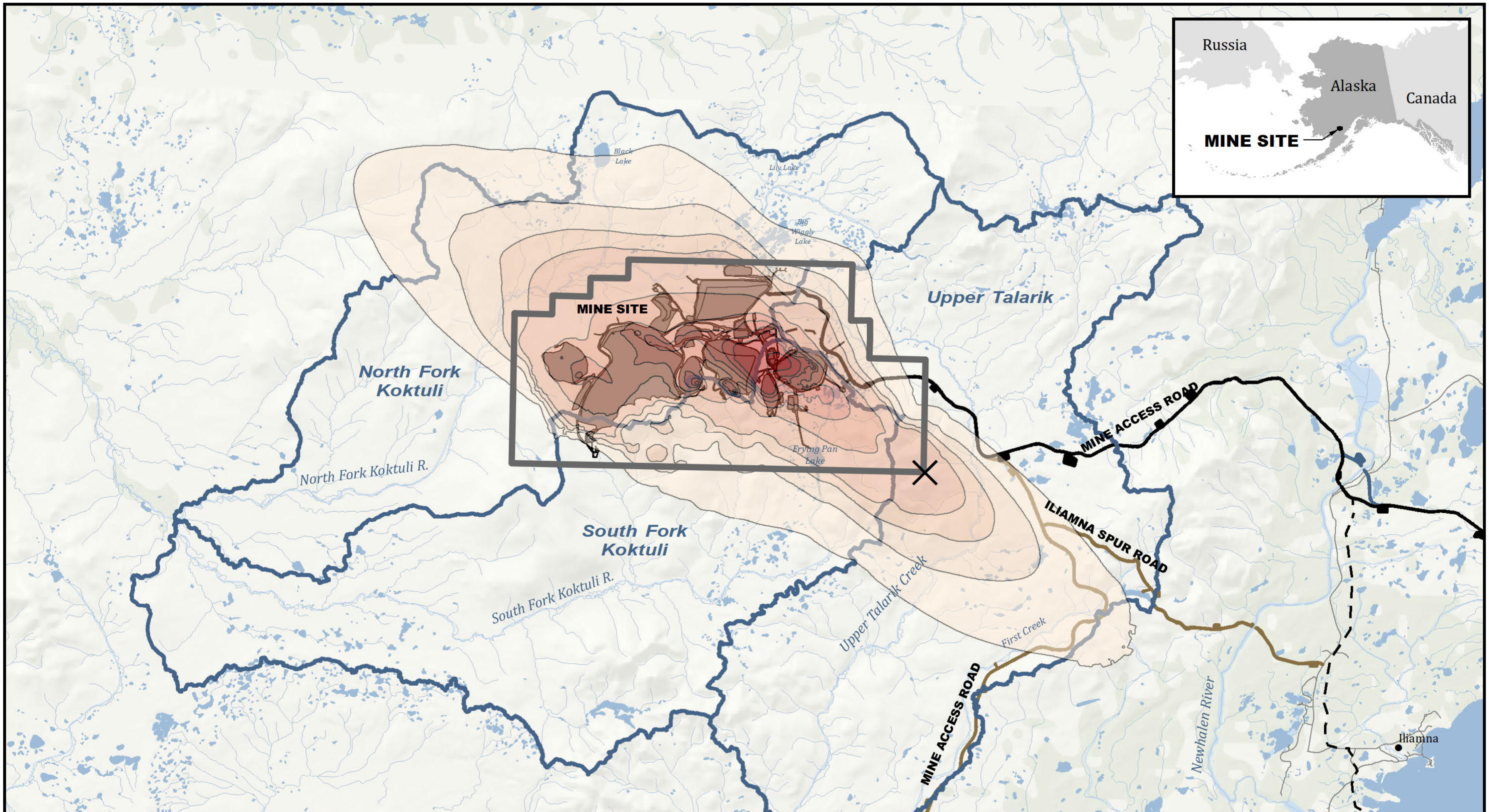
Analyte	Baseline Mean[1] (mg/kg)	Post-Dust Deposition			Comparative Action Levels	
		Incremental Increase over 20 Years (mg/kg)[2,3]	Baseline + 20 Years of Dust Deposition	Percent Increase after 20 Years	Human Health[4] (mg/kg)	Migration to Groundwater[4] (mg/kg)
Antimony	0.24	0.0075	0.25	3.04%	33	4.6
Arsenic	10.2	0.0589	10.3	0.57%	7.2 (inorganic)	0.2
Beryllium	0.41	0.00213	0.412	0.52%	170	260
Cadmium	0.24	0.00173	0.242	0.72%	76 (diet)	9.1
Chromium (total)	17.7	0.0733	17.77	0.41%	1.0 x 10^5 (Cr^3)	1.0 x 10^5 (Cr^3)
Cobalt	6.55	0.0195	6.57	0.30%	—	—
Copper[5]	27.4	1.69	29.09	6.18%	3300	370
Lead	8.74	0.0205	8.76	0.23%	400	—
Manganese	388	0.693	388.69	0.18%	—	—
Mercury	0.12	0.00013	0.12	0.11%	3.1 (elemental)	0.36
Nickel	9.16	0.0176	9.18	0.19%	1,700 (soluble salts)	340
Selenium	2.76	0.00753	2.77	0.27%	410	6.9

Notes:
[1] Three Parameters Plus 2011a
[2] Based on PLP 2018-RFI 009 total HAPs concentration in dust and EPA 2005.
[3] Assumptions include life of mine (20 years) deposition period, soil mixing zone of 2 centimeters, and bulk soil density of 1.5 grams per cubic centimeter based on US Geological Survey estimate for silty soils (NRCS 2018; EPA 2005).
[4] ADEC 18 AAC 75, Oil and Other Hazardous Substances Pollution Control, September 29, 2018, Table B1. Method Two—Soil Cleanup Levels, Human Health, Over 40 Inch Zone, and Migration to Groundwater (ADEC 2017a). No available reference value per ADEC 18 AAC 75. Additional human health evaluation of all HAP metals is provided in Section 4.10, Health and Safety, based on published EPA Regional Screening Levels (RSLs).
[5] Based on PLP 2018-RFI 009b total HAPs concentration in dust and EPA 2005
Cr^3 = trivalent chromium
mg/kg = milligrams per kilogram

Dust Deposition on Soils

Figure 4.14-1 depicts results of modeling dust deposition at the mine site during operations. Potential increase in metal concentration in the top 1 inch of soil at the mine site was estimated using modeling data for airborne metals concentrations and dust deposition (PLP 2018-RFI 009). Description of the approach, model, and parameters is provided in Appendix K4.14.

The expected constituent soil concentration after the 20-year mine life due to operational dust deposition was calculated by adding the incremental increase to baseline soil concentrations provided in Appendix K3.14. Calculated results are summarized in Table 4.14-2. The greatest accumulation of dust deposition at the mine site safety boundary is provided in Figure 4.14-1, which coincides with the greatest prevailing wind direction toward the southeast.



Sources: PLP 2018-RFI009a; PLP 2019-RFI153

US Army Corps of Engineers

Miles: 2 0 2 4

Average annual PM_{10} deposition ($g/m^2/yr$)

- 0.3 - 0.5
- 0.5 - 0.7
- 0.7 - 0.9
- 0.9 - 2.0
- 2.0 - 4.0
- 4.0 - 6.0
- 6.0 - 8.0
- 8.0 - 10.0
- 10.0 - 20.0
- > 20.0

Mine Site Safety Boundary, Point of Greatest Dust Deposition Accumulation

Mine Site Safety Boundary

Action Alternatives

Natural Gas Pipelines

Alternative 1a

Alternative 1

Alternative 1 Kokhanok East Ferry Terminal Variant

Alternative 2 Newhalen River North Crossing Variant

Other Features

Local Roads

Major Drainage Boundary

DUST DEPOSITION DURING MINE SITE OPERATIONS

PEBBLE PROJECT EIS

FIGURE 4.14-1

The calculated percent increase in HAP metals from 20 years of dust deposition at the mine site would not be considered of sufficient magnitude to have an adverse impact on surface soils relative to baseline conditions and ADEC action levels used for purposes of comparative evaluation. The greatest percent increase in baseline metals concentration (3.04 percent) is associated with antimony, although the concentrations with dust are still below ADEC levels. All calculated percent increases of other HAP metals were all below 1 percent, with the exception of copper. With the exception of arsenic, all evaluated metals were well below ADEC levels. The presence of naturally occurring arsenic above the ADEC level is readily apparent, with a reported mean of 10.2 milligrams per kilogram (mg/kg). For these reasons, the incremental arsenic increase of 0.57 percent from fugitive dust in surface soils is considered negligible relative to baseline conditions and documented presence of elevated concentrations in soils throughout the state. The natural occurrence of elevated chromium and arsenic concentrations in soil is acknowledged in ADEC Technical Memorandum, Arsenic in Soil, dated March 2009; and notes 11 and 12 of Table B1 (ADEC 2013d).

Similar to arsenic, elevated baseline concentrations of total chromium are present at the mine site, but well below the ADEC action level for trivalent chromium. Because there are no anthropogenic sources of hexavalent chromium (Cr^{6+}), nor are mineral assemblages considered favorable for Cr^{6+} genesis (e.g., chromite), no further evaluation was conducted. Additional human health evaluation of all HAP metals, based on published EPA Regional Screening Levels (RSLs), is provided in Section 4.10, Health and Safety, and includes metals for which no ADEC reference value is shown in Table 4.14-2.

Dust Control

The project design incorporates measures to minimize fugitive dust and prevent or minimize transfer of concentrate dust outside the mine site. The project has developed a conceptual fugitive dust control plan for mitigation and control of fugitive dust and wind erosion related to project activities (PLP 2019-RFI 134; PLP 2019-RFI 135). The final fugitive dust control plan would be developed as the project design advances and would include use of BMPs and best available control technology. Among other measures, the plan would enforce separation of mine site and access road traffic to minimize cross-contamination of vehicles, and would implement the use of sealed containers (i.e., containerized bulk-handling technology) for the transport of concentrate. Wet mill processes, the use of enclosures and dust collection systems in process plant operations, the watering of haul roads, use of wetting material, washing of concentrate containers, and covering and/or revegetation of stockpiled soil would also be used as controls on fugitive dust generation and deposition. See Chapter 5, Mitigation, for more information on BMPs captured in proposed mitigation measures.

Coarse ore would be stockpiled in a covered steel-frame building to minimize dust emissions. Baghouse-type dust collectors would be present at each conveyor-fed ore transfer point between the coarse ore stockpile and semi-autogenous grinding (SAG) (“ball”) mills. Water would be added during operations at the SAG mill to suppress dust. Specialized bulk cargo containers equipped with removable locking lids would contain thickened concentrates for transport to Amakdedori port.

