3.14 SOILS

This section describes the soil types in the project area, and evaluates project disturbance/ removal, susceptibility to erosion, and soil chemical quality. In addition, soil conditions such as permafrost and soil impairment from contaminated sites are briefly addressed in this section. Descriptions of unconsolidated overburden at the mine site and other project components are provided in Section 3.13, Geology; and Section 3.15, Geohazards and Seismic Conditions. 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.

3.14.1 De Minimis/Insignificant Soil Conditions

Some soil conditions that may be important in other areas of Alaska have minimal presence in the project area, as described below.

3.14.1.1 Permafrost

Permafrost is soil that is permanently frozen. This condition can cause problems during development because changes to the overlying vegetation can cause a thermal disturbance to this condition, resulting in melting and erosion.

To date, investigations in the project area (including all project components) have not reported widespread permafrost. Small patches of permafrost may occur in the project area; however, occurrence is presumed to be relict permafrost from prior glacial periods (Knight Piésold 2011b). Recorded variations in ground temperature at depth in the mine site study area do not support the presence of permafrost, based on measured mean annual ground temperatures above freezing (39.1 degrees Fahrenheit [°F]). Recorded groundwater temperatures from the deposit area were also above freezing throughout the year. Although such conditions do not preclude the occurrence of small localized areas of permafrost, current conditions do not support permafrost development or wide-spread occurrence. Additional technical discussion regarding potential permafrost occurrence in the study area is provided in Appendix K3.14.

3.14.1.2 Soil Impairments

A review was conducted of the Alaska Department of Environmental Conservation (ADEC) Contaminated Sites Program database (ADEC 2018d), which lists known contaminated sites and leaking underground storage tanks throughout Alaska. The database provides information regarding the type of contaminant released to the environment, the type(s) of media (e.g., air, water, soil, and rock) affected by the contaminant, the potential responsible party for the documented release, and the location where the release occurred. No contaminated site records coincided with or were in proximity to the project footprint.

3.14.2 Alternative 1a

3.14.2.1 Mine Site

<u>Available Soil Information</u>

Available literature directly associated with the mine site and transportation corridor components for all alternatives is limited to the US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS; formerly known as the Soil Conservation Service) 2016 Soil Survey

Geographic Database (SSURGO) for the Bristol Bay-Northern Alaska Peninsula, North and Bordering Areas (NRCS 2019), and the Exploratory Soil Survey of Alaska (ESS) (Rieger et al. 1979). Literature provided by the NRCS generally covers a variety of baseline soil data intended to assist in land resource planning and management, including classifications based on soil taxonomy, drainage, slopes, vegetative growth potential, and suitability for various land uses and development.

The ESS is not sufficient for site-specific interpretation, but is useful as a general soils map. Although some soils information provided in the ESS does not translate directly to current classification system standards, comparative equivalent soil type estimates can be made. Technical information regarding soil types in the project footprint is provided in Appendix K3.14.

Soil Types

Soils at the mine site are generally acidic, gravelly, and formed from volcanic source rocks. Most of the mine site area (approximately 69 percent) is associated with soil map unit D36MTG that consists of hilly to steep terrain that supports vegetation such as alder, grasses, or low shrubs in a thin surface cover of decomposed plant material and organic silt loam. Shallow surface materials overlie gravelly silt loam mixtures which are underlain by extremely stony loam mixtures and bedrock (25 to 67 inches). Approximately 25 percent of the mine site area is associated soil map unit D36HIL that consists of hills and plains landscape. Typical profile characteristics for these soils include a thin surface layer of moderately decomposed plant material and highly organic silt loam over sandy and silty loam mixtures. Approximately 6 percent of the mine site area is associated with soil map unit D36HIJ that consists of highly organic soil conditions associated with a plains landscape. Typical profile characteristics for these soils include peat and mucky peat over very fine sandy loam mixtures. Physical properties and detailed descriptions of soil types and distribution present at the mine site are provided in Appendix K3.14.

