APPENDIX 11A

SOILS

Section 11A Table of Contents

DOMINION DIAMOND

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Section 11A Abbreviations

Abbreviation	Definition
BSA	baseline study area
CCME	Canadian Council of Ministers of the Environment
CEC	cation exchange capacity
CO	carbon monoxide
DAR	Developer's Assessment Report
Dominion Diamond	Dominion Diamond Ekati Corporation
EDIS	Existing Disturbance
Ekati Mine	Ekati Diamond Mine
e.g.	for example
ELC	Ecological Landscape Classification
ESA	effects study area
et al.	and more than one additional author
GIS	Geographic Information System
H^+	hydrogen
ICRP	Interim Closure and Reclamation Plan
i.e.	that is
LiDAR	Light Detection and Ranging
N/A	not applicable
NO_x	oxides of nitrogen
NWT	Northwest Territories
OH^-	hydroxide
$PM_{2.5}$	particulate matter with a mean aerodynamic diameter of 2.5 microns (μm) or smaller
Project	Jay Project
RFD	reasonably foreseeable development
SO_2	sulphur dioxide
SO_x	oxides of sulphur
TOR	Terms of Reference
TSP	total suspended particulates
VC	valued component
WROMP	Waste Rock and Ore Storage Management Plan
WRSA	waste rock storage area
ZW	Open Water

Section 11A Units of Measure

Unit	Definition
%	percent
°C	degrees Celsius
$\mu g/m^3$	micrograms per cubic metre
cm	centimetre
dw	dry weight
ha	hectare
keq/ha/yr	kiloequivalents per hectare per year
km	kilometre
km^2	square kilometre
m	metre
mg/kg	milligrams per kilogram
pH	potential of hydrogen; a quantitative measure of the acidity or basicity

DOMINION DIAMOND

11A1 SOILS

11A1.1 Introduction

11A1.1.1 Background

The existing Dominion Diamond Ekati Corporation (Dominion Diamond) Ekati Diamond Mine (Ekati Mine) and its surrounding claim block are located approximately 300 kilometres (km) northeast of Yellowknife in the Northwest Territories (NWT) (Map 11A1.1-1). Dominion Diamond proposes to develop the Jay Project (Project), which includes associated mining and transportation infrastructure to add 10 or more years of operating life to the Ekati Mine. The majority of the facilities required to support and process the kimberlite currently exist at the Ekati Mine, including:

- Misery Pit mining infrastructure (e.g., fuel facility, explosives magazines);
- primary roads and transportation infrastructure (e.g., Ekati airstrip, Misery Haul Road);
- Ekati main camp and supporting infrastructure;
- Ekati processing plant; and,
- fine processed kimberlite management facilities.

The Jay kimberlite pipe is located beneath Lac du Sauvage in the southeastern portion of the Ekati claim block approximately 25 km from the main facilities and approximately 7 km to the northeast of the Misery Pit. A horseshoe-shaped dike will be constructed to isolate the portion of Lac du Sauvage overlying the Jay kimberlite pipe. The isolated portion of Lac du Sauvage will be dewatered to allow for open-pit mining of the kimberlite pipe. The Project will also require an access road, pipelines, and power lines to the Jay Pit from the Misery Pit.

11A1.1.2 Purpose and Scope

This appendix of the Developer's Assessment Report (DAR) for the Project addresses the impacts to soils and eskers from Project components identified in the Terms of Reference (TOR) issued by the Mackenzie Valley Review Board in July 2014 (Appendix 1A). The Table of Concordance for the DAR is provided in Appendix 1D.

The purpose of this appendix is to meet the TOR issued by the Mackenzie Valley Review Board and, specifically, to assess the effects the Project may have on soils and eskers, which are linked to vegetation. Eskers are important habitat for some species of wildlife; therefore, effects to eskers are also considered in Sections 12 and 13.

LEGEND

- JAY PROJECT
- EXISTING MINE OR PROJECT
- TERRITORIAL CAPITAL
- POPULATED PLACE
- HIGHWAY
- ALL-SEASON ROAD
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- TERRITORIAL/PROVINCIAL BOUNDARY
- TREELINE
- WATERCOURSE
- WATERBODY

150 0 150

SCALE 1:6,000,000 KILOMETRES

REFERENCE

WATER OBTAINED FROM ATLAS OF CANADA
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
PROJECTION: CANADA LAMBERT CONFORMAL CONIC

DOCUMENT

DEVELOPER'S ASSESSMENT REPORT

PROJECT

DOMINION DIAMOND

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

LOCATION OF THE JAY PROJECT

Golder Associates

PROJECT		13-1328-0041	FILE No. DAR_Soils_001_GIS	
DESIGN	JF	25/07/14	SCALE AS SHOWN	REV. 0
GIS	LMR	07/10/14	MAP 11A1.1-1	
CHECK	JF	07/10/14		
REVIEW	CD	07/10/14		

