K3.14 SOILS

This appendix contains additional technical information on the following topics related to baseline soil conditions provided in Section 3.14, Soils:

- Technical classification of soils in the project footprint
- Permafrost occurrence in the project footprint
- Baseline soil chemistry

K3.14.1 Project Footprint Soil Classification

Available literature directly associated with the mine site and transportation corridor components 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).

Some soils information provided in the ESS does not translate directly to current 2006 classification system standards, *Keys to Soil Taxonomy, 10th edition* (USDA 2006), but comparative equivalent soil-type estimates can be made. Two additional soil orders that occur in the project area (i.e., Andisols and Gelisols) have been added to the ESS since 1979. Where applicable, soil descriptions from the ESS have been translated to current 2006 classification system equivalents (Three Parameters Plus 2011a). Corresponding equivalents are based on available ESS descriptions and extrapolations from other nearby studies for the village of Nondalton and Chisik Island (Table K3.14-1).

Table K3.14-1: Corresponding ESS and 2006 Classifications for Applicable Soils

ESS Map Units	1979 Classification	2006 Classification
HY4, SO11, IA7	Pergelic cryofibrists	Typic fibristels
SO11	Humic cryothods	Typic humicryods
IA7, IA9	Typic cryandepts	Typic haplocryands Typic vitricryands

Notes:
ESS = Exploratory Soil Survey of Alaska
Source: Three Parameters Plus 2011a, Table 5-2

K3.14.1.1 Mine Site Soil Types

Soil descriptions obtained from SSURGO include the entire mine site footprint, and to a lesser extent, portions of the transportation corridor and pipeline in proximity to the mine site. Soil descriptions for all other portions of the project footprint are limited to the ESS. All the soil types in the project footprint are not likely addressed in the ESS, because the ESS is limited to a general soils map and does not provide site-specific interpretations. Although not a direct comparison to NRCS soil descriptions, available project soil classification information acquired from shallow sampling activities (18-inch depth) have been incorporated (where available). Soil map units and acreages associated with the mine site based on information obtained using SSURGO are listed below. Additional soil characteristics for each soil map unit and major components are provided in Table K3.14-2.

Table K3.14-2: Mine Site Soil Types and Characteristics

Soil Map Unit and Major Components	Parent Material Description	Taxonomy	Landscape Position	Slope Range (%)	Natural Drainage Class	Runoff Class	Erosion Water (Kw Factor)	Erosion Wind (WEG)	Flooding	Ponding	Frost Action
D36MTG—Western Maritime Mountains											
Dwarf scrub residual slopes and similar soils	Herbaceous organic material over gravelly cryoturbate, over weathered igneous and sedimentary rock	Loamy-skeletal, isotic Typic Dystrocryepts	Mountains, hills (upper third)	1 to 50	Well Drained	High	0.37 to 0.10	5	None	None	Moderate
Scrub gravelly colluvial slopes and similar soils	Herbaceous organic material over gravelly slope alluvium, over gravelly colluvium and/or gravelly till	Loamy-skeletal, isotic Typic Humicryepts	Hills, plains	0 to 38	Well Drained	High	0.20 to 0.05	3	None	None	Moderate
Sedge organic mountains and similar soils	Mossy organic material over gravelly slope alluvium	Loamy, isotic, euic Terric Cryosaprists	Depressions on mountains	4 to 7	Very Poorly Drained	Very High	0.02 to 0.37	8	None	Occasional	High
D36HIL—Western Maritime Glaciated Hills and Plains											
Dwarf scrub loamy eolian slopes	Organic material over coarse-loamy eolian deposits	Coarse-loamy, isotic Typic Haplocryods	Plains, hills	1 to 5	Well Drained	High	0.43 to 0.64	5	None	None	Moderate
Low scrub loamy eolian slopes	Mossy organic material over coarse-loamy cryoturbate, over coarse-loamy eolian deposits	Coarse-loamy, isotic Typic Dystrocryepts	Hills, plains	0 to 13	Moderately Well Drained	Medium	0.43 to 0.64	7	None	None	Moderate
Scrub loamy eolian slopes	Herbaceous organic material over coarse-loamy eolian deposits	Coarse-silty, isotic Typic Haplocryods	Hills, plains	0 to 42	Well Drained	High	0.49 to 0.64	7	None	None	High
D36HIJ—Western Maritime Eolian Plains Sloping											
Dwarf scrub loamy eolian slopes	Organic material over coarse-loamy eolian material	Coarse-loamy, isotic Typic Dystrocryepts	Hills, plains	1 to 10	Well Drained	High	0.43 to 0.64	5	None	None	Moderate
Sedge organic depressions	Mossy organic material over organic material, over coarse-loamy eolian deposits	Loamy, isotic, euic Terric Cryosaprists	Plains	0 to 7	Very Poorly Drained	Negligible	0.02 to 0.64	8	None	Frequent	High