The pyritic tailings and potentially acid-generating (PAG) waste would be stored sub-aqueously during operations, removing the potential for wind erosion and dust dispersion from sources with elevated metals concentrations. The bulk TSF would have tailings beaches, of which areas would be susceptible to wind erosion and fugitive dust emissions throughout operations on a variable basis. The tailings slurry and water component would be actively spigoted into the bulk TSF at variable locations along the main and south embankments and east ridge for development of a consistent tailings beach around the perimeter. Although spigoted distribution of tailings and water are anticipated to result in a sloped, coarser-grained tailings beach that transitions to finer-grained materials beneath the pond, portions of the tailings beach are expected to decrease in moisture content between variable spigot discharge locations on a temporal basis. These portions of the TSF beach would be most susceptible to wind erosion and potential fugitive dust emissions. Mitigation measures would include watering to reduce fugitive dust emissions (see Chapter 5, Mitigation). The bulk TSF would eventually be reclaimed through contouring of surfaces and application of growth media for revegetation and surface stabilization, eliminating the beaches as a dust source following closure activities. Dispersion of post-deposition dust throughout closure and post-closure would progressively diminish through natural and enhanced surface stabilization processes; however, deposition of fugitive dust would likely continue into closure and post-closure phases of mining as service vehicles and closure activities are conducted as needed along travel routes and work areas. The magnitude of dust dispersed during closure and post-closure phases is expected to be negligible relative to fugitive particulate dispersion during mining operations, and would likely be negligible in terms of environmental impacts.

Erosion

The duration and extent of impacts from hydraulic erosion under planned conditions at the mine site would be during the year-round construction phase, coinciding with the longest period of soil disturbances. The magnitude of the impact of removing vegetative matting would be the exposure of fine-grained silty loam (i.e., volcanic ash mixtures in shallow surface soils [less than 30 inches deep] that are susceptible to water and wind erosion). Deeper soils consisting of coarser-grained glacial till and colluvium mixtures would be comparatively less susceptible to erosion. Much of the finer-grained (i.e., shallow) soil mixtures exposed during construction would be removed due to undesirable engineering properties (e.g., loading and compaction) required for infrastructure construction, and placed in salvaged growth media stockpiles.

Seasonal variations in weather conditions would influence potential erosional susceptibilities of disturbed ground surfaces. The timing of seasonal construction schedules for various project components is provided in PLP 2018-RFI 037. Wind and hydraulic erosion are not anticipated to occur when soils are frozen during winter. Frozen soil conditions generally occur for about 4 or 5 months per year (Hoefler 2010a). The greatest potential for hydraulic erosion would be during rainfall events, which typically occur during the fall. Soil susceptibility to wind erosion is influenced by moisture and particle size. Wind-induced erosion would be comparatively less than hydraulically driven processes in the construction phase, due to seasonal meteorological conditions and cohesive forces associated with soil moisture. A soil matrix composed of larger grains is less capable of retaining moisture, but less susceptible to wind transport. Although finer-grained soils are generally less tolerant to wind erosion, they are more capable of retaining cohesive moisture. Moisture is anticipated to minimize wind erosion of finer-grained surface soils for most of the year; however, the potential for erosion would be greatest during drier periods lasting 1 to 2 months during the summer.

All runoff water that comes in contact with mine site facilities, or is derived from the open pit, would be captured, including any entrained sediment in runoff from erosion (Knight Piésold 2018a). An Erosion and Sediment Control Plan (ESCP) would be developed for the project and BMPs would be implemented to prevent or minimize erosion and sedimentation associated with the project prior to beginning construction (see Chapter 5, Mitigation).

Water management structures (e.g., berms, channels, collection ditches) would be designed to accommodate a 100-year, 24-hour rainfall event. Sediment control ponds would be designed to treat a 10-year, 24-hour rain event, and safely accommodate a 200-year, 24-hour rainfall event. Mine site water management infrastructure would include freshwater diversion channels, an open pit water management pond (WMP), the main WMP, the bulk and pyritic TSFs, the bulk TSF main embankment seepage collection pond, seepage collection and recycle ponds, sediment ponds, and two WTPs. Water management design criteria and structure configurations are further discussed in Section 4.16, Surface Water Hydrology; and in the Operations Water Management Plan (Knight Piésold 2018a).

During construction, runoff upgradient of the TSFs would be intercepted by a cofferdam and released at a discharge point downgradient of all construction activities in the same watershed. Runoff from the TSF embankments during construction would also be captured. Similarly, runoff from larger excavations associated with the construction of long-term infrastructure (e.g., process plant, camps, power plant, and storage areas) would be routed to settling ponds prior to discharge. During operations, comparatively less soil erosion from water would occur because of diminished need for soil removal. Non-contact runoff would be captured in engineered diversion channels and discharged downgradient. In addition, completed construction of most long-term infrastructure would coincide with established water management and sediment control plan measures. Stormwater runoff from mine facilities that only requires sediment removal would be captured in sediment ponds, treated, and discharged under general APDES stormwater permits. Mine site drainage surface water that comes in contact with infrastructure would be diverted to WTPs for processing prior to discharge. Although water and sediment control during the operations phase would emphasize contact water minimization and management, runoff and sediment control measures would continue to be managed through BMPs and adaptive control strategies per the SWPPP(s) (see Chapter 5, Mitigation). Reduction in water management during operations would be limited to concurrent reclamation of overburden stockpiles.

The magnitude, duration, and extent of impacts from planned management of slurried tailings delivered to the bulk TSF would be the transport of dried, fine-grained tailings materials through wind erosion during operations. Bulk tailings would be pumped and discharged through spigots along the interior of the perimeter cell, with the slurry preferentially discharged to maintain an exposed tailings beach between the TSF embankment and supernatant pond. Although this approach minimizes potential risks associated with seepage effects on embankment stability, the fine tailings (e.g., beaches) would be susceptible to wind erosion when dried. Additional information regarding fugitive dust derived from the bulk TSF is presented in the Soil Quality discussion for the mine site.

The mine site would be reclaimed per an ADNR-approved reclamation plan that establishes requirements for designated post-mining land use. The reclamation plan would supplement or describe measures to control and mitigate erosion at the mine site through the post-closure period. Erosion during closure would be less than during construction, primarily because of comparatively less surface disturbances. Erosion would be greater during closure than operations because of reclamation earthwork required during closure. The magnitude of the impacts from reclamation would be the destabilization of large soil surface areas from decommissioning activities. Earthwork associated with the preparation and application of growth media would likely result in erosion until surface stabilization is achieved. At a minimum, similar measures established for construction in the ESCP would address runoff through erosion and sediment controls and BMPs. Additional measures may include future developments in available technologies or practices, and refined adaptive control strategies acquired throughout operations. Removal and reclamation of long-term water management infrastructure would progressively coincide with surface stabilization objectives established in the ADNR-approved reclamation plan.

The duration of impacts from erosion during reclamation from destabilized surfaces would likely continue for several years beyond closure. Prescribed design standards for reclaiming infrastructure and monitoring are established in reclamation plans required by the State of Alaska. Prescribed monitoring would likely occur annually until surface conditions are stabilized and meet land use objectives. Although reclaimed infrastructure would be designed to withstand storm events (e.g., 100-year, 24-hour rain event), monitoring would be necessary immediately after any occurrence.

4.14.3.2 Transportation Corridor

This section describes potential effects on soils along the transportation corridor. Impacts associated with the natural gas pipeline on the western side of Cook Inlet are also included in this section, because this segment of pipeline would predominantly coincide (i.e., be buried) with the road prism. Pipeline-only segments (not co-located with a road) of Alternative 1a are addressed under the “Natural Gas Pipeline Corridor” subsection, below.

Soil Disturbance

Approximate soil disturbance areas associated with the Alternative 1a transportation corridor include the following total acreages, post-construction acreages, and temporary acreages of disturbance:

- Port access road: south ferry terminal to Amakdedori port—699 acres (total), 411 acres (post-construction), 288 acres (temporary)
- Mine access road: mine site to Eagle Bay ferry terminal site—643 acres (total), 353 acres (post-construction), 290 acres (temporary)
- Kokhanok Airport Spur Road—25 acres (total), 15 acres (post-construction), 10 acres (temporary)
- Explosives Storage Spur Road—6 acres (total), 4 acres (post-construction), 2 acres (temporary)
- Ferry Terminals—37 acres (total), 30 acres (post-construction), 7 acres (temporary)
- Material Sites—380 acres (total, post-construction)

The magnitude of shared pipeline and transportation corridor ground disturbance (total acreage) under this alternative is approximately 1,793 acres, which includes the port and mine site roads, ferry terminals, material sites, and spur and access roads. Total post-construction and temporary acreages are 1,194 acres and 599 acres, respectively.

Material Sites

The magnitude of disturbances would include the complete removal and segregation of surface soils and overburden materials considered unsuitable for construction purposes. The duration of the disturbance would be long-term, lasting through the life of the project, but these materials would be salvaged for future reclamation as a growth medium. These impacts on surface soils at material sites would be certain to occur if the project is permitted and constructed as described for Alternative 1a. However, mitigation measures described in the following sections and in Chapter 5, Mitigation, would be expected to reduce impacts. Portions of sites no longer used for material extraction would be progressively reclaimed. This would mainly occur after the construction phase, once the bulk demand for materials has been met with infrastructure completion (e.g., roads). Material sites and access roads would continue to be used throughout operations for maintenance of project infrastructure, as needed. Less soil disturbance would occur during operations than during construction, but soil disturbance during operations would be caused by excavation or blasting on an as-needed basis. A need for materials would also persist throughout the post-closure period for continued road maintenance and other limited post-closure needs. Incremental reclamation of disturbance at materials sites would be required. Typical reclamation at gravel material sites would likely include grading and contouring of sidewall slopes; scarification or ripping to promote surface water infiltration and vegetation growth; application of salvaged growth media; and seeding with proposed mixtures as needed. No sidewall reclamation would be conducted at shot-rock material sites with 20-foot bench heights on exposed rock walls.

Soil Quality

Dust from truck traffic and wind erosion of roadbed aggregate sourced from materials sites would not be expected to impact chemical concentrations in soils along the access roads. This is because material sites along the access roads are well outside the Pebble deposit, which is supported through available baseline surface soil samples along transportation corridor alternatives (see Appendix K3.14). Although available transportation corridor shallow soils chemistry data are not directly representative of Alternative 1a transportation corridor footprints, they are indicative of soils present among portions of all transportation alternatives outside the mine site study area. The hierarchy of trace elements (i.e., mean concentration) reported in surface soil along transportation corridor alternatives is similar to trends for the mine site (Table 4.14-2). However, in all circumstances, trace element concentrations were lower in the transportation corridor, indicating less mineral-rich conditions than the mine site study area (SLR et al. 2011a).

The reported baseline arsenic concentrations in surface soil samples from the transportation corridor are lower than the mine site study area, but persist at naturally elevated concentrations of up to 50.1 mg/kg, with a reported mean of 4.40 mg/kg. Similarly, mean concentrations of most evaluated analytes were less than half of the reported concentrations at the mine site. For example, the maximum concentration of selenium in the transportation corridor surface soil sample area (2.06 mg/kg) was less than the mean concentration at the mine site (2.76 mg/kg) (see Appendix K3.14).

Because metal concentrations in mine site dust are considered to be of insufficient magnitude to have an adverse impact on surface soils, this is also anticipated for the less mineralized soil conditions along the transportation corridor. Field review has not identified PAG rock at any of the road material sites. If PAG material were to be identified at a material site evaluation prior to use, another suitable material site would be selected (PLP 2018-RFI 035). Therefore, the material sites are not expected to introduce chemical impairments to soil. Transportation of concentrate from the mine site would be in sealed containers, and therefore is not expected to be a source of fugitive dust along the roads.