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11A1.1.3 Valued Components, Assessment Endpoints, and Measurement Indicators

The TOR identified soils and eskers as valued components (VCs) that should be included in the assessment of effects to the terrestrial environment (Table 11A1.1-1). Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered important by society. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). The soils and eskers VC was selected based on the following criteria:

- represent important ecosystem processes;
- can be measured or described with one or more practical indicators;
- soils and eskers support plant populations and communities; and,
- eskers are known to be important traditional use, cultural, and caribou movement sites.

Assessment endpoints are qualitative expressions used to assess the significance of effects on a VC and represent the key properties of the VC that should be protected for future human generations (i.e., incorporate sustainability). Assessment endpoints are general statements about what is to be protected. Measurement indicators are quantitative and/or qualitative expressions of change to assessment endpoints.

The soils and eskers VC has measurement indicators, but does not have an explicit assessment endpoint (Table 11A1.1-1). Although soils and eskers do not have an assessment endpoint, this VC is still analyzed for Project-specific changes in measurement indicators. Project-related changes are characterized in terms of magnitude, duration, and geographic extent, but are not classified using typical definitions of impact criteria (e.g., low magnitude and long-term duration). The results of the analysis of changes in measurement indicators for soils and eskers are provided to other VCs with assessment endpoints (e.g., vegetation and wildlife) for inclusion in the analysis and evaluation of significance of residual effects.

Table 11A1.1-1 Summary of Soils and Eskers Measurement Indicators

Valued Component	Assessment Endpoint	Measurement Indicators
Soils and eskers[a]	• no assessment endpoint	• soil quality, quantity, and distribution • abundance and distribution of eskers

a) No assessment endpoint because the soils and eskers represents measurement indicators and pathways to other valued components with assessment endpoints.

11A1.1.4 Spatial Boundaries

11A1.1.4.1 Baseline Study Area

The baseline study area (BSA) is approximately 236 square kilometres (km^2) (23,578 hectares [ha]) and includes the existing Ekati Mine (Soils Baseline Report, Annex V, Section 1.4.2). The BSA was designed to measure and characterize existing environmental conditions on a continuum of scales from the anticipated Project footprint.

The BSA occurs entirely within the Tundra Shield Low Arctic (south) Level III Ecoregion (ECG 2012) and is characterized by undulating to rolling terrain with northwest to southeast trending ridge features, known as eskers, and exposed bedrock outcrops. Brunisolic, Gleysolic, and Regosolic soils have developed on the extensive till and outwash deposits, with Cryosolic soils dominating the region. Peat polygons, non-sorted circles, frost-shattered bedrock, and heaving of the active layer are evidence of continuous permafrost reflecting the influence of a mean annual temperature of approximately -9 degrees Celsius (°C) (ECG 2012). The BSA is located in a transitional area between the boundaries of the Level IV Point Upland Ecoregion and the Contwoyto Upland Ecoregion (ECG 2012).

The western portion of the BSA occurs within the Point Upland Ecoregion, which is characterized by a rugged landscape dominated by exposed bedrock with extensive boulder tills and patches of dwarf-shrub and rock lichen communities. Frost-shattered boulder till plains occur among the large exposed areas of fractured and ice-scoured bedrock. The bare bedrock exposures that dominate the ecoregion do not have soil development on them. Permafrost is continuous, and Turbic and Static Cryosolic soils have developed on the till veneers that overlie the bedrock. Organic Cryosol areas associated with the wetlands and high-centre peat polygons occur in low-lying areas (ECG 2012).

The Contwoyto Upland Ecoregion occurs in the eastern portion of the BSA. The ecoregion includes deposits of level to hummocky bouldery till with nearly continuous shrub cover. The underlying Precambrian bedrock outcrops are overlain with till hummocks and bouldery till veneers and blankets. The bedrock outcrops exist as scattered ice-scoured and frost-shattered knobs and hills (ECG 2012). Small eskers and kame deposits are scattered throughout the region. Permafrost is continuous; non-sorted circles are the most prominent evidence of permafrost. Turbic and Static Cryosolic soils have developed on the till hummocks, veneers, and blankets, and glaciofluvially influenced eskers and kames. Cryosolic soils are characteristic of deep, well-drained, coarse-textured landforms, while Organic Cryosolic soils are associated with low-lying wetlands (ECG 2012).