Notes:

Drainage Class: Classes of natural soil drainage that range from excessively drained, somewhat excessive drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained.

Runoff Class: The loss of water from an area by flow over the land surface assuming soil surfaces are bare. Classes range from negligible, very low, low, medium, high, and very high.

Frost Action: The likelihood of upward or lateral expansion of the soil caused by frost heave processes. Clayey soils with a high water table are most susceptible, whereas well-drained coarse soil textures are least susceptible.

Kw Factor: Erosion factor of the whole soil for the surface mineral horizon that indicates the susceptibility of the soil to sheet and rill erosion by water. Values range from 0.02 to 0.69. Higher values correspond to soils more susceptible to sheet and rill erosion by water.

WEG (Wind Erodibility Group): Susceptibility of soil to wind erosion. Values range from 1 (most susceptible) to 8 (least susceptible).

Source: NRCS 2019

- D36MTG Western Maritime Mountains—5,796 acres (approximately 69 percent): Typical soil profile characteristics for soils at greater elevations (upper third of elevation range) on mountains and hills (slopes 0 to 50 percent) consist of 0 to 2 inches of decomposed plant material and organic silt loam over gravelly silt loam mixtures that are underlain by extremely stony loam mixtures and lithic bedrock (25 to 67 inches). Typical soil profile characteristics for soils associated with hill/plains (slopes 0 to 38 percent) consist of 0 to 2 inches of decomposed plant material over gravelly silt loam of gravelly and very gravelly silt loam mixtures. Typical soil profile characteristics for soils associated with depressions on mountains (slopes 4 to 7 percent) consist of 0 to 10 inches of mucky peat over muck and gravelly silt loam.
- D36HIL Western Maritime Glaciated Hills and Plains—2,092 acres (approximately 25 percent): Typical soil profile characteristics for soils associated with hills/plains (slopes 0 to 13 percent) consist of 0 to 4 inches of moderately decomposed plant material and highly organic silt over medial highly organic silt loam, over silt loam and sandy silt loam mixtures. Typical soil profile characteristics for soils associated with plains/hills (slopes 1 to 5 percent) consist of 0 to 5 inches of moderately decomposed plant matter and highly organic silt loam over very fine sandy loam and stratified silt loam mixtures. Typical soil profile characteristics for soils associated with hills/plains (slopes 0 to 42 percent) consist of 0 to 6 inches of slightly decomposed plant material and highly organic silt loam over medial highly organic silt loam and very fine sandy loam, over very fine sandy loam mixtures.
- D36HIJ Western Maritime Eolian Plains, Sloping—503 acres (approximately 6 percent): Typical soil profile characteristics for soils associated with hills/plains (slopes 1 to 10 percent) consist of 0 to 5 inches of moderately decomposed plant material and highly organic silt loam and very fine sandy loam mixtures. Typical soil profile characteristics for soils associated with plains (slopes 0 to 7 percent) consist of peat and mucky peat to 28 inches, underlain by very fine sandy loam.

K3.14.1.2 Transportation Corridor Soil Types

Available SSURGO soil descriptions for the transportation corridor are limited to those in proximity to the mine site area. Soil map units for these portions of the transportation corridor are the same as those described above for 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

Soil descriptions for the remaining portions of the transportation corridor are limited to the ESS. The ESS recognizes four soil map units in the transportation corridor study area, which are described below with corresponding acreages.