Effects from Small Spills of Hydrocarbons or Other Contaminants

Inadvertent release of hydrocarbons or other contaminants would result in a direct impact to soil quality. The likelihood of these small spills from mine-related sources (e.g., mine machinery, product or waste storage facilities, or transfer operations) would be prevented or minimized 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, response measures and 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.

Erosion

Similar to all other project components, stormwater and erosion mitigation and control measures would incorporate structural and non-structural BMPs (PLP 2020d) (see Chapter 5, Mitigation and PLP 2018-RFI 071a). Impacts from ground disturbance at pipeline stream crossings (trenching and horizontal directional drilling [HDD] installation) are addressed in Section 4.16, Surface Water Hydrology; and Section 4.18, Water and Sediment Quality. Wind-induced erosion would be comparatively less than hydraulically driven processes throughout all phases of the project along the transportation corridor, due to seasonal meteorological conditions; physical attributes associated with soil types; infrastructure configuration and construction methods; and planned mitigation. Soils capable of retaining moisture in the project area are generally considered to have a low susceptibility to wind erosion, due to inherent moisture content from periodic precipitation or snowmelt throughout the year. For this reason, the potential for wind erosion would be greatest during drier periods lasting 1 to 2 months during the summer. If necessary, wind erosion can be mitigated through dust-control watering during the summer.

The duration and extent of impacts from hydraulic erosion would be through the project life cycle along the transportation corridor. Precipitation events resulting in the greatest erosional losses from surface runoff and flooding generally occur from late September through November, based on erosion assessment observations of the Williamsport-Pile Bay Road, approximately 30 miles northeast of the port access road.

Soil types and general terrain descriptors present along the transportation corridor are summarized in Table 4.14-3. Moderate to rough terrain descriptors are based on the presence of anticipated rock cuts or blasting along portions of route segments in steeper and or shallow bedrock conditions to accommodate road construction. Cut-and-fill construction methods would be more prevalent in moderate to rough terrain. Gentle to moderate terrain coincides with a reduced frequency of anticipated rock cuts, and flatter or rolling landscapes are associated with glacial fluvial and moraine soil conditions. These segments would require comparatively less cut-and-fill construction practices due to less variation in roadbed grade.

Table 4.14-3: Alternative 1a Approximate Road Terrain and Soil Types

ESS Soil Type	Gentle to Moderate Terrain	Moderate to Rough Terrain
D36HIJ[1]	4 miles (5%)	—
D36HIL[2]	<1 mile (1%)	—
D36MTG[3]	4 miles (5%)	—
IA17[4]	7 miles (10%)	22 miles (29%)
IA7[5]	27 miles (37%)	5 miles (7%)
IA9[6]	4 miles (6%)	<1 mile (<1%)
Percent Total Terrain Type	46 miles (63%)	28 miles (37%)

Notes:
1 HIJ: Organic material over loamy to coarse-loamy eolian deposits. Hills and plains
2 HIL: Organic material over coarse loamy eolian deposits. Glaciated hills and plains
3 MTG: Organic material (loamy) over gravelly slope colluvium/alluvium. Mountainous to hills and plains
4 IA7: Typic Cryandepts—very gravelly, nearly level to rolling association
5 IA17: Dystric Lithic Cryandepts—loamy, hilly to steep association
6 IA9: Typic Cryandepts—very gravelly, hilly to steep association
ESS = Exploratory Soil Survey of Alaska
Kokhanok airport spur road is not included in the evaluation due to the comparatively short road length and similar conditions to other project access roads
Total length deviates approximately 1 mile from those shown in Table K2-1 due to rounding discrepancy
Source: Rieger et al. 1979; PLP 2020d; NRCS 2019 (see Appendix K3.14)

The length of roads under Alternative 1a is approximately 74 miles. Approximately 46 miles (63 percent) of the transportation corridor generally coincide with gentle to moderate terrain, whereas 28 miles (37 percent) are associated with moderate to rough terrain. Gently sloping or level transportation infrastructure would be less susceptible to erosional processes. This includes ferry terminal sites, access roads, and other terrain-specific infrastructure (Table 4.14-3). Physical conditions more susceptible to hydraulic erosion in moderate to rough terrain along the transportation corridor include poorly drained, fine-grained loess or colluvium on sloped topography, waterbody crossings, road prism drainages (e.g., swales), higher-gradient slopes, and sidehill cuts.

Construction-phase activities that would potentially cause or contribute to erosion include:

- Removal and clearing of vegetation for access roads, material sites, and terminal facilities.
- Overburden clearing and vegetative mat removal for cut and/or fill placement of engineered materials (e.g., aggregate, substrates).
- Overburden management that would include stockpiles or windrows of organic-rich materials and vegetation, or excavated substrates considered unsuitable for infrastructure construction.
- Development of material sites and material site access roads.
- Blasting of bedrock to support roadbed construction.

The magnitude of effects from erosion during construction would vary along project road segments depending on soil types and physical conditions present, seasonal conditions, and construction requirements. The extent of impacts from erosion may be localized at susceptible locations, such as waterbody drainages and crossings (e.g., culverts, bridges, and swales), wetlands, or intermittent sloped topography. Impacts of erosion, although generally expected to only occur during the construction phase, would be long-term because the results of the erosion would be evident until the sites are reclaimed. Broader areas considered more susceptible to runoff and erosion would include continuous segments of road through rough terrain; and to a lesser extent, moderate terrain. These conditions would require steeper roadbed grades and side-hill cuts that could result in greater erosion potential from runoff (i.e., greater energy) and slope failure.

Terrain and soil conditions considered most susceptible to erosion along the transportation corridor are those present along the port access road. Most of the port access road would be predominantly constructed over rough, variable terrain (Table 4.14-3), where fine-grained soil types reportedly overlie shallow bedrock. Although conditions along the port access road appear most vulnerable to hydraulic erosion processes, the evaluation is based on generalized soil descriptions provided in the Exploratory Soil Survey of Alaska (ESS) (Rieger et al. 1979) and does not account for local variations in soil conditions or bedrock outcrops where no soil horizon may exist. With the exception of the northernmost 4- to 6-mile portion of the port access road route, blasting would be required for most roadbed construction, supporting the prevalence of shallow bedrock and moderate to rough terrain conditions (PLP 2018-RFI 084).

Portions of the mine access road northward from the Eagle Bay ferry terminal to the mine access road junction traverse toe slopes of elevated topographic relief in low to moderately sloping terrain. The potential for hydraulic erosion along these route segments is considered greater than those along broader and flat landscapes. Areas of cut-and-fill road construction along toe-slopes would require more drainage control measures, in addition to a greater frequency of perennial and ephemeral waterbody crossing prevalence.

Similar to access roads, the magnitude of effects of hydraulic erosion at material sites would also vary based on source material competency (e.g., shot bedrock or aggregate) and conditions unique to each borrow site location. Construction of material sites and transportation corridor infrastructure would use structural and non-structural BMPs and employ erosion control measures adequate to satisfy appropriate ADEC discharge permit requirements and coverage under an SWPPP (PLP 2020d).

Ground disturbances would be progressively restored throughout construction until stabilization and restoration are achieved. Most disturbances would likely be stabilized during construction, or several years thereafter, at locations considered less susceptible.

The least erosion would likely occur during operations, when stabilization of disturbed surfaces would be achieved through natural recovery, applied restoration measures, and long-term or permanent stabilization measures. Material sites and access roads would be progressively reclaimed. Typical reclamation BMPs at material sites include benching or sloping of sidewalls to suitable grades, based on material types (e.g., aggregate or bedrock); distribution of salvaged overburden growth media on pit floors and slopes; and tracking and seeding.

Continuous feedback from truck traffic during operations and/or prescribed follow-up inspections would identify areas of acute or persistent erosion. Areas of concern would be identified, and additional or more robust measures applied to meet local site-specific conditions. This would most likely be required along rough terrain associated with the port access road, and/or areas requiring permanent drainage controls (e.g., culverts, bridges, swales).

The magnitude of erosion during closure and post-closure would likely be greater than during operations. Some erosion may be cause by the removal and reclamation of long-term facilities (e.g., ferry terminals) before complete restoration and surface stabilization objectives are met. However, most erosion would likely be associated with permanent roads to the mine site. Monitoring frequencies in post-closure would typically be less than during operations, and there would be reduced access to equipment and resources. Required permanent transportation corridor access would result in an indefinite potential for erosion monitoring and maintenance.

4.14.3.3 Amakdedori Port

This section describes potential effects on onshore (i.e., upland) soils at the Amakdedori port site during construction through closure. Primary components associated with the Amakdedori port site include a terminal facility, airstrip, water extraction site, overburden stockpile, and a caisson-supported dock. Offshore sediment impacts resulting from intertidal and open-water construction (e.g., dock), operations, and closure of marine facilities are discussed in Section 4.18, Water and Sediment Quality.

Soil Disturbance

No current development exists at the Amakdedori port site. Onshore soil disturbances would mostly be attributed to construction of the terminal, uplands overburden stockpile, water extraction site access road, and airstrip. The magnitude and extent of impact would be the disturbance of approximately 29 acres of soil at the onshore portion of Amakdedori port site from construction through operation. Approximately 7 acres of the 29 acres of soil disturbance would be temporary. Temporary disturbances would be reclaimed once no longer used after the construction period. Imported engineered fill from material sites would be sourced from locations discussed under the transportation corridor, and summarized material site soil quality impacts are discussed under Alternative 1, which requires the greatest amount of fill under a comparable scenario.

The duration of these disturbances would be long-term to permanent, and the impact would be certain to occur if the project is permitted and the port is built. Because no construction would be required during operations, subsequent disturbances to soil would likely be limited. With the exception of necessary infrastructure to support shallow-draft tug and barge access to the dock, onshore port facilities would be removed during closure. No additional soil disturbances are anticipated during closure, and restoration of post-disturbance soil conditions would occur through reclamation activities (e.g., scarification, growth media, contouring, and seeding).

Soil Quality

Engineered fill or locally sourced materials at the port site are not expected to introduce chemical impairments to soils. Material sites that would be used are well outside the Pebble deposit and previous field reviews have not identified the presence of PAG rock at any of the proposed road material sites. Material site evaluations would be conducted prior to use and if PAG material were identified, an alternative material site would be used (PLP 2018-RFI 035). Additionally, coarse-grained engineered fill textures would be less susceptible to erosion or fugitive dust generation, mitigating the potential for associated impacts.

The most probable source/activity of soil quality impairment at the Amakdedori port would be concentrate handling. Sealed bulk containers would be emptied offshore into the hold of bulk carriers (i.e., ship), at a depth of no less than 20 feet below the hatch (PLP 2018-RFI 009c) (see Section 4.27, Spill Risk). The calculated magnitude of total fugitive PM generated on a yearly basis during offshore transfers is 0.002 ton per year (4 pounds). For these reasons, the magnitude and potential of soil quality impact from project activities at the port are considered negligible, and unlikely to impact soil quality in upland conditions. The geographic extent of soil quality impacts (if any) would be confined to the immediate port footprint, of which the duration would be predominantly limited to the construction and operations phases.