11A1.1.4.2 Effects Study Area

The effects study area (ESA) is within the BSA, is approximately 146 km^2 (14,557 ha), and includes the existing Ekati Mine plus the Project footprint and a 500 metre (m) buffer (Map 11A1.1-2). The ESA is within the same ecoregions as the BSA (described above). The ESA was based on the expected spatial extent of immediate direct and indirect effects from the Project on soils and eskers, and includes unaffected (i.e., reference) areas. Direct effects include removal of soils or disturbances to eskers from the Project footprint. Indirect effects include changes to soils from air emissions and subsequent deposition (e.g., dust) and changes to surface water levels and flows from the Project. Although soil development and distribution can change over geological time, it is expected that the soil types will not be naturally altered within the temporal boundary of the assessment. Therefore, the ESA is large enough to provide ecologically relevant and confident assessment of the direct and indirect effects on soils and eskers from the Project and other, previous, existing, and reasonably foreseeable developments.

LEGEND

- EKATI MINE FOOTPRINT
- DIAVIK MINE FOOTPRINT
- PROPOSED JAY FOOTPRINT
- KIMBERLITE PIPE
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (10 m INTERVAL)
- ESKER
- WATERCOURSE
- WATERBODY
- EFFECTS STUDY AREA

REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

DEVELOPER'S ASSESSMENT REPORT

3 0 3

SCALE 1:150,000 KILOMETRES

PROJECT

DOMINION DIAMOND™

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

LOCATION OF THE SOILS EFFECTS STUDY AREA

Golder Associates

PROJECT	13-1328-0041		FILE No. DAR_Soils_002_GIS
DESIGN	DB	14/01/14	SCALE AS SHOWN REV 0
GIS	LMR	07/10/14	
CHECK	JF	07/10/14	MAP 11A1.1-2
REVIEW	CD	07/10/14	

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11A1.2 Existing Environment

The purpose of this section is to describe the existing composition and distribution of soil types and eskers within the ESA as a basis to assess Project effects on soils and eskers. The soils ESA is within the BSA and exhibits the same general characteristics and properties. The detailed methods and results for the baseline surveys are located in Annex V.

11A1.2.1 Methods

11A1.2.1.1 Soil Distribution

A baseline soil survey in the ESA was completed from August 28, 2013 through September 1, 2013. The field program was designed as a level four intensity, broad reconnaissance survey that identified representative soil subgroups used to delineate map units (Agriculture Canada 1987). Terrain and soil data collected during the field program were used for soil classification and mapping descriptions. Soil characteristics were documented using the principles and methods outlined by the Expert Committee on Soil Survey (Agriculture Canada 1983) and the Mapping System Working Group (Agriculture Canada 1981). All soils were classified to the subgroup level in accordance with the *Canadian System of Soil Classification* (SCWG 1998).

Soil mapping involved the correlation of Ecological Landscape Classification (ELC) vegetation polygons with field observations, soil classification, and Light Detection and Ranging (LiDAR) imagery (Annex V, Section 2.2). The primary characteristics used to group soil types into map units were dominant soil texture and parent material, soil moisture regime, soil subgroup, and terrain (slope and surface expression). As there are no published soil surveys for the ESA, soil map unit names were assigned based on the dominant parent material (e.g., Mineral-1 [M1]) or dominant landform (e.g., Esker Complex [E1]) within the map unit area.

Due to the coarse resolution of the ELC data, the extent of the ESA, and the reconnaissance-level soil survey, many soil map units include both mineral and organic soils. Soil subgroups within map units are defined as dominant, co-dominant, or sub-dominant. All map units may contain soil types not described in the map unit because inclusions do not represent the dominant soil type. The soil map unit delineations are largely inferred from the interpretation of landscape features and ELC map units, and should be viewed as a predictive model of soil distribution. The information should not be applied for mapping site-specific characteristics without collecting additional field data.

11A1.2.1.2 Permafrost Potential

Permafrost potential was assigned to the soil types within the ESA. Permafrost potential ratings for each soil subgroup were assigned based on soil type, soil texture, and drainage observed during the field program. Location of the Project, with respect to the permafrost zone in which it occurs, was also considered. In addition, permafrost conditions within the Ekati Mine footprint were examined through geotechnical investigations carried out since the 1990s, which confirmed the presence of permafrost in the ESA (Permafrost Baseline, Annex IV).

11A1.2.1.3 Soil Sensitivity and Quality

11A1.2.1.3.1 Erosion Sensitivities

Soil sensitivity to water and wind erosion were assigned to soil types within the ESA. Water erosion ratings and potentials were assigned to soil subgroups based on characteristics of soils and terrain (i.e., mineral soil texture, slope length, and gradient) recorded during the field programs.