- IA7 Typic Cryandept—344 acres (approximately 39 percent): Very gravelly, nearly level to rolling Peregelic Cryofibrists, nearly level association. Soils are also associated with rolling plains bordering Iliamna Lake and rolling ground moraines, terminal moraines, outwash plains, and paleo-beach ridges, small lakes, and muskegs. Typic Cryandepts are well-drained, acidic, and formed in shallow volcanic material over gravelly glacial material dominated by low-tundra vegetative species. Shallow permafrost can reportedly be associated with a Pergelic Cryofibrists component (where present) consisting of sedge peat muskegs and coarse acid moss.

- IA9 Typic Cryandepts—203 acres (approximately 23 percent): Very gravelly, hilly to steep association, and likely to exhibit variable characteristics similar to soil map unit D36MTG. Soils are well-drained, strongly acidic, and formed in volcanic material with a thin surface cover of decomposed plant matter mixed with volcanic ash. Common vegetation includes alder, grasses, or low shrubs.
- IA17 Dystric Lithic Cryandepts—328 acres (approximately 37 percent): Hilly to steep association. Soils are associated with low hills and ridges bordering mountainous areas. Well-drained loamy soils are formed in volcanic ash over shallow (20-inch) metamorphic bedrock or gravelly till and overlain with a thin layer of organic material.
- HY4 Pergelic Cryofibrists—13.5 acres (approximately 1 percent): Nearly level association. Soils are associated with nearly level, broad, wet lowlands near lakes and coastal margins. Organic-rich sedge and moss (e.g., muskeg) soils underlain by silt and sand mixtures are poorly drained, and can reportedly be associated with the presence of shallow permafrost. Vegetation includes water-tolerant sedges, low shrubs, and black spruce.

K3.14.1.3 Pipeline Corridor Soil Types

Soil types along the shared route for the transportation corridor are the same as those described above. This also includes the pipeline-only segment of Alternative 1a from Iliamna Lake near Newhalen to the mine access road. Two detailed soil map units are associated with the approximately 6 acres of pipeline infrastructure ground disturbance on the eastern side of Cook Inlet:

- Unit 640—Qutal silt loam, 0 to 4 percent slopes, 5.5 acres: Medial over loamy, amorphic over mixed, superactive Aquandic Haplocryods. Soils are associated with moraines on till plains and depressions on till plains dominated by a spruce-birch forest spruce-willow community. Soils consist of very gravelly sand overlain with silt loam and a thin interval of decomposed plant material. Soils are somewhat poorly drained with no flooding or ponding, with a slight hazard of erosion for water, but severe hazard of erosion by wind.
- Unit 568—Island silt loam, 0 to 4 percent slopes, 0.25 acre: Medial over loamy, amorphic over mixed, superactive Pachic Fulvicryands. Soils are associated with till plains dominated by shallow kettles. Soils consist of gravelly sandy loam overlain with silt loam and a thin interval of decomposed plant material. Soils are well drained with no flooding or ponding, with a slight hazard of erosion by water, but severe hazard of erosion by wind.

K3.14.1.4 Soil Types Unique to Alternatives

ESS soil types (i.e., principal component) that coincide with footprints associated with alternatives are described below.

- RM1 Rough Mountainous Land: Steep rocky slopes.
- SO1 Typic Cryorthods: Nearly level association. Soils are associated with low-rolling glacial moraines, broad terraces, and lake- and muskeg-filled depressions. Well-drained to very poorly drained soils formed in silty loess (20 to 40 inches) over gravelly glacial till to fibrous organic soils in depressions between moraines.
- SO11 Humic Cryorthods: Hilly to steep association. Soils are associated with foot slopes and moraines. Well-drained soils formed in silty volcanic ash (10 to 24 inches) over very gravelly glacial till, and overlain by partially decomposed organic matter.