Erosion

Earthwork during construction of the port would incorporate erosion control measures specified in an approved SWPPP. Typical measures may include silt fences, hay bales, temporary sedimentation basins; and repurposed brush for berms and watering for dust suppression. BMPs may include crowning or in-sloping of running surfaces and temporary drainage channels, berms, and catchment basins. Similarly, interim stabilization measures for stockpiled soils would minimize wind and hydraulic erosion processes, which may include dimensional sloping (e.g., reduced slope angles), roughening, and compaction. If necessary, stockpile erosion control and catchment berms would likely mitigate erosional runoff concerns if any material remains as salvaged growth media following post-construction reclamation activities.

Water- and wind-induced erosion would occur at the port site throughout construction, and to a limited extent during operations and closure. The caisson dock design would reduce the potential for erosion. Hydraulic erosion during operations would be less than during construction due to little additional soil removal and effects of established SWPPP design features (e.g., culverts, swales). Erosion during closure would be less than during construction, but likely greater than during operations. Exposed ground surfaces at sites of removed infrastructure not required for post-closure would be susceptible to wind and water erosion for an interim period until reclamation and restoration activities are completed. The potential for erosion would be mitigated using measures similar to those described for construction. See Section 4.16, Surface Water Hydrology, for a discussion of sediment transport at Amakdedori.

4.14.3.4 Natural Gas Pipeline Corridor

This section describes potential effects of Alternative 1a on onshore soils from pipeline infrastructure on the eastern side of Cook Inlet, pipeline-only (not co-located with a road) segments on the western side of Cook Inlet, and pipeline landings (on the western side of Cook Inlet and on the southern and northern shoreline of Iliamna Lake). Pipeline impacts for segments of the pipeline coincident with the transportation corridor on the western side of Cook Inlet are addressed above.

Soil Disturbance

The magnitude of onshore soil disturbances from pipeline infrastructure on the eastern side of Cook Inlet is approximately 3 acres. This would include the compressor station, laydown area, access road, metering pad, and HDD work area, of which less than 1 acre would be disturbed on a temporary basis.

The magnitude and extent of impact on the western side of Cook Inlet would be the disturbance of approximately 219 total acres of soil associated with the onshore pipeline-only segment from Newhalen to the mine access road (175 acres over low-sloping terrain) and pipeline-associated disturbance at the mine site, ferry landings, and Amakdedori port. Soil types associated with the pipeline corridor on the western side of Cook Inlet are common to the transportation corridor described above. Impacts would be short-term during construction, and would be expected to occur if the project is permitted and the gas pipeline is built. Pipeline activities resulting in disturbances to unconsolidated sediment associated with wetlands, subsea, and waterbodies (e.g., streams, lake) settings are described in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites; Section 4.18, Water and Sediment Quality; and Section 4.16, Surface Water Hydrology.

Erosion

Similar to other project components, mitigation and control measures would incorporate structural and non-structural BMPs to address erosion, sedimentation, and stormwater runoff (PLP 2020d). Pipeline construction would follow guidelines and accepted common practices for stabilization and sedimentation control for pipeline projects (USACE 2018c) (see Chapter 5, Mitigation).

The topography associated with the pipeline infrastructure on the eastern side of Cook Inlet is gently sloping or nearly level. Reported soil survey attributes (physical properties) for the silty loam soils associated with these conditions are considered to have a “slight” hazard of erosion by water (organic mat/top cover removed) but are vulnerable (“severe”) to erosion by wind (USDA 2005). Although the slight erosion hazard by water is primarily associated with low-angle slopes for these soil types in the disturbed footprint, this does not preclude accelerated erosional processes attributed to human-made ground disturbances such as channelized surface water runoff. Use of HDD would provide a sufficiently wide setback distance between the project footprint and Cook Inlet bluff (about 200 feet); project activities are not expected to contribute to ongoing natural erosion in this area (Section 3.15, Geohazards and Seismic Conditions).

Trenching for pipeline construction would require the removal of vegetation and excavation of soil, sediments, and rock, which would result in increased potential for impacts associated with erosion, sedimentation, and runoff. The potential for these impacts would be reduced after construction activities cease and vegetation is re-established. The magnitude, duration, extent, and potential for these impacts would be the same as those associated with the removal of vegetation for road construction.

Erosion impacts would be short-term, mainly during construction and would be mitigated through erosional controls and BMPs. Stockpile management practices that would minimize the potential for hydraulic and wind erosion would include strategic positioning relative to ground slopes and receiving waterbodies (e.g., set-back distance); placement in low-slope profiles; surface roughening; or runoff capture through filter structure placement (see Chapter 5, Mitigation).

4.14.4 Alternative 1

The potential impacts of Alternative 1 on the mine site, transportation corridor, Amakdedori port location, and natural gas pipeline corridor are described in the following subsections. Alternative 1 variants are also discussed.

4.14.4.1 Mine Site

The magnitude, duration, extent, and likelihood of impacts to soils in the mine site would be the same as those described under Alternative 1a.

4.14.4.2 Transportation Corridor

Under Alternative 1, the total acreage of transportation corridor soil disturbance is less than Alternative 1a; however, the port access road from the south ferry terminal to Amakdedori port and Kokhanok spur road would be the same. Therefore, impacts for the port access road would be the same as discussed above for Amakdedori port for Alternative 1a. Under Alternative 1, the mine access road would trend south from the mine site to a north ferry terminal on Iliamna Lake. The south ferry terminal would be at the same site as described for Alternative 1a.

Impacts at material sites, changes to soil quality, and effects from small spills of hydrocarbons or other toxins would be the same as those described under Alternative 1a. The following subsections discuss soil disturbance and erosion effects specific to Alternative 1.

<u>Soil Disturbance</u>

Approximate soil disturbances associated with the Alternative 1 transportation corridor include the following total acreages, post-construction acreages, and temporary acreages of disturbance:

- Port access road—699 acres (total), 411 acres (post-construction), 288 acres (temporary)
- Mine access road—565 acres (total), 341 acres (post-construction), 224 acres (temporary)
- Kokhanok Airport spur road—25 acres (total), 15 acres (post-construction), 10 acres (temporary)
- Iliamna spur road—191 acres (total), 119 acres (post-construction), 72 acres (temporary)
- Explosives spur road—6 acres (total), 4 acres (post-construction), 2 acres (temporary)
- Ferry terminals—34 acres (total), 27 acres (post-construction), 7 acres (temporary) approximate
- Material sites—251 acres (total, post-construction)

Cumulative total acreages of soil disturbance for Alternative 1 transportation corridor components include 1,778 total acres (1,744 total acres excluding ferry terminals), 1,171 post-construction acres, and approximately 607 temporary acres.

Erosion

As described above, wind and hydraulically induced erosion of soils would occur along the access road corridors. Construction-phase activities that would potentially cause or contribute to erosion are the same as those described for Alternative 1a. Physical conditions more susceptible to hydraulic erosion along the transportation corridor include poorly drained, fine-grained loess or colluvium on sloped topography, waterbody crossings, road prism drainages (e.g., swales), higher-gradient slopes, and side-hill cuts. As described for Alternative 1a, the magnitude of effects from erosion during construction would vary along project road segments depending on soil types and physical conditions present, seasonal conditions, and construction requirements. Approximate transportation corridor road lengths traversing gentle to moderate and moderate to rough terrain under Alternative 1 are listed in Table 4.14-4.

Table 4.14-4: Alternative 1 Road Lengths, Terrain, and Soil Types

ESS Soil Type	Gentle to Moderate Terrain	Moderate to Rough Terrain
D36HIJ	4 miles (5%)	None
D36HIL	<1 mile (1%)	None
D36MTG	4 miles (5%)	None
HY4	1 mile (2%)	None
IA17	7 miles (9%)	22 miles (28%)
IA7	19 miles (24%)	5 miles (7%)
IA9	12 miles (15%)	3 miles (4%)
Percent Total Terrain Type	~47 miles (61%)	30 miles (39%)

Notes:
[1] HIJ: Organic material over loamy to coarse-loamy eolian deposits. Hills and plains
[2] HIL: Organic material over coarse loamy eolian deposits. Glaciated hills and plains
[3] MTG: Organic material (loamy) over gravelly slope colluvium/alluvium. Mountainous to hills and plains
[4] IA7: Typic Cryandepts—very gravelly, nearly level to rolling association
[5] IA17: Dystric Lithic Cryandepts—loamy, hilly to steep association
[6] IA9: Typic Cryandepts—very gravelly, hilly to steep association
Kokhanok airport spur road is not included in the evaluation due to the comparatively short road length and similar conditions to other project access roads
Total length deviates approximately 1 mile from those shown in Table K2-9 due to rounding discrepancy
ESS = Exploratory Soil Survey of Alaska
Source: Rieger et al. 1979; PLP 2020d; NRCS 2019 (see Appendix K3.14)

The port access road corridor would be the same as described for Alternative 1a. Erosional impacts along the port access road are described above.

Approximately 47 miles (61 percent) of the transportation corridor generally coincide with gentle to moderate terrain, whereas 30 miles (39 percent) generally correspond with moderate to rough terrain. The Iliamna spur road, which is exclusive to this alternative, would require continuous and multiple segments of blasting (see Figure 3.13-5). The mine access road would be least susceptible to hydraulic erosion for transportation segments exclusive to this alternative based on terrain types traversed and soil conditions. The mine access road segment exclusive to this alternative also has a blasting frequency that is comparable to the mine access road segment under Alternative 1a (i.e., Eagle Bay to mine access road).

Alternative 1 has approximately 3 additional miles of total length and moderate to rough terrain requiring blasting construction methods compared to Alternative 1a. Although the total acreage of soil disturbance under this alternative is about 15 acres less than Alternative 1a, it would likely require more cut-and-fill road construction and use of erosion control and mitigation measures.

For these reasons, the potential for erosion under Alternative 1 is considered comparable or appreciably greater than Alternative 1a.

All other aspects of the discussion of erosion along Alternative 1a transportation corridor also apply to this alternative. Similar to Alternative 1a, the duration and extent of impacts from hydraulic erosion would be throughout the entire project life cycle along the transportation corridor.

4.14.4.3 Amakdedori Port

The Amakdedori port is the same as described for Alternative 1a. However, under Alternative 1, the port design would include a sheet pile solid fill dock rather than a caisson-supported dock as described for Alternative 1a. Offshore sediment impacts resulting from intertidal and open-water construction (e.g., dock), operations, and closure of marine facilities are discussed in Section 4.18, Water and Sediment Quality.

Soils Disturbance

Soil disturbances would mostly be attributed to construction of the terminal. Other soil disturbance would be due to the uplands overburden stockpile, water extraction site access road, and airstrip. Although the Alternative 1 port includes a sheet pile solid fill dock rather than a caisson-supported dock as described for Alternative 1a, the onshore port disturbance would be the same as Alternative 1a. The magnitude and extent of impact would be the disturbance of approximately 29 acres of soil at the Amakdedori port site from construction through operation.

This magnitude of soil disturbances at the port would include the complete removal of soil cover at the terminal during construction and placement of engineered fill at the terminal. The duration of these disturbances would be long-term to permanent, and the impact would be certain to occur if the project is permitted and the port is built. Because no construction would be required during operations, subsequent disturbances to soil would likely be limited. With the exception of necessary infrastructure to support shallow-draft tug and barge access to the dock, onshore port facilities would be removed during closure. No additional soil disturbances are anticipated during closure, and restoration of post-disturbance soil conditions would occur through reclamation activities (e.g., scarification, growth media, contouring, and seeding).