The uppermost mineral soil horizon textures of soil subgroups were used to determine the water erosion sensitivity. In areas where slope gradient increases, so does the potential for soil erosion regardless of soil texture. Water erosion potentials are based on bare, unprotected soils.

Wind erosion ratings were evaluated using the uppermost mineral soil horizon texture. Wind erosion ratings for Organic soils were assigned based on degree of peat decomposition. Wind erosion ratings are based on disturbed, bare soils for mineral soils, and dry, disturbed conditions for Organic soils.

11A1.2.1.3.2 Sensitivity to Acidification

Soils are categorized as having High, Medium, or Low sensitivity ratings to acid deposition. The ratings are based on the sensitivity to loss of basic cations (primarily calcium, magnesium, and potassium), sensitivity to acidification, and sensitivity to solubilization of aluminum. The sensitivity of mineral soils to acid deposition was evaluated using the chemical criteria published by Holowaychuk and Fessenden (1987). Analyzed cation exchange capacity (CEC) and pH values from soils sampled during the baseline field program were used to estimate the sensitivities of soils to acidification.

The sensitivity rating for wetland soil types (Gleysolic, peaty Cryosolic, and Organic soils) is based on the type of wetland (i.e., bog, poor fen, moderate rich fen, and extreme rich fen) (Turchenek et al. 1998). In general, moderate rich and extreme rich fens (moderate to high nutrient status and neutral pH or greater) tend to be least susceptible to acidification. Wetland soils that occur in moderate and rich fens are least susceptible to acidification and therefore have a Low sensitivity rating. Wetland soils that occur in bogs and in poor fens are most susceptible to acidification and therefore have a Medium sensitivity rating. Mineral soil properties of Gleysolic soils were considered in the classification.

11A1.2.1.3.3 Sensitivity to Compaction

Compaction ratings for soil types in the ESA were determined using the criteria outlined in Lewis et al. (1989) under prevailing moisture conditions. Soils occurring at toe slopes and in depressions (wetlands) were assigned compaction ratings based on soil texture under wet (saturated) soil conditions. Organic soils and bedrock were not assigned compaction ratings.

11A1.2.1.3.4 Soil Metal Chemistry

Chemical constituents of underlying bedrock and associated rock leachate have the potential to be present in the overlying soil materials because of soil formation from bedrock parent material, as well as upward leaching of metals from rock (Turk et al. 2012). Metals in soils were measured to provide baseline concentration levels in the ESA, and to identify the presence of naturally high metal concentrations. Measured metal concentrations were compared to the residential/parkland values of the Canadian Council of Ministers of the Environment (CCME) *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health* (CCME 2013).

11A1.2.1.3.5 Reclamation Suitability

The reclamation suitability of soils in the ESA was evaluated to support reclamation planning, because construction activities will disturb soil and may include the removal and salvage of soil materials for use in subsequent reclamation activities. Individual soil subgroups were rated as Good, Fair, Poor, or Unsuitable by evaluating soil properties including texture, coarse fragment content, and select soil chemistry parameters (Alberta Agriculture 1987).

Reclamation suitability ratings for the rooting zone material were determined from the soil characteristics of the uppermost mineral soil horizons in Brunisolic, Regosolic, Cryosolic, and Gleysolic soils. The thick organic layers associated with peaty Cryosolic soils and Organic soils identified in wetlands were rated as "Organic" because they are not considered in the criteria. Mineral soil underlying peaty Cryosolic soil was considered, although mineral materials were generally deeper than the rooting zone. Mineral soil underlying Organic soils was not rated. The most limiting property of soil chemical or physical parameter was used to determine the final overall rating (Alberta Agriculture 1987).

11A1.2.2 Results

11A1.2.2.1 Soil Distribution

In total, 49 sites were surveyed within and adjacent to the ESA. Of the 49 sites surveyed, 32 sites were upland mineral soils, 5 were mineral soils found along the margins and transitional areas, 8 were peaty phase soils in wetlands, and 4 were Organic soils. The soil classification to the subgroup level is provided in the Soils Baseline Report (Annex V, Section 3.2.1).

Mineral soils identified during the baseline field program were Cryosolic, Brunisolic, Gleysolic, and Regosolic soils. Organic soils identified included subgroups within the Fibrisol, Mesisol, and Folisol great groups. One site was identified as bedrock (classified as a non-soil). Turbic Cryosolic soils were generally found at upland landscape positions, while peaty Static Cryosolic and peaty Turbic Cryosolic soils were generally found in wetlands. Brunisolic and Regosolic soils were found at upland landscape positions. Gleysolic soils were found in transition areas between upland and depressional landscape positions (i.e., wetlands) and in wetlands. Organic soils were found in wetlands.