K3.14.2 Permafrost Occurrence

Recent permafrost distribution estimates that coincide with project components on the western side of Cook Inlet are considered to be isolated occurrences (Jorgenson et al. 2008). Isolated permafrost varies from 0 to 10 percent of the landscape subsurface. No permafrost occurrence is anticipated to coincide with project infrastructure on the eastern side of Cook Inlet. Thermokarst landform features, which are the result of permafrost freeze and thaw processes, can be indicative of permafrost, or residual expressions of where permafrost no longer exists. Existing thermokarst landscape features and future areas susceptible to thermokarst processes in the project footprint are generally not present (Olefeldt et al. 2016). Frozen ground conditions have been observed in near-surface soils in a few test pits and soil borings, but conditions were indiscernible from active layer processes that annually freeze and thaw at depths of up to 10 feet. Ground temperature measurements at depth in the mine site study area (SLR et al. 2011a) reported a mean temperature of 39.1 degrees Fahrenheit. Groundwater temperature measurements from the deposit area were also above freezing throughout the year. Although such conditions do not preclude the occasional occurrences of permafrost, current conditions do not support increased permafrost development, and any remaining permafrost is considered to be a relic from past conditions. Where present, relic permafrost is likely limited to shaded areas and north-facing slopes; poorly drained shallow surface soils overlain with insulative organics; and deep, coarse-grained soils (Three Parameters Plus 2011a). Based on information provided in the ESS, principal components associated with Pergelic Cryofibrists (HY4) and Typic Cryandepts (IA7) soil types in the project footprint may coincide with relic permafrost occurrence in areas of very poorly drained organic soils (e.g., fibrous sedge and muskeg) of nearly level association that include depressions and valley bottoms.

K3.14.3 Baseline Soil Chemistry

Baseline shallow surface soil samples (less than 0.5 foot deep) were collected to determine the variability in naturally occurring constituents at the mine site and along limited segments of transportation corridor alternatives. Lists of naturally occurring compounds (i.e., analytes) evaluated as part of the mine site surface soil studies are presented in Table K3.14-3 and Table K3.14-4, and transportation corridor surface soil studies are presented in Table K3.14-5 and Table K3.14-6. Results associated with each are discussed separately below.

K3.14.3.1 Mine Site

A total of 237 surface soil samples were collected from 117 locations in the mine site study area (SLR et al. 2011a). These samples were analyzed for trace elements, cyanide, and sodium at 237 surface soil locations; anions and cations at 235 surface sample locations; petroleum hydrocarbons as diesel-range organics (DRO) and residual range organics (RRO), respectively, at 23 surface soil locations; and total organic carbon (TOC) at 53 surface sample locations. The sample locations were considered representative of undisturbed baseline conditions.

Table K3.14-3: Mine Site Study Area Surface Soil Trace Elements and Cations

Analyte	Frequency of Detection[a]	Percent Detected	Range of Detects (mg/kg) (Min-Max)	Range of Method Detection Limits (mg/kg) (Min-Max)	Range of Method Reporting Limits (mg/kg) (Min-Max)	Mean[b] (mg/kg)	Median[b] (mg/kg)	Standard Deviation[b]	Coefficient of Variation	Comparative Action Levels[c] (mg/kg)
Trace Elements										
Aluminum	237/237	100%	932 – 109,000	0.67 – 100	2.14 – 500	17,644	16,400	12,175	0.69	N/A
Antimony	211/237	89%	0.040 – 2.14	0.033 – 2.13	0.11 – 6.86	0.24	0.20	0.22	0.93	33
Arsenic	227/237	96%	1.03 – 73.8	0.30 – 21.3	0.50 – 68.6	10.2	8.07	10.1	0.99	7.2 (inorganic)
Barium	237/237	100%	14.8 – 576	0.050 – 10.0	0.30 – 50.0	84.9	65.5	67.1	0.79	17,000
Beryllium	224/237	95%	0.051 – 5.89	0.033 – 2.13	0.11 – 6.86	0.41	0.34	0.45	1.09	170
Bismuth	105/237	44%	0.073 – 1.05	0.066 – 20.0	0.21 – 100	1.30	0.13	4.26	3.27	N/A
Boron	65/237	27%	0.54 – 9.34	0.36 – 50.0	1.16 – 117	4.82	3.45	4.62	0.96	N/A
Cadmium	146/237	62%	0.072 – 3.06	0.050 – 4.26	0.21 – 13.7	0.24	0.16	0.32	1.33	76 (Diet)
Calcium	237/237	100%	222 – 31,100	10.0 – 645	31.9 – 2,060	2,577	1,700	2,993	1.16	N/A
Chromium	233/237	98%	1.15 – 113	0.050 – 8.24	0.30 – 27.5	17.7	14.7	14.5	0.82	1.0×10^5 (Cr^3) 3.9 (Cr^6)
Cobalt	232/237	98%	0.45 – 24.2	0.030 – 10.3	0.10 – 34.3	6.55	5.63	4.60	0.70	N/A
Copper	236/237	100%	2.65 – 197	0.19 – 12.4	0.64 – 41.2	27.4	16.3	35.2	1.28	3,300
Iron	237/237	100%	588 – 103,000	2.00 – 452	4.00 – 1,460	20,694	19,300	13,532	0.65	N/A
Lead	236/237	100%	0.66 – 78.4	0.050 – 4.26	0.21 – 13.7	8.74	7.54	8.85	1.01	400
Magnesium	237/237	100%	74.1 – 9,930	10.0 – 795	31.9 – 2,540	3,076	2,930	2,022	0.66	N/A
Manganese	237/237	100%	5.43 – 6,560	0.066 – 50.0	0.21 – 300	388	279	559	1.44	N/A
Mercury	224/237	95%	0.014 – 0.72	0.013 – 0.30	0.042 – 2.00	0.12	0.072	0.12	0.98	3.1 (elemental)
Molybdenum	179/237	76%	0.40 – 68.1	0.30 – 21.3	1.00 – 68.6	1.82	0.92	4.71	2.59	N/A
Nickel	235/237	99%	0.59 – 53.8	0.066 – 4.26	0.21 – 13.7	9.16	7.42	7.10	0.77	1,700 (soluble salts)
Potassium	224/237	95%	100 – 5,510	30.0 – 2,130	106 – 6,860	621	511	523	0.84	N/A