Erosion

Erosion resulting from surface and subsurface soil disturbances would be attributed to both wind and hydraulic processes. Numerous conditions can influence a soil's susceptibility to wind and hydraulic erosion. Such conditions include weather (e.g., wind, precipitation), season (e.g., ground freeze), soil type (e.g., texture and cohesion), slope angle and length, vegetative cover, and severity of disturbance. In most circumstances, soil disturbances and subsequent exposure would accelerate erosion by wind and water. Finer-grained soil types such as silt and sand are generally more susceptible to erosion than gravels and coarser material. Flowing water over ground surfaces results in hydraulic erosion that also removes and transports soils. Possible consequences of erosion include sediment loading in surface water runoff, and alteration of soil profile characteristics and ecological communities. Downslope movement of surface materials from other slope instability processes (e.g., landslides, solifluction) is addressed in Section 3.15, Geohazards and Seismic Conditions.

With the exception of the limited occurrence of organic-rich soils associated with nearly level topographic conditions, soils at the mine site are generally well drained to moderately well drained with no ponding or flooding. Soils associated with the most prevalent soil map unit (D36MTG) are the least susceptible to the hydraulic erosion process; however, prevalent silt and sandy loam mixtures associated with soil map units D36JIL and D36HIL are more susceptible to sheet and rill erosion from water. The variability in hydraulic erosion potential for these soil types would be influenced by the conditions described above (e.g., slope, weather, and severity of disturbance). Furthermore, soils at the mine site are considered to have a moderate to low susceptibility for wind erosion potential.

Soil Chemistry

A baseline soil chemistry description is provided for the mine site to compare anticipated effects resulting from the deposition of fugitive dust from sources of concern. Fugitive dust sources of concern at the mine site include mining operations; material (e.g., rock) storage, processing, and handling (including concentrate); tailings storage; and repurposing materials derived from the mine site (e.g., aggregates).

The baseline soil chemistry evaluation is exclusive to the mine site. Further evaluation of limited upland soil chemistry baseline data for the transportation corridor and natural gas pipeline corridor was not conducted because neither of these components is considered to have mechanisms or chemical sources that could result in adverse impacts to soil (see Section 4.14, Soils). Furthermore, the limited upland soil chemistry data for the transportation corridor and natural gas pipeline corridor are chemically consistent with those described for the mine site study area (SLR et al. 2011a).

To establish baseline soil chemistry conditions at the mine site, more than 200 shallow surface soil samples (i.e., less than 0.5 foot below ground surface) were collected from a total of 117 locations (SLR et al. 2011a). The samples were analyzed to determine the variability in naturally occurring constituents (NOCs), which included trace elements, hydrocarbons, total carbon, cyanide, sodium, and ions. Sample analytical results and more detailed discussion are provided in Appendix K3.14.

All trace elements (mostly metals) evaluated were detected in some of the surface samples. Although reported concentrations of most NOCs were generally low and consistent with undeveloped areas of Bristol Bay drainages, analytical results of some sample locations reported elevated NOCs at levels considered elevated in literature. Variations across up to 16 different landform types and seven different habitat types reportedly influence the ranges of elemental concentrations throughout the study area (SLR et al. 2011a).

Iron and aluminum are the most abundant elements reported throughout the mine site study area surface soils, followed by calcium and magnesium. Concentrations of other trace elements are substantially lower. Trace elements with the lowest average concentrations include mercury and silver. The relative distribution of trace elements in the mine site study area surface soils is generally consistent with those reported across the US, based on published US Geological Survey (USGS) evaluations. Comparison of co-located shallow subsurface soil sample results (18 inches in depth) reported similar relative and mean concentrations of trace elements; however, less variability among sample locations was observed (where present). Notable deviations include those associated with bismuth and mercury. The mean concentration of bismuth in surface soil is approximately 13 times greater than concentrations for deeper soils. The mean concentration of mercury in surface soils is almost two times greater than concentrations for subsurface soil (SLR et al. 2011a).

Because arsenic, copper, and lead are considered key trace elements associated with the deposit, additional depth-based and temporal (i.e., yearly) statistical tests were performed to identify differences. The statistical tests identified no significant[1] differences in depth-based or temporal variables (SLR et al. 2011a).