Soil Quality

Potential impacts to soil quality would be the same as those described for Alternative 1a.

Erosion

Erosion effects under Alternative 1 would be the same as those for Alternative 1a. See Section 4.16, Surface Water Hydrology, for a discussion of sediment transport at Amakdedori.

4.14.4.4 Natural Gas Pipeline

This section describes potential effects of Alternative 1 on onshore soils from pipeline infrastructure on the eastern and western side of Cook Inlet, including the pipeline landings (on the western side of Cook Inlet and on the southern and northern shoreline of Iliamna Lake). Pipeline-related impacts for segments of the pipeline coincident with the transportation corridor on the western side of Cook Inlet are addressed above under “Transportation Corridor.”

Soil Disturbance

The magnitude of acreage of onshore soil disturbances from pipeline infrastructure on the eastern side of Cook Inlet would be the same as that described for Alternative 1a.

Under this alternative, there are relatively short pipeline segments that would be constructed separate from the transportation corridor (i.e., pipeline-only segments). The magnitude and extent of impacts on the western side of Cook Inlet associated with these segments of pipeline would be the disturbance of approximately 61 acres of soil. Soil types associated with the pipeline segments on the western side of Cook Inlet are common to the transportation corridor and are described above. Impacts would be short-term during construction and would be expected to occur if the project is permitted and the gas pipeline is built. Pipeline-related disturbances to unconsolidated sediment associated with wetlands, subsea, and lake settings are described in Section 4.22, Wetlands and Other Waters/Special Aquatic Sites; Section 4.18, Water and Sediment Quality; and Section 4.16, Surface Water Hydrology.

Erosion

General erosion impacts and mitigation and control measures along the natural gas pipeline corridor are the same as those described for Alternative 1a. The pipeline-only segment under this alternative is much shorter than that for Alternative 1a and would impact about 157 fewer acres. Although erosional impacts for both Alternative 1a and Alternative 1 would be short-term during construction and would be mitigated through erosional controls and preventative measures (BMPs), the overall potential for impacts would be less under Alternative 1. This is because Alternative 1a has a larger combined pipeline and transportation corridor acreage of disturbance.

4.14.4.5 Alternative 1—Summer-Only Ferry Operations Variant

This variant would require an increase in soil disturbance associated with the construction of designated concentrate container storage areas at the mine site and Amakdedori port. The magnitude and extent of impacts on soil would be the disturbance of approximately 33 additional acres of storage area at the mine site, and approximately 27 additional acres at Amakdedori port, yielding a total of approximately 60 additional acres under this variant compared to Alternative 1. The duration of these impacts would be long-term, remaining throughout the mine operations; but not permanent, because these areas would be reclaimed during closure. These disturbances to soil would be certain to occur if the project is permitted, the Summer-Only Ferry Operations Variant is chosen, and the project is built.

Impacts to soil quality would be expected to be the same as Alternative 1; however, the potential for soil quality impacts could be greater due to additional concentrate handling and transport steps required under this alternative.

This variant would also temporally compress road traffic during ice-free months, which could result in a greater potential for hydraulic and wind erosion along the transportation corridor.

4.14.4.6 Alternative 1—Kokhanok East Ferry Terminal Variant

Differences between this variant and the base case Alternative 1 are limited to transportation corridor and pipeline-only segments between ferry terminal(s). Despite a shorter transportation route and reduced ferry terminal footprint, the total acreage of soil disturbance under this variant would be slightly greater than, but comparable to Alternative 1. The magnitude and extent of impacts on soil would be the disturbance of approximately 13 additional acres along the transportation corridor, primarily due to material site acreage, and approximately 25 additional acres associated with the natural gas pipeline component, yielding a total of approximately 38 additional acres under this variant compared to Alternative 1. Impacts on soils associated with the transportation corridor would be long-term and would be expected to occur if the project is permitted and the east ferry terminal is built. Impacts to soils associated with construction of the pipeline would be short-term during construction, and would be expected to occur if the project is permitted and the gas pipeline is built.

Although soil disturbance acreage is slightly greater under this variant than under the base case Alternative 1, the potential for erosion is likely to be less. This is based on a shorter road length and a greater proportion of soil disturbances associated with material sites. Roads generally require a greater diversity of erosion control measures (e.g., waterbodies, cross slopes, inclines); whereas material sites inherently consist of coarser-grained materials (or bedrock) that are less susceptible to hydraulic and wind erosion. Furthermore, sediment runoff at material sites is more likely to be retained in the footprint of disturbance (e.g., depressions).

4.14.4.7 Alternative 1—Pile-Supported Dock Variant

Although the Pile-Supported Dock Variant would reduce impacts to marine sediments compared to the sheet pile solid fill dock described for Alternative 1, the onshore port disturbance to soils would be the same as described for Alternative 1. Offshore sediment impacts resulting from intertidal and open-water construction (e.g., dock), operations, and closure of marine facilities are discussed in Section 4.18, Water and Sediment Quality.

4.14.5 Alternative 2—North Road and Ferry with Downstream Dams

The following section describes impacts to soil resources under Alternative 2. Infrastructure descriptions, usage, physical reclamation, and closure would be the same as Alternative 1a, but would occur at the locations described under this alternative.

4.14.5.1 Mine Site

The bulk TSF dam at the mine site would be constructed using different methods under this alternative (i.e., downstream method with buttress). The magnitude of the impact of this construction method on soils would result in an increased impoundment footprint compared to Alternative 1a, and the overall total increase in additional acreage would be approximately 107 acres. Overall, the duration and extent of impacts to soil from ground disturbances would be comparable to Alternative 1a; however, there would be greater impact magnitude based on the increased acreage of disturbance. Erosion impacts would be the same as Alternative 1a; however, there would be an increased potential for erosion based on infrastructure build-out.

4.14.5.2 Transportation Corridor

Soil Disturbance

Transportation corridor components under Alternative 2 would also incorporate two ferry terminals on Iliamna Lake, and road access to the mine and port (i.e., Diamond Point port). The road would bypass all but 5 miles of the existing Williamsport-Pile Bay Road; however, these sections would require upgrades to accommodate larger vehicles associated with the project. The magnitude and extent of total soil disturbance acreages, post-construction acreages, and temporary acreages of disturbance associated with Alternative 2 transportation infrastructure (including the co-located portion of roadbed pipeline) include:

- Mine access road: mine site to Eagle Bay ferry terminal site—644 acres (total), 353 acres (post-construction), 291 acres (temporary)
- Port access road: Pile Bay ferry terminal to Diamond Point port site—347 acres (total), 209 acres (post-construction), 138 acres (temporary)
- Ferry terminal sites—30 acres (total), 25 acres (post-construction), 5 acres (temporary)

- Material sites and access roads—321 acres
- Explosives storage spur road—6 acres (total), 4 acres (post-construction), 2 acres (temporary)

The cumulative total acreage of upland soil surface disturbances associated with the transportation corridor under Alternative 2 is approximately 1,349 acres, of which 912 are post-construction acres and 437 are temporary. Although disturbance mechanisms, nature of impacts, and erosion mitigation and control measures during construction, operations, and closure of transportation corridor infrastructure would be comparable to those described under Alternative 1a, the overall magnitude of soil disturbance would be less. Although the mine access road under both Alternative 1a and this alternative are the same, Alternative 2 would require fewer total miles of road because the port road for Alternative 2 is approximately 20 miles shorter. Alternative 1a and Alternative 2 would have the same ferry terminal at Eagle Bay, but the other terminal locations would differ. The footprint for the terminal at Pile Bay under Alternative 2 would be 5 acres less than that for the south ferry terminal location under Alternative 1a. The duration of and potential for impacts would be comparable to Alternative 1a.

Soil Quality

Impacts to soil quality along the transportation corridor under Alternative 2 would be the same as described for the corridor under Alternative 1a.

Erosion

Soil types and general terrain descriptors present along the Alternative 2 transportation corridor are summarized in Table 4.14-5. Terrain descriptors are based on the presence of shallow bedrock or terrain requiring blasting to accommodate road construction.

Table 4.14-5: Alternative 2 Approximate Road Terrain and Soil Types

ESS Soil Type	Gentle to Moderate Terrain	Moderate to Rough Terrain
D36HIJ	4 miles (7%)	None
D36HIL	<1 mile (1%)	None
D36MTG	4 miles (7%)	None
IA7	22 miles (41%)	1 mile (2%)
IA9	4 miles (8%)	<1 mile (1%)
RM1	8 miles (14%)	5 miles (10%)
SO11	4 miles (8%)	1 mile (2%)
Percent Total Terrain Type	46 miles (85%)	8 miles (15%)

Notes:
1 HIJ: Organic material over loamy to coarse-loamy eolian deposits. Hills and plains
2 HIL: Organic material over coarse loamy eolian deposits. Glaciated hills and plains
3 MTG: Organic material (loamy) over gravelly slope colluvium/alluvium. Mountainous to hills and plains
4 IA7: Typic Cryandepts—very gravelly, nearly level to rolling association
5 RM1: Rough Mountainous Land – Steep rocky slopes
6 IA9: Typic Cryandepts—very gravelly, hilly to steep association
7 SO11: Humic Cryorthods—silty volcanic ash over gravelly till, hilly to steep association
ESS = Exploratory Soil Survey of Alaska
Total length deviates approximately 1 mile from those shown in Table K2.1 due to rounding discrepancy
Source: Rieger et al. 1979; PLP 2020d; NRCS 2019 (see Appendix K3.14)

A greater proportion of coarse-grained materials is present along the transportation corridor route based on generalized soil descriptions provided in the ESS, whereas the occurrence of finer-grained silt/sand loam mixtures is reportedly less prevalent than Alternative 1a (Table 4.14-3). Therefore, less wind erosion is anticipated under this alternative, based on the prevalence of coarser-grained substrates along the transportation corridor; a comparatively smaller acreage of soil disturbance that would reduce the potential for wind shear on disturbed surfaces; and a reduced vehicle travel distance for dust dispersion. Because the route under this alternative is also lower in elevation than Alternative 1, overall wind-driven forces (e.g., velocity) are also likely to be less. However, this would not preclude occurrence of episodic high-wind processes that are commonly associated with valley features present along the port access road.

Most hydraulic erosion mechanisms, nature of impacts, and mitigation and control measures during construction, operations, and closure of transportation corridor infrastructure would be comparable to those described under Alternative 1a. Similar to Alternative 1a, hydraulic erosion susceptibility under this alternative would be greatest in steep, hilly to mountainous terrain along the southernmost port access road segment.

Heavy precipitation and flooding during fall months have previously resulted in significant hydraulic erosion losses along the Williamsport-Pile Bay Road (KPB 2014; USACE 2007a). Specific conditions that resulted in impassable erosion washout at multiple points along the Williamsport-Pile Bay Road in the fall of 2003 included culvert and bridge crossings, and surface water erosion in drainages aligned adjacent (e.g., swale or ditch) to the road (USACE 2007a).