Table K3.14-3: Mine Site Study Area Surface Soil Trace Elements and Cations

Analyte	Frequency of Detection[a]	Percent Detected	Range of Detects (mg/kg) (Min-Max)	Range of Method Detection Limits (mg/kg) (Min-Max)	Range of Method Reporting Limits (mg/kg) (Min-Max)	Mean[b] (mg/kg)	Median[b] (mg/kg)	Standard Deviation[b]	Coefficient of Variation	Comparative Action Levels[c] (mg/kg)
Selenium	219/237	92%	0.18 – 79.3	0.050 – 10.3	0.30 – 34.3	2.76	1.10	7.34	2.66	410
Silver	117/237	49%	0.030 – 1.45	0.030 – 2.13	0.10 – 6.86	0.11	0.059	0.20	1.80	410
Thallium	179/237	76%	0.0099 – 5.00	0.0066 – 5.00	0.021 – 30.0	0.24	0.088	0.61	2.53	0.83 (soluble salts)
Tin	27/237	11%	1.06 – 2.90	0.33 – 21.3	1.06 – 100	1.94	0.96	2.99	1.54	N/A
Vanadium	210/237	89%	4.67 – 227	0.10 – 64.5	0.50 – 206	46.4	47.0	31.1	0.67	420
Zinc	235/237	99%	2.77 – 228	0.33 – 21.3	1.06 – 68.6	43.9	40.0	33.2	0.76	25,000
Anions and Cations[d]										
Ammonia (as nitrogen)	214/235	91%	0.50 – 2,200	0.50 – 120	3.00 – 382	363	179	440	1.21	N/A
Chloride	158/237	67%	0.40 – 28.3	0.30 – 30.0	0.98 – 100	2.74	1.50	3.73	1.36	N/A
Cyanide	199/237	84%	0.028 – 0.75	0.024 – 4.00	0.049 – 20.0	0.19	0.15	0.18	0.92	26 (CN^-)
Fluoride	54/235	23%	0.33 – 39.3	0.30 – 18.4	0.98 – 59.5	0.88	0.36	2.67	3.04	N/A
Sodium	215/237	91%	56.2 – 1,860	30.0 – 2,130	106 – 6,860	208	153	181	0.87	N/A
Sulfate	211/237	90%	0.41 – 1,820	0.30 – 30.0	0.98 – 100	19.8	4.26	122	6.19	N/A

Notes:

[a] Number of samples with detectable concentrations/total number of samples analyzed.
[b] When calculating the mean, median, and standard deviation, non-detect results were included as one-half the method detection limit. Non-detect results assigned a "U" or "UJ" qualifier were included as one-half the reporting limit.
[c] Where provided, comparative action level is based on Alaska Department of Environmental Conservation (ADEC) 18 Alaska Administrative Code (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 (ADEC 2017a).
[d] All data presented on a dry-weight basis.