[1] The term “significant” is used correctly as it applies to statistical testing, p-value.

3.14.2.2 Transportation Corridor and Amakdedori Port

Soil Types

Because almost all of the land-based portions of the natural gas pipeline corridor on the western side of Cook Inlet would be buried in the roadbed of the transportation corridor, soil types for both the transportation corridor and natural gas pipeline corridor for all alternatives are collectively described in this section, in addition to those present at the Amakdedori port site. This discussion also includes the pipeline-only segment for Alternative 1a, from Iliamna Lake near Newhalen to the mine access road.

Soil descriptions available through SSURGO for the transportation corridor are limited to areas in proximity to the mine site. Soil map units and corresponding acreages associated with these portions of transportation corridor for all alternatives are as follows:

- D36MTG Western Maritime Mountains—approximately 87 acres
- D36HIL Western Maritime Glaciated Hills and Plains—approximately 82 acres
- D36HIJ Western Maritime Eolian Plains, Sloping—approximately 9 acres

Based on soil-type descriptions provided in the ESS, approximately 60 percent of the soil types associated with the transportation corridor footprint are the same as those described for the mine site. Most of the remaining acreage consists of varying sand, silt, and clay mixtures (i.e., loam) over shallow bedrock or gravel till materials. The soils are generally well-drained and occur in variable terrain, of which hilly and mountainous terrain and shallow bedrock are most prevalent south of Iliamna Lake along the port access road. A limited occurrence (13.5 acres) of poorly drained organic-rich muskeg soils also coincides with the transportation corridor. Soil type distribution and additional details are provided in Appendix K3.14.

The Amakdedori port site is generally level and includes upland (shore-based) soil types that transition seaward to intertidal dunes and a gravel-lined shoreline. ESS soil types associated with the Amakdedori port site and immediate area are limited to loamy upland soils with hilly to steep associations.

Erosion

The ESS does not provide wind and water erosion descriptors (i.e., suitability ratings) for all soil types; where present, they are limited to unique physical conditions or soil types. None were listed for map units corresponding to the transportation corridor; however, generalized inferences regarding susceptibility to erosion can be made assuming surface cover would be removed or disturbed. Similar to soil erosion susceptibility descriptions provided for the mine site, silt and sandy loam mixtures would be most susceptible to erosional processes depending on slope gradients, weather, and severity of disturbance in the transportation corridor.

Finer-grained loamy soils over shallow bedrock in hilly or steep terrain are considered to be most susceptible to erosional processes in the transportation corridor (including the Amakdedori port site). This is attributed to the erosional susceptibility of finer-grained materials that overlie bedrock conditions that are generally resistant to erosional processes, and potentially facilitate overland flow. Comparatively increased surface water flow velocities associated with hilly to steep terrain would likely increase the susceptibility of soils to erosion. Soils associated with nearly level terrain are likely the least susceptible to hydraulic erosion in the transportation corridor.

Soil Chemistry

A baseline soil chemistry description is provided for portions of the transportation corridor for comparative evaluation of the same suite of analyses for shallow surface soil samples collected in the mine site study area. Sample analytical results and additional discussion are provided in Appendix K3.14.

Seventeen baseline surface soil samples were collected from Bristol Bay drainage uplands along the transportation corridor route that most approximates the north access road associated with Alternative 3—North Road Only. Six (of 17 total) baseline soil sample locations coincide with the transportation corridor associated with Alternative 1a from the mine site to the Eagle Bay ferry terminal and are also representative of the northern pipeline-only segment from Iliamna Lake to the mine access road.

The hierarchy of trace element mean concentration trends were similar to those in the mine site study area; however, in all circumstances, trace element mean concentrations were lower. Comparisons of trace element values to those documented at the mine site indicate less mineral-rich soil conditions in the transportation corridor. Mean concentrations of iron (8,986 milligrams per kilogram [mg/kg]) and aluminum (8,281 mg/kg) were the highest, followed by calcium (2,491 mg/kg), magnesium (977 mg/kg), and potassium (238 mg/kg). The hierarchy is reportedly consistent with a variety of soil types (SLR et al. 2011a). Although Coefficient of Variation (CV) ranges for trace elements in the transportation corridor were greater than the mine site, the average CV for all trace elements was substantially less (SLR et al. 2011a).