Although the route is commonly aligned with 5 miles of the existing Williamsport-Pile Bay Road, the remaining road would be newly constructed to minimize conditions historically susceptible to erosional processes along the current Williamsport-Pile Bay Road alignment. The southernmost uplands road segment has comparatively fewer cross cuts along toe-slopes in areas of greater vertical relief, and traversed terrain is considered to be gentler and moderate in character (Table 4.14-5). Rock cuts along the southernmost uplands segment and other discrete segments would require blasting; however, it would be comparatively less than the port access road under Alternative 1a. Furthermore, the road alignment, which would be shared with the existing Williamsport-Pile Bay Road, would be improved to accommodate large trucks associated with the project.

Approximately 3 miles of road extending from the Diamond Point port site would follow the coastline of Iliamna Bay. This coastline road segment is considered most susceptible to erosion under all alternatives. The coastal road is situated along the toe-slopes of mountainous terrain and would likely be subjected to marine-driven processes. The topographic relief immediately adjacent to the road from the port is characteristic of a high-energy environment, where natural hydraulic erosion and slope failure processes are likely to be more prevalent. Portions of roadway along this coastline segment could also be more susceptible to tidal action: ice scour/rafting, storm surge, and wave action. Additional discussion regarding slope failure processes and occurrence are presented in Section 4.15, Geohazards and Seismic Conditions.

In summary, the greatest magnitude of corridor erosion under Alternative 2 would occur along the port access route. Erosion along the port access route under Alternative 2 would likely be less than Alternative 1a, based on a smaller acreage of soil disturbance and presence of terrain types that are associated with a reduced erosion potential. However, the initial 2 miles of road extending from the port under Alternative 2 could be the most erosion-susceptible segment of road. This nearshore segment of road is unique to Alternative 2 and Alternative 3—North Road Only and would require enhanced design and mitigation measures to account for the high-energy environment. The duration of these impacts would be long-term, and they would be expected to occur if Alternative 2 is chosen, the project is permitted, and the transportation corridor is built.

4.14.5.3 Diamond Point Port

Soil Disturbance

Soils in the port footprint under Alternative 2 are reportedly associated with rough, mountainous land (RM1) consisting of sparsely vegetated soil over shallow bedrock or stones/boulders. The port terminal facility and dredge material stockpile would result in soil disturbances. The magnitude of onshore soil disturbances at Diamond Point port would be approximately 50 acres, of which 9 acres would be temporary and 41 acres would be post-construction. The estimated acreage of disturbance includes the footprints of the port terminal facility and uplands disposal of dredged materials (e.g., stockpile). The magnitude of dredge material stockpile footprints would total approximately 16 acres and would be managed similarly to overburden stockpiles. The total acreage of soil disturbance at Diamond Point port is approximately 72 percent greater than Amakdedori port under Alternative 1a and Alternative 1 (approximately 21 acres greater).

Dredge stockpiles would include berms to contain sediments, collection of seepage, and stormwater runoff, as well as treatment in settling ponds prior to discharge (PLP 2018-RFI 099). These effects on soils would be long-term and certain to occur if Alternative 2 is chosen and the Diamond Point port is permitted and built.

Most soil disturbance mechanisms and impacts during construction, operations, and closure at the port would be similar in magnitude, duration, and extent to those described under Alternative 1a; however, disturbances unique to this alternative include the following:

- Blasting of shallow bedrock at discrete locations to accommodate port infrastructure
- Uplands disposal of dredge material

Soil disturbances during construction would involve grading and contouring of ground surfaces, and extensive blasting of shallow bedrock to accommodate port construction. Removal of soil considered unsuitable for construction purposes would be limited due to prevalent shallow bedrock and coarse alluvium outwash. The bermed dredge material stockpile would be built immediately adjacent to the port terminal to receive spoils from dredge channel clearance.

Because no additional construction would be required during operations, soil disturbances during port operations would primarily be limited to dredge material stockpile expansion from maintenance dredging. The magnitude of dredged materials to be stockpiled would be, at a minimum, half of the material dredged for channel construction and maintenance (approximately 325,000 cubic yards). This material would be disposed of onshore in a bermed facility. Soil disturbance impacts associated with the dredge material stockpile could range from the direct burial of existing soils, to potential acute or obvious changes associated with any stockpiled marine sediment in an upland environment. These impacts would be long-term, lasting for the duration of the project, and would be expected to occur if Alternative 2 is chosen and permitted, and the Diamond Point port is constructed.

Soil Quality

Impacts to soil quality along the transportation corridor under Alternative 2 would be the same as those described for the corridor under Alternative 1a.

Erosion

Most hydraulic erosion mechanisms, nature of impacts, and mitigation and control measures during construction, operations, and closure of port facilities would be comparable to those described under Alternative 1a. The magnitude, duration, extent, and potential of impacts due to erosion would also be comparable to Alternative 1a. Because coarse alluvium outwash and shallow bedrock conditions at the Diamond Point port site are less susceptible to erosion compared to the Amakdedori port site, the period of greatest ground disturbance during port facility construction would generally result in less erosion under Alternative 2 compared to Alternative 1a. However, unique conditions specific to this alternative that could potentially increase erosional susceptibility or require additional design and mitigation measures throughout construction, operations, and post-closure include the following:

- Uplands disposal of dredge material
- Topographic relief and slope stability

Hydraulic erosion of stockpiled dredge materials would be mitigated through proper impoundment and drainage design. Stockpiled materials could be susceptible to wind erosion, depending on the physical attributes of dredge materials (particle size distribution and cohesion); interim surface stabilization measures; constructed dimensions; and frequency and magnitude of coastal and seasonal winds. Physical conditions that are considered less susceptible to wind erosion include high moisture contents or frozen conditions; larger particle sizes; presence of surface cover, and lower slope angles to reduce wind shear. Mitigation measures that may reduce the potential for wind erosion include wind breaks, snow fencing, reduced slope angles, or watering during increased periods of susceptibility. Final closure of the stockpile would include drainage and surface stabilization. Typical measures that could facilitate stockpile surface stabilization include slope and top-cover engineering, tracking (rolling), seeding, and repurposing of material as growth media.

The topographic relief immediately inland of the eastern port footprint (to the jetty/causeway) is characteristic of an environment where natural hydraulic erosion and slope failure processes are likely to be more prevalent. Sloped ground conditions bordering the port footprint have a greater potential for increased surface water runoff, which could result in greater rates of scouring or aggradation. This could potentially include slope failure processes that indirectly impact port infrastructure. Recent slope failure occurrence (e.g., landslide) is present along the access road that would extend from the port to the jetty. These conditions would require additional design and mitigation measures; however, the potential for slope failure to compromise discrete portions of port infrastructure would likely persist. This would also include infrastructure at the base of headwall cuts in bedrock. Additional discussion regarding slope failure processes and occurrence are presented in Section 4.15, Geohazards and Seismic Conditions.

4.14.5.4 Natural Gas Pipeline Corridor

The eastern landfall of the pipeline under Alternative 2 would be at Ursus Cove. The pipeline would be constructed below grade along a valley floor (trench installation), and resurface at the Diamond Point port site after the short (trenched and buried) marine crossing of Cottonwood Bay. The magnitude of effects would be disturbance to 5.5 miles of uplands that coincide with shallow bedrock and coarse soil textures (e.g., boulder and cobble) in rough mountainous terrain; however, it is likely that an appreciable gravelly sand colluvium is present along the valley floor. The pipeline from the port would follow a shared road corridor towards the Pile Bay ferry terminal. The pipeline-only (not co-located with a road) segment between the Pile Bay and Eagle Bay road off-takes would be 36 miles in length.

Soil Disturbance

The magnitude and extent of upland ground disturbance associated with pipeline-only components under Alternative 2 totals approximately 1,106 acres that include:

- Pipeline-only construction ROW—777 acres (temporary)
- Material sites—298 acres (permanent)

- Compressor station infrastructure—2 acres (permanent)
- Temporary construction access—29 acres (temporary)

Although the pipeline construction corridor would be 150 feet wide during construction to accommodate trench spoils and heavy equipment traffic, complete removal of the overlying vegetative mat would be limited to an 8-foot span directly above the trench (see Figure 2-48). The total acreage of vegetative mat that would be completely removed during construction is approximately 40 acres. Shallow soil on the spoils and working sides of the trench would mostly be limited to disturbances from working equipment resulting in ground compaction, rutting, or tearing of ground surfaces. The duration of impacts would be comparable to Alternative 1a; however, the magnitude and extent would be greater due to a larger area of post-construction and temporary soil disturbances.

Construction would occur year-round along simultaneous or overlapping construction efforts on segments; construction would include preliminary ROW clearing and preparation, followed by pipeline installation, and rehabilitation/commissioning. Temporary pipeline camps and material sites would be required.

Soils that are more susceptible to surface disturbances (e.g., wetlands) would incorporate additional mitigation measures and BMPs. Working pads constructed of swamp mats along the working ROW would be used to minimize surface disturbances during summer months, and frost-packing of the entire construction ROW during winter months. Frost-packing would involve clearing the snow from the ROW to achieve a frost depth of 2 feet below ground surface. Although no other mitigation and restoration activities have been specified, common practices that could be used during construction include salvaging of timber for corduroy matting or ice-pad construction. To the extent practicable, backfilling would occur as soon as possible to minimize additional equipment efforts or soil disturbances. Temporary impoundment of saturated spoils and/or drainage control measures for water accumulation in the trench may be required for construction in wetlands.

Most mitigation and restoration measures would be implemented during and immediately after construction; however, follow-up measures may be necessary on a case-by-case basis, particularly after winter construction activities. Surface disturbances are expected to recover within the first few years following construction. Soil disturbances during operations would be less than during the construction period. The permanent pipeline ROW may require periodic brush-clearing to accommodate routine and non-routine pipeline monitoring and maintenance over the operational period. Disturbances may result from intermittent corrective maintenance activities or additional surface stabilization measures on a case-by-case basis.

Erosion

Similar to other project components, mitigation and control measures would incorporate structural and non-structural BMPs to address erosion and stormwater runoff. Soils corresponding to pipeline-only segments are summarized under Alternative 3 in Table 4.14-6. Approximately 44 miles of pipeline-only segments under this alternative follow the same transportation route as that under Alternative 3.

The magnitude and extent of hydraulic and wind erosion impacts would be greatest along pipeline segments in moderate to rough terrain, where finer-grained silty loess or volcanic ash materials are present at shallow depth. The duration and potential of these impacts would be similar to Alternative 1a. A 24-mile pipeline-only segment from the port access road to Canyon Creek west of Pedro Bay generally coincides with finer-grained silty volcanic ash soils (shallow) overlying glacial till. Slopes range from hilly to steep, and slightly less than half of this segment (12 miles) may require some blasting. Based on the presence of rougher terrain (e.g., blasting), steeper slopes, and finer-grained shallow soils, this segment is considered more susceptible to erosion relative to other sections of the pipeline route to the mine site.

Erosion management during and immediately after construction is anticipated through applied erosional control measures and BMPs. Activities that could potentially accelerate or influence erosional processes in upland areas during the construction include clearing and grading of ground surfaces for access; trench excavation and spoils management (e.g., windrows and stockpiles); and backfilling.