mg/kg = milligram per kilogram
Max = maximum
Min = minimum
N/A = none available

Source: SLR et al. 2011a, Table 10.1-3

Table K3.14-4: Mine Site Study Area Surface Soil Diesel Range Organics and Residual Range Organics, and Total Organic Carbon

Analyte	Frequency of Detection[a]	Percent Detected	Range of Detects (mg/kg) (Min-Max)	Range of Method Detection Limits (mg/kg) (Min-Max)	Range of Method Reporting Limits (mg/kg) (Min-Max)	Mean[b] (mg/kg)	Median[b] (mg/kg)	Standard Deviation[b]	Coefficient of Variation	Comparative Action Levels[c]
DRO[d]	13/23	57%	11.7 – 1300	2.01 – 127	20.1 – 1,270	209	72.5	299	1.43	8,250
RRO[d]	23/23	100%	32.7 – 12,300	2.01 – 127	20.1 – 1,270	2,028	1,150	2,895	1.43	8,300
TOC[d,e]	53/53	100%	0.3% – 65.1%	0.00026% – 2.08%	0.0061% – 4.16%	6.51%	2.20%	12.6%	1.93	N/A

Notes:

[a] Number of samples with detectable concentrations/total number of samples analyzed.
[b] When calculating the mean, median, and standard deviation, non-detect results were included as one-half the method detection limit. Non-detect results assigned a "U" or "UJ" qualifier were included as one-half the method reporting limit.
[c] Where provided, comparative action level is based on ADEC 18 AAC 75, Oil and Other Hazardous Substances Pollution Control, September 29, 2018, Table B2. Method Two – Petroleum Hydrocarbon Soil Cleanup Levels, Ingestion, Over 40 Inch Zone (ADEC 2017a).
[d] All data presented on a dry-weight basis.
[e] For TOC, unit of measure is percentage rather than milligrams per kilogram (mg/kg).

DRO = diesel range organics
mg/kg = milligram per kilogram
Max = maximum
Min = minimum
N/A = none available
RRO = residual range organics
TOC = total organic carbon

Source: SLR et al. 2011a, Table 10.1-5.