Because only one sample was collected and analyzed for Diesel Range Organics (DRO), Residual Range Organics (RRO), and Total Organic Carbon (TOC), no comparison of mean values to the mine site study area was conducted. Reported concentrations of DRO, RRO, and TOC were 1,520 mg/kg, 9,220 mg/kg, and 18.20 percent, respectively. The elevated concentrations are representative of naturally occurring organic presence in a moist tundra/shrub habitat type.

3.14.2.3 Natural Gas Pipeline Corridor

Soil Types

Because the natural gas pipeline on the eastern side of Cook Inlet would predominantly incorporate existing infrastructure, potential soil disturbances directly associated with the project would be limited to the horizontal directional drilling (HDD) work area and compressor station area. The most detailed resource for soil data in this area is the USDA NRCS Soil Survey of Western Kenai Peninsula Area, Alaska. Available NRCS data for the area include a land capability classification, which provides a general suitability index for agriculture or farming (USDA 2005). Soils in the footprint are considered to have severe limitations for these purposes.

Two detailed soil map units coincide with approximately 6 acres of pipeline footprint ground disturbance on the eastern side of Cook Inlet. The soils consist of silt and sand mixtures (i.e., silt loam). Additional details for soils associated with the pipeline infrastructure on the eastern side of Cook Inlet are provided in Appendix K3.14 along with descriptions of all soil types associated with project alternatives and variants. This includes soil types for pipeline-only segments on the western side of Cook Inlet, which also correspond to those associated with transportation infrastructure (i.e., no soil types unique to pipeline-only segments).

Erosion

Soils in the pipeline infrastructure footprint on the eastern side of Cook Inlet predominantly consist of silt and sand mixtures (i.e., silt loam) along slope angles ranging from 0 to 4 percent. The soil is poorly to well-drained, with no flooding or ponding. The soils have a severe susceptibility to wind erosion, assuming disturbance and removal of surface cover, and a “slight” water erosion hazard.

Soil Chemistry

Soil chemistry information for the pipeline corridor on the northern side of Iliamna Lake is addressed above, including the transportation corridor associated with Alternative 1a from the mine site to the Eagle Bay ferry terminal, which is also representative of the northern pipeline-only segment from Iliamna Lake near Newhalen to the mine access road.

3.14.3 Alternative 1

3.14.3.1 Mine Site

Soil types, erosion, and soil chemistry at the mine site would be the same as those under Alternative 1a.

3.14.3.2 Transportation Corridor and Amakdedori Port

The soil, erosion, and soil chemistry for the transportation corridor would be similar to Alternative 1a. Soil characteristics at Amakdedori port would be the same as those under Alternative 1a.

3.14.3.3 Natural Gas Pipeline Corridor

The soil, erosion, and soil chemistry tor the pipeline corridor would be the same between Amakdedori port and the south ferry terminal at Kokhanok as those under Alternative 1a, and similar to Alternative 1a on the northern side of Iliamna Lake.

3.14.3.4 Alternative 1—Summer-Only Ferry Operations Variant

The Summer-Only Ferry Operations Variant would necessitate additional project footprint to store and manage concentrate (see Chapter 2, Alternatives). The soils descriptions provided in this section address the locations where surface soils may be affected by increased project footprint.

3.14.3.5 Alternative 1—Kokhanok East Ferry Terminal Variant

This area is east of the south ferry terminal site. Soil conditions at the south ferry terminal include soils that are common to the transportation corridor, but are exclusive to (13.5 acres) varying sand, silt, and clay mixtures (i.e., loam) over shallow bedrock or gravelly glacial till materials.

3.14.3.6 Alternative 1—Pile-Supported Dock Variant

This variant would not cause change in the land footprint of Alternative 1; therefore, soils are the same as those described under Alternative 1.

3.14.4 Alternative 2—North Road and Ferry with Downstream Dams

3.14.4.1 Mine Site

The downstream dams would necessitate increased project footprint. Soils in the mine site area, described above under Alternative 1a, address the locations where surface soils may be affected by increased project footprint.