Although no erosional controls or BMPs are specified, pipeline construction would foreseeably incorporate guidelines and acceptable common practices for stabilization and sedimentation control for pipeline projects (USACE 2018c). Sediment barriers or filter structures consisting of silt fences, straw bales, filter bags, brush berms, or other comparable material(s) could be used to retain sediment in surface water runoff. Series of interceptor dikes and diversion ditches equipped with wattles or sediment retention measures would manage surface runoff and flow conditions (e.g., direction, velocity, and run) on steeper gradients. Similarly, placement of trench plugs or ditch breakers in the open-cut trench on steeper gradients could control runoff of sediment–laden water movement under channelized flow conditions. If necessary, sediment entrained in dewatering activities could be filtered prior to discharge using a variety of comparable alternatives (natural vegetation, silt fencing, filter bags, hay bales), or clarification prior to controlled discharge through sediment catchment basins or settling ponds.

Trench spoils would be temporarily stockpiled for pipeline installation. To the extent practicable, stockpiled soils would foreseeably be segregated for backfill characteristics (e.g., drainage and basal materials) and surface cover (e.g., organic mat). Stockpile management practices that would minimize the potential for hydraulic and wind erosion include positioning relative to ground slopes and receiving waterbodies (e.g., set-back distance); placement in low-slope profiles, surface roughening, or runoff capture through filter structure placement.

Erosional controls and preventative measures to manage runoff to surface waters at open-cut waterbody crossings may include seasonal construction (low flow) windows; temporary bladder (water) dams during bed excavation, and filter structures (silt fencing and straw bales). Rig mats and placement of larger preassembled pipeline sections across variable wetland crossings would minimize surface disturbance and erosion potential. Sediment controls and surface water processes at waterbody crossings and wetlands are further discussed in Section 4.16, Surface Water Hydrology; and Section 4.22, Wetlands and Other Waters/Special Aquatic Sites, respectively.

Surface stabilization would be concurrent with, and immediately after construction. Temporary measures may include selective placement of segregated salvaged materials, mulch, brush barriers, or matting. Additional stabilization and restoration measures may also include seeding on a case-by-case basis until surface stabilization objectives are achieved. Post-construction or operations phase, inspections may identify localized conditions requiring installation of long-term surface stabilization controls. Areas considered more susceptible to erosion, where longer-term surface stabilization controls may be required to promote recovery, include sloped topography in silty volcanic soil conditions, wetlands, and waterbody crossings. Pipeline maintenance and monitoring would likely require differential pipeline settlement evaluation. Although the potential for differential settlement occurrence is perceived to be limited based on the general absence of permafrost conditions throughout the project area, variations could potentially occur due to frost action processes. Materials most susceptible to frost action would include poorly drained soils above a shallow water table, such as depressions or along valley bottoms. Silt loam and sandy loam mixtures, which are anticipated to be most prevalent along the alignment, are likely to have moderate frost action. To a lesser extent, areas of poorly drained organic-rich soils on low-angle slopes are likely to have high frost action characteristics (Appendix K3.14).

The least amount of anticipated erosion would occur during closure and post-closure. The pipeline would be abandoned in place, and areas requiring more intensive surface stabilization measures would likely be addressed over the period of operation. Surface facilities associated with the pipeline would be removed and reclaimed.

4.14.5.5 Alternative 2—Summer-Only Ferry Operations Variant

The Alternative 2 Summer-Only Ferry Operations Variant would have the same impact at the mine site as the Alternative 1 variant. However, the magnitude of impacts from the Alternative 2 Summer-Only Ferry Operations Variant would result in 23 additional acres of disturbance along the Williamsport-Pile Bay Road for seasonal storage of concentrate containers, of which 2 acres would be on a temporary basis. The additional transportation corridor acreage of disturbance under this variant is correspondingly greater than Alternative 2, but is still significantly less than Alternative 1a, Alternative 1, or the Alternative 1 Summer-Only Ferry Operations Variant. Although soil quality impacts would be the same as Alternative 2, a greater (perceived) potential exists for soil quality impacts due to additional concentrate handling and transport steps.

The duration of the additional disturbances associated with seasonal storage would remain throughout the period of mine operations and be reclaimed during closure. No other pipeline, transportation corridor, or mine site infrastructure would change under this variant.

4.14.5.6 Alternative 2—Newhalen River North Crossing Variant

Under this variant, impacts to soil resources at the mine, port, and along the natural gas pipeline would be the same as Alternative 2; however, this variant would increase the total soil disturbance acreage by 19 acres along the transportation corridor compared to the Alternative 2 base case. Because this variant would only increase the total acreage of soil disturbance by approximately 1 percent compared to Alternative 2, it is considered comparable.

4.14.5.7 Alternative 2—Pile-Supported Dock Variant

Impacts to soil resources under this variant would be the same as those described for Alternative 2.

4.14.6 Alternative 3—North Road Only

A continuous overland access road would connect the port site north of Diamond Point to the mine site. The magnitude, duration, extent, and potential of impacts to soil resources at the mine site would be the same as Alternative 1a. Impacts at the port site north of Diamond Point would be similar to those described under Alternative 2, with some slight variation in magnitude and location.

Because the natural gas pipeline would predominantly be aligned with the transportation corridor under this alternative, both are collectively evaluated together for soil disturbance and erosion impacts. However, the magnitude of impacts under Alternative 3 for the pipeline-only segments is approximately 138 acres of soil disturbance, which includes the compressor station and access road, material sites, and an HDD pullback work area. The following section describes impacts for the transportation corridor and port that would be appreciably different under Alternative 3.

4.14.6.1 Transportation Corridor

Soil Disturbance

The gas pipeline trench would be adjacent to the road (road-bed prism) to facilitate construction, maintenance, and inspection. The pipeline(s) would use vehicle bridges to span major stream crossings, and HDD drilling or trenching across smaller drainages as appropriate. No Iliamna

Lake ferry infrastructure would be required under this alternative, based on the continuous overland route to the mine site. Estimated magnitudes of total, post-construction, and temporary acreages (including barge landing) of shared transportation corridor and pipeline ground disturbances under this alternative include:

- North access road, shared road corridor/pipeline(s)—1,727 acres (total), 1,077 acres (post-construction), 650 acres (temporary)
- Spur and access roads—16 acres (total), 10 acres (post-construction), 6 acres (temporary)
- Shared transportation and pipeline material sites—604 acres (does not include material sites for the pipeline-only segments).

The total magnitude of acreage of ground disturbance from material sites and shared road and pipeline under this alternative is approximately 2,350 acres, or approximately 25 percent greater than Alternative 1a. Total shared transportation and pipeline acreages under Alternative 3 (2,465 acres) are significantly greater than Alternative 2 (1,345 acres); however, this does not include pipeline-only acreages (approximately 1,135 acres) under Alternative 2 that would be expected to recover to pre-disturbance conditions during the operations phase. The permanent need for transportation corridor access throughout post-closure under Alternative 3 would create a contiguous, permanent ground disturbance in the footprint, unlike the pipeline-only segments associated with Alternative 2. This impact would occur if Alternative 3 is chosen, and if the project is permitted and the transportation corridor as described for Alternative 3 is built.

Erosion

Soil types corresponding to transportation corridor terrain under Alternative 3 are summarized in Table 4.14-6.

Table 4.14-6: Alternative 3 Approximate Road Terrain and Soil Types

ESS Soil Type	Gentle to Moderate Terrain	Moderate to Rough Terrain
D36HIJ	3.8 miles (5%)	None
D36HIL	0.4 mile (1%)	None
D36MTG	3.6 miles (4%)	None
IA7	29 miles (35%)	1.8 miles (2%)
IA9	4.1 miles (5%)	0.5 mile (1%)
RM1	7.6 miles (10%)	5.0 miles (6%)
SO11	12.9 miles (14%)	13.5 miles (17%)
Percent Total Terrain Type	61.6 miles (73%)	20.7 miles (27%)

Notes:
[1] HIJ: Organic material over loamy to coarse-loamy eolian deposits. Hills and plains
[2] HIL: Organic material over coarse loamy eolian deposits. Glaciated hills and plains
[3] MTG: Organic material (loamy) over gravelly slope colluvium/alluvium. Mountainous to hills and plains
[4] IA7: Typic Cryandepts—very gravelly, nearly level to rolling association
[5] IA9: Typic Cryandepts—very gravelly, hilly to steep association
[6] RM1: Rough Mountainous Land—steep rocky slopes
[7] SO11: Humic Cryorthods—silty volcanic ash over gravelly till, hilly to steep association
Total length deviates approximately 1 mile from those shown in Table K2-1, Appendix K2, due to rounding discrepancy
ESS = Exploratory Soil Survey of Alaska
Source: Rieger et al. 1979; PLP 2020d; NRCS 2019 (see Appendix K3.14)

Mitigation and control measures for erosion and stormwater runoff would incorporate structural and non-structural BMPs common to transportation and pipeline construction practices described under Alternative 1a, Alternative 1, and Alternative 2. The greatest potential for hydraulic and wind erosion impacts would correspond with invasive ground disturbance during construction. Disturbed surfaces would remain susceptible to erosion until concurrent or follow-up stabilization is achieved. Permit-required mitigation measures and BMPs are anticipated to alleviate most conditions throughout or immediately after construction.

More robust mitigation and follow-up stabilization measures during and after construction are likely to be required in areas of moderate to rough terrain, where fine-grained soil conditions exist. This coincides with the pipeline-only segment from the port road to Canyon Creek west of Pedro Bay under Alternative 2 (SO11 soils). The least amount of erosion would likely occur during operations, when stabilization of disturbed surfaces would be achieved through natural or applied restoration and stabilization measures, and continued (i.e., real-time) monitoring along the corridor. Erosion throughout post-closure would likely be greater than the operations phase, based on an indefinite need for transportation corridor access; a reduced erosion monitoring frequency; and reduced access to equipment and resources.

Summary of Erosion Impacts

Enhanced design and mitigation measures would be implemented along discrete segments; in particular, the segment of coastline road through rugged terrain from Diamond Point port, approximately 2.5 miles for Alternative 3. More robust mitigation and restoration measures may be needed in moderate to rough terrain with finer-grained soil conditions (SO11 soils). The duration of erosion would vary from completion of the activity (e.g., construction or reclamation), to an indefinite period in post-closure. The extent of erosion effects would be mostly limited to the immediate vicinity of disturbance or footprint.

The overall magnitude, extent, and potential for erosion under this alternative are considered to be greater than the transportation corridor for Alternative 2, based on total footprint acreage of contiguously shared transportation and pipeline alignment, presence of fine-grained soils in moderate to rough terrain, and increased number of waterbody crossings. The duration would be comparable to Alternative 2, because both alternatives indefinitely retain transportation corridor infrastructure.

4.14.6.2 Diamond Point Port

Impacts associated with the port site under Alternative 3 are similar in type to those described for the Alternative 2 Diamond Point port. Soil disturbances would mostly be attributed to construction of the terminal and onshore dredge material storage areas. The magnitude and extent of impact would be the disturbance of approximately 36 acres of soil at the Diamond Point port site from construction through operation. This area of disturbance is greater than Alternative 1a and Alternative 1 (approximately 24 percent), and less than Alternative 2 (approximately 28 percent). Approximately 4 acres of the 36 acres of soil disturbance would be temporary. Temporary disturbances would be reclaimed once no longer used after the construction period. Alternative 3 includes a caisson-supported dock design similar to Alternative 1a; however, it would be constructed in shallower water. As a result, an increased amount of dredging would be required and therefore require increased dredge material storage on uplands. 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). Impacts to soils associated with the storage of dredged material would be similar in type to those described for Alternative 1a; however, the magnitude of impacts may be increased as a result of the increased volume of material stored. Additionally, because of the upland location of dredge storage sites away from marine waters, there is potential for high salinity runoff to impact soil quality adjacent to stockpiles. Offshore sediment impacts resulting from intertidal and open-water construction, operations, and closure of marine facilities are discussed in Section 4.18, Water and Sediment Quality.

4.14.6.3 Alternative 3—Concentrate Pipeline Variant

This variant includes a high-density polyethylene-lined steel pipeline that would convey slurried copper and gold concentrates from the mine site to the port facility (PLP 2018-RFI 066). The pipeline would be predominantly buried sub-grade in the same trench as the gas pipeline, with approximately 36 inches of top cover. Impacts to soil resources at the mine site and port would be the same as those described under Alternative 2; however, a small soil disturbance increase would be anticipated due to a concentrate pipeline pump house at the mine (1 acre).

The shared transportation and concentrate pipeline corridor would increase the road corridor width by less than 10 percent, resulting in a proportional soil disturbance increase. The duration and geographic extent of soil disturbance and erosion would be the same as Alternative 3; however, there would be an appreciable increase in erosion magnitude and potential, based on the additional acreage of disturbance associated with the transportation corridor to accommodate the concentrate pipeline. Impacts on soil quality would be the same as for Alternative 3. However, the potential for an uncontrolled release of concentrates is considered less likely, because there are no container (concentrate) transport, handling, or storage activities under this variant. The concentrate pipeline variant using a return-water pipeline option would not result in any increased footprint and would not be expected to result in any additional impacts to soil resources.

4.14.7 Cumulative Effects

Impacts to soils resources would include those related to soil disturbance and erosion, and deposition of dust from mining activities potentially affecting soil quality. The cumulative effects analysis area for soils encompasses the footprint of the project, including alternatives and variants, the Pebble Project expansion scenario (including road, pipeline, and port facilities), and any other reasonably foreseeable future actions (RFFAs) in the vicinity of the project that would result in potential synergistic and interactive effects. In this area, a nexus may exist between the project and other past, present, and RFFAs that could contribute to a cumulative effect on soils. 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 would be considered to have no potential of contributing to cumulative effects on soils in the analysis area. These include offshore-based developments; activities that may occur in the analysis area but are unlikely to result in any appreciable impact on soil resources (such as tourism, recreation, fishing, and hunting); or actions outside of the cumulative effects analysis area.

4.14.7.1 Past and Present Actions

Past and present actions that have impacted soils in the analysis area are limited and include transportation development where existing roads intersect the project footprint, and mineral exploration in locations where past or current activities have impacted soils (e.g., work pads or camp areas). Although these actions affect localized areas, they are additive to other actions that may occur, slightly increasing the total cumulative effect on geologic resources. Overall, the cumulative effects on soils from past and present actions are minimal in extent and minor in magnitude for all alternatives.

4.14.7.2 Reasonably Foreseeable Future Actions

RRFAs that could contribute cumulatively to soils impacts, and are therefore considered in the analysis of cumulative effects to soils, include: Pebble Project expansion scenario; mining exploration activities for Pebble South, Big Chunk South, Big Chunk North, Fog Lake, and Groundhog mineral prospects; onshore oil and gas development; road improvements and the continued development of the Diamond Point Rock Quarry.

The contribution of RFFAs to cumulative effects on soils are summarized by alternative in Table 4.14-7.

Table 4.14-7: Contribution to Cumulative Effects on Soils

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 manage water and store tailings and waste rock, which would contribute to cumulative effects on geologic resources through removal of overburden, waste rock, and ore. Pebble Project expansion and associated development would be similar for all alternatives. **Other Facilities:** A north access road and concentrate and diesel pipelines would be constructed from Eagle Bay along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. Pipeline construction would have potentially limited impacts on soils from trenching activities. **Magnitude:** The Pebble Project expansion scenario footprint would impact approximately 31,892 total acres, compared to 9,612 total acres under Alternative 1a. **Duration/Extent:** The duration and extent of cumulative impacts to soil would vary from temporary soil disturbance during construction to permanent soil removal in the footprint of mine and other project facilities. Similarly, erosion would vary from minimal surface stabilization efforts to indefinite erosion maintenance (e.g., roads, mine site infrastructure). Additional modeling would be warranted at the time of permitting to re-evaluate and refine fugitive dust scenarios (e.g., identification and quantification of parameters) through comparison of baseline, mine operation, and foreseeable conditions, and comparison to regulatory thresholds at the time of permitting.	**Mine Site:** Identical to Alternative 1a. **Other Facilities:** A north access road and concentrate and diesel pipelines would be constructed along the Alternative 3 road alignment and extended to a new deepwater port site at Iniskin Bay. Pipeline construction would have potentially limited impacts on soils from trenching activities. **Magnitude:** The Pebble Project expansion scenario footprint would impact approximately 32,418 total acres, compared to 9,608 total acres under Alternative 1. The Pebble Project expansion under this alternative is greater than Alternative 1a. **Duration/Extent:** The duration and extent of cumulative impacts to soil would be similar to duration and extent of Alternative 1a, although affecting a larger amount of acreage. **Contribution:** The contribution to cumulative effects from Alternative 1 would be appreciably more than all other alternatives.	**Mine Site:** Identical to Alternative 1a. **Other Facilities:** The north access road would be extended, similar to Alternative 1a. Concentrate and diesel pipelines would also be constructed, similar to Alternative 1a. **Magnitude:** Overall expansion would impact 31,528 acres, which is less acreage than the Pebble Project expansion scenario for Alternative 1a (31,892 acres), given that a portion of the north road and all of the gas pipeline would already be constructed. **Duration/Extent**: The duration and extent of cumulative impacts to soil would be similar to duration and extent of Alternative 1a, although affecting a larger amount of acreage. **Contribution:** The contribution to cumulative impacts would be similar to Alternative 1a, but affecting a smaller amount of acreage.	**Mine Site:** Identical to Alternative 1a. **Other Facilities:** Overall expansion would use the existing north access road; concentrate and diesel pipelines would be constructed along the existing road alignment and extended to a new deepwater port site at Iniskin Bay. **Magnitude:** Overall expansion would impact 31,541 acres, which is less acreage than Alternative 1a (31,892 acres) and Alternative 1 (32,418 acres), given that the north access road and gas pipeline would already be constructed. However, the overall expansion would be greater than Alternative 2. **Duration/Extent:** The duration and extent of cumulative impacts to soil would be similar to duration and extent of Alternative 1a, although affecting a smaller amount of total acreage. **Contribution:** The contribution to cumulative impacts would be similar to Alternative 1a, although

Table 4.14-7: Contribution to Cumulative Effects on Soils

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Contribution: This contributes to cumulative effects on soil through removal of overburden and surficial bedrock, tailings/waste rock storage, and water management. However, the area in the Kvichak and Nushagak river watersheds is relatively undeveloped, and effects would be limited to the project footprint, which is a relatively small area in the watersheds.			affecting a smaller amount of acreage.
Other Mineral Exploration Projects	**Magnitude:** Mining exploration activities, including additional borehole drilling, road and pad construction, and development of temporary camp facilities would contribute a small amount of soil disturbance at discrete locations, depending on landowner permitting and restoration requirements. For example, the 2018 drilling program proposed by PLP consisted of 61 geotechnical boreholes and 19 diamond-drilled core boreholes with diameters ranging from 2 to 8 inches. **Duration/Extent:** Exploration activities typically occur at a discrete location for one season, although a multi-year program could expand the geographic area affected in a specific mineral prospect. Table 4.1-1 in Section 4.1, Introduction to Environmental Consequences, identifies 7 mineral prospects in the analysis area where exploratory drilling is anticipated (4 of which are in relatively close proximity to the Pebble Project). **Contribution:** This contributes to cumulative effects of soil disturbance, although the areal extent of disturbance is a relatively small portion of the Kvichak/Nushagak watersheds. Assuming compliance with permit requirements, contributions to soil erosion and quality would be minimal.	Similar to Alternative 1a.	Similar to Alternative 1a.	Similar to Alternative 1a.

Table 4.14-7: Contribution to Cumulative Effects on Soils

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
Oil and Gas Exploration and Development	**Magnitude:** Onshore oil and gas exploration activities could involve seismic and other forms of geophysical exploration, and in limited cases, exploratory drilling. Seismic exploration would involve temporary overland activities, with permit conditions that avoid or minimize soil disturbance. Should it occur, exploratory drilling would involve the construction of temporary pads and support facilities, with permit conditions to minimize soil disturbance and restore drill sites after exploration activities have ceased. **Duration/Extent:** Seismic exploration and exploratory drilling are typically single-season temporary activities. The 2013 Bristol Bay Area Plan Amendment shows 13 oil and gas wells drilled on the western Alaska Peninsula, and a cluster of 3 wells near Iniskin Bay. It is possible that additional seismic testing and exploratory drilling could occur in the analysis area, but based on historic activity, it is not expected to be intensive. **Contribution:** Onshore oil and gas exploration activities would be required to minimize surface disturbance, and would occur in the analysis area, but distant from the project. The project would have minimal contribution to cumulative effects.	Similar to Alternative 1a.	Similar to Alternative 1a.	Similar to Alternative 1a.
Road Improvement and Community Development Projects	**Magnitude:** Road improvement projects would take place in the vicinity of communities, and have impacts through grading, filling, and potential increased erosion. Communities in the immediate vicinity of project facilities, such as Iliamna, Newhalen, and Kokhanok, would have the greatest contribution to cumulative effects. Some limited road upgrades could also occur in the vicinity of the natural gas pipeline starting point near Stariski	Similar to Alternative 1a.	Similar to Alternative 1a.	Similar to Alternative 1a.

Table 4.14-7: Contribution to Cumulative Effects on Soils

Reasonably Foreseeable Future Actions	Alternative 1a	Alternative 1 and Variants	Alternative 2 and Variants	Alternative 3 and Variant
	Creek, or in support of mineral exploration previously discussed. The Diamond Point Rock Quarry has potential to increase soil disturbance and erosion in the analysis area. The estimated area that would be affected is approximately 140 acres (ADNR 2014a). **Duration/Extent:** Disturbance from road construction would typically occur over a single construction season. Geographic extent would be limited to the vicinity of communities and Diamond Point. **Contribution:** Road construction would be required to minimize surface disturbance, and would occur in the analysis area, but removed from the project. The project would have minimal contribution to cumulative effects.			
Summary of Project contribution to Cumulative Effects	Overall, the contribution of Alternative 1a to cumulative effects to soils, when taking other past, present, and reasonably foreseeable future actions into account, would be minor in terms of magnitude, duration, and extent, given the limited acreage affected and permit requirements regarding soil disturbance and erosion.	Similar to Alternative 1a, although slightly more acreage would be affected by Pebble Project expansion.	Similar to Alternative 1a, but less acreage would be affected by Pebble Project expansion.	Similar to Alternative 1a, but less acreage would be affected by Pebble Project expansion than either Alternative 1a or Alternative 1, but more than Alternative 2.

Notes:
PLP = Pebble Limited Partnership