Table K3.14-5: Transportation Corridor Surface Soil Trace Elements and Cations

Analyte	Frequency of Detection[a]	Percent Detected	Range of Detects (mg/kg) (Min-Max)	Range of Method Detection Limits (mg/kg) (Min-Max)	Range of Method Reporting Limits (mg/kg) (Min-Max)	Mean[b] (mg/kg)	Median[b] (mg/kg)	Standard Deviation[b]	Coefficient of Variation	Comparative Action Levels[c] (mg/kg)
Trace Elements										
Aluminum	17/17	100%	1,350 – 24,300	0.62 – 56.4	1.99 – 182	8281	6,840	6,360	0.77	N/A
Antimony	6/17	35%	0.055 – 1.29	0.031 – 0.28	0.10 – 0.91	0.14	0.055	0.30	2.17	33
Arsenic	8/17	47%	1.47 – 50.1	0.57 – 3.72	1.79 – 11.8	4.40	1.47	11.8	2.69	7.2 (inorganic)
Barium	17/17	100%	8.36 – 53.7	0.094 – 0.61	0.30 – 1.96	29.2	24.7	14.8	0.51	17,000
Beryllium	10/17	59%	0.070 – 0.26	0.031 – 0.20	0.10 – 0.65	0.11	0.10	0.073	0.66	170
Bismuth	0/17	0%	N/A – N/A	0.062 – 0.41	0.20 – 1.31	N/A	N/A	N/A	N/A	N/A
Boron	1/17	6%	7.95 – 7.95	3.09 – 20.3	9.97 – 65.3	4.13	3.82	2.22	0.54	N/A
Cadmium	7/17	41%	0.076 – 0.59	0.062 – 0.41	0.20 – 1.31	0.14	0.10	0.13	0.95	76 (Diet)
Calcium	7/17	100%	469 – 8130	9.37 – 123	29.9 – 394	2,491	1,860	1,983	0.80	N/A
Chromium	17/17	100%	0.93 – 21.4	0.12 – 0.78	0.40 – 2.61	5.25	3.84	4.84	0.92	1.0×10^5 (Cr^3) 3.9 (Cr^6)
Cobalt	16/17	94%	0.63 – 6.56	0.15 – 0.98	0.50 – 3.27	1.92	1.41	1.54	0.80	N/A
Copper	17/17	100%	2.06 – 18.2	0.18 – 1.18	0.60 – 3.92	7.84	7.37	3.80	0.48	3,300
Iron	17/17	100%	1,830 – 23,200	4.41 – 282	14.2 – 909	8,986	6,370	6,947	0.77	N/A
Lead	17/17	100%	0.72 – 6.30	0.062 – 0.41	0.20 – 1.31	2.15	1.62	1.39	0.65	400
Magnesium	17/17	100%	117 – 3,960	9.37 – 123	29.9 – 394	977	497	1,114	1.14	N/A
Manganese	17/17	100%	13.8 – 382	0.062 – 0.81	0.20 – 2.63	88.7	52.8	98.1	1.11	N/A
Mercury	15/17	88%	0.034 – 0.19	0.012 – 0.081	0.041 – 0.27	0.081	0.087	0.047	0.57	3.1 (elemental)
Molybdenum	4/17	24%	0.58 – 2.03	0.31 – 2.03	1.00 – 6.53	0.58	0.40	0.50	0.86	N/A
Nickel	16/17	94%	0.46 – 9.79	0.062 – 0.41	0.20 – 1.31	2.44	1.86	2.28	0.93	1,700 (soluble salts)
Potassium	14/17	82%	114 – 734	30.9 – 407	99.7 – 1310	238	204	156	0.66	N/A
Selenium	15/17	88%	0.19 – 2.06	0.15 – 0.98	0.50 – 3.27	0.63	0.54	0.47	0.75	410
Silver	1/17	6%	0.14 – 0.14	0.031 – 0.20	0.10 – 0.65	0.060	0.050	0.038	0.64	410

Table K3.14-5: Transportation Corridor Surface Soil Trace Elements and Cations

Analyte	Frequency of Detection[a]	Percent Detected	Range of Detects (mg/kg) (Min-Max)	Range of Method Detection Limits (mg/kg) (Min-Max)	Range of Method Reporting Limits (mg/kg) (Min-Max)	Mean[b] (mg/kg)	Median[b] (mg/kg)	Standard Deviation[b]	Coefficient of Variation	Comparative Action Levels[c] (mg/kg)
Thallium	1/17	6%	0.081 – 0.081	0.0062 – 0.041	0.020 – 0.13	0.012	0.0077	0.018	1.50	0.83 (soluble salts)
Tin	1/17	6%	2.83 – 2.83	0.31 – 2.03	1.00 – 6.53	1.32	1.04	0.75	0.57	N/A
Vanadium	17/17	100%	7.05 – 60.7	0.94 – 8.54	2.99 – 27.3	28.0	24.1	17.2	0.61	420
Zinc	17/17	100%	5.85 – 39.9	0.31 – 2.03	1.00 – 6.53	18.3	15.0	10.9	0.59	25,000
Anions and Cations[d]										
Ammonia (as nitrogen)	17/17	100%	5.62 – 1,030	2.30 – 40.1	7.30 – 127	411	349	261	0.63	N/A
Chloride	13/17	76%	0.44 – 9.69	0.31 – 1.96	1.00 – 6.33	2.20	1.63	2.48	1.13	N/A
Cyanide	14/17	82%	0.049 – 0.21	0.024 – 0.13	0.049 – 0.27	0.11	0.11	0.064	0.58	26 (CN^-)
Fluoride	4/17	24%	0.31 – 1.37	0.31 – 1.96	1.00 – 6.33	0.52	0.38	0.35	0.68	N/A
Sodium	16/17	94%	124 – 508	30.9 – 407	99.7 – 1310	297	304	105	0.35	N/A
Sulfate	16/17	94%	1.08 – 341	0.31 – 1.96	1.00 – 6.33	26.0	4.10	81.7	3.14	N/A

Notes:

[a] Number of samples with detectable concentrations/total number of samples analyzed.
[b] When calculating the mean, median, and standard deviation, non-detect results were included as one-half the method detection limit. Non-detect results assigned a "U" or "UJ" qualifier were included as one-half the reporting limit.
[c] Where provided, comparative action level is based on 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 (ADEC 2017a).
[d] All data presented on a dry-weight basis.

mg/kg = milligram per kilogram
Max = maximum
Min = minimum
N/A = none available

Source: SLR et al. 2011a, Table 10.4-2

Table K3.14-6: Transportation Corridor Surface Soil Diesel Range Organics and Residual Range Organics, and Total Organic Carbon

Analyte	Frequency of Detection[a]	Percent Detected	Range of Detects (mg/kg) (Min-Max)	Range of Method Detection Limits (mg/kg) (Min-Max)	Range of Method Reporting Limits (mg/kg) (Min-Max)	Mean[b] (mg/kg)	Median[b] (mg/kg)	Standard Deviation[b]	Coefficient of Variation	Comparative Action Levels[c]
DRO[d]	1/1	100%	1,520	58.6	586	1,520	1,520	N/A	N/A	8,250
RRO[d]	1/1	100%	9,220	58.6	586	9,220	9,220	N/A	N/A	8,300
TOC[d,e]	17/17	100%	0.13% – 45.7%	0.026% – 1.74%	0.052% – 3.48%	18.2%	15.1%	12.4%	0.68	N/A

Notes:

[a] Number of samples with detectable concentrations/total number of samples analyzed.
[b] When calculating the mean, median, and standard deviation, non-detect results were included as one-half the method detection limit. Non-detect results assigned a "U" or "UJ" qualifier were included as one-half the method reporting limit.
[c] Where provided, comparative action level is based on ADEC 18 AAC 75, Oil and Other Hazardous Substances Pollution Control, September 29, 2018, Table B2. Method Two – Petroleum Hydrocarbon Soil Cleanup Levels, Ingestion, Over 40 Inch Zone (ADEC 2017a).
[d] All data presented on a dry-weight basis.
[e] For TOC, unit of measure is percentage rather than milligrams per kilogram (mg/kg).

DRO = diesel range organics
mg/kg = milligram per kilogram
Max = maximum
Min = minimum
N/A = none available
RRO = residual range organics
TOC = total organic carbon

Source: SLR et al. 2011a, Table 10.4-2

Anions and cations evaluated in surface soil samples included chloride, cyanide, fluoride, sulfate, ammonia (as nitrogen), and sodium. The highest mean concentration among evaluated ions was ammonia, followed by sodium. The lowest mean concentration among evaluated ions was cyanide. Depth-based variations in ion concentrations were apparent, based on comparison to co-located shallow subsurface soil sample results. Mean concentrations of cyanide and ammonia were greater in surface samples; while mean sulfate concentrations were greater in shallow subsurface samples (SLR et al. 2011a).

RRO hydrocarbons were detected at all 23 surface sample locations, and DRO was detected at 13 surface sample locations. Mean concentrations of 209 milligrams per kilogram (mg/kg) and 2,028 mg/kg were reported for DRO and RRO, respectively (Table K3.14-4). The elevated presence and wide range of reported hydrocarbon concentrations are attributed to naturally occurring biogenic sources, based on absence of prior disturbances, analytical fingerprint methods, and presence of TOC (SLR et al. 2011a).

Similar to hydrocarbons, reported TOC concentrations varied significantly. TOC concentrations varied from 0.36 to 65.1 percent among surface soil locations. The wide range is attributed to variable quantities of organic material retained in sampled matrices during collection.

K3.14.3.2 Transportation Corridor

A total of 17 baseline surface soil samples was collected and evaluated using the same analyses as for the mine site study area. The surface samples were collected from Bristol Bay drainage uplands along the transportation corridor following the north access road associated with Alternative 3—North Road Only. Six of the 17 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 pipeline-only segment from Iliamna Lake near Newhalen to the mine access road.

The hierarchy of trace element mean concentration trends were similar to those at the mine site; however, in all circumstances, trace element mean concentrations were lower in the transportation corridor (Table K3.14-5). Comparison 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 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 of 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 DRO, RRO, and 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.