3.14.4.2 Transportation Corridor and Diamond Point Port

This section addresses the road and pipeline corridor from the mine site to Diamond Point port site.

Soil Types

The soil types along the transportation corridor from the mine site to Eagle Bay ferry terminal are the same as those under Alternative 1a.

Approximately one-half of the transportation corridor footprint and Eagle Bay ferry terminal under Alternative 2 consist of the same ESS soil types as those described for the mine site under Alternative 1a. Approximately one-third of the Alternative 2 transportation corridor footprint and Pile Bay ferry terminal footprint consist of well-drained soils on foot slopes associated with hilly to steep terrain. The shallow soils are formed in silty volcanic ash (10 to 24 inches thick) overlying very gravelly glacial till. The appreciable presence of variable silt and sandy loam soil mixtures throughout the corridor would be anticipated. Based on generalized ESS descriptions, the remaining area in the transportation corridor consists of rough mountainous land along steep rocky slopes overlying shallow bedrock and boulder-sized rock fragments. Less than 1 percent of the total footprint consists of silty loess (20 to 40 inches) over gravelly glacial till to fibrous organic soils in depressions. These soils are associated with level or nearly level terrain and range from well-drained to very poorly drained soils. Additional soil type details are provided in Appendix K3.14.

Erosion

Soils associated with nearly level terrain are likely the least susceptible to hydraulic erosion in the transportation corridor. Soils considered most susceptible to erosion include those with finer-grained textures (e.g., volcanic ash, silt and sandy loam mixtures) that are associated with hilly to steep terrain. This is attributed to the erosional susceptibility of finer-grained materials and comparatively increased surface water flow velocities associated with hilly to steep terrain.

Coarse-grained soil textures or shallow bedrock in rough mountainous terrain should not preclude the potential for erosion susceptibility or location-specific conditions where erosion may be comparatively greater. Enhanced design or stabilization measures may be required on a case-by-case basis to mitigate steep side slopes, cross-slope toe-cuts, or slope failure. Erosion associated with potential high-energy environments in mountainous terrain includes, but is not limited to, increased surface water runoff flow velocities, up- or down-slope failure (e.g., slumping, washout), or impacts to infrastructure from natural process (e.g., landslides). Because the ESS is broadly based and is not intended to be used for site-specific information, general terrain conditions (e.g., topography) are considered in Section 4.14, Soils.

Soil Chemistry

Soil chemistry information for the natural gas pipeline corridor on the northern side of Iliamna Lake is addressed above.

3.14.4.3 Natural Gas Pipeline Corridor

This section addresses the overland portion of the natural gas pipeline corridor (Diamond Point to Ursus Cove). The pipeline would be constructed below grade along a valley floor, and eventually resurface at the Diamond Point port site after a short marine crossing of Cottonwood Bay. The 5.5 miles of uplands pipeline along this segment coincide with shallow bedrock and coarse soil textures (e.g., boulder and cobble) in rough mountainous terrain; however, it is likely that appreciable gravel/sand-bearing colluvium is present along the valley floor. The pipeline from the port would follow a shared road corridor towards the Pile Bay ferry terminal.

3.14.4.4 Alternative 2—Summer-Only Ferry Operations Variant

Baseline soil characteristics are the same as described under this variant in Alternative 1.

3.14.4.5 Alternative 2—Pile-Supported Dock Variant

This variant would not cause change in the land footprint of Alternative 2; therefore, soils are the same as described under Alternative 2.

3.14.5 Alternative 3—North Road Only

The occurrence and distribution of soil types and terrain under Alternative 3 are generally the same as Alternative 2. The primary difference between Alternative 2 and Alternative 3 is a shared overland transportation and pipeline infrastructure under Alternative 3, and absence of ferry terminal infrastructure.

3.14.5.1 Alternative 3—Concentrate Pipeline Variant

The concentrate pipeline under this variant would follow the same corridor as the north road and natural gas pipeline corridor. The soil characteristics are the same as described for the north access road corridor for Alternative 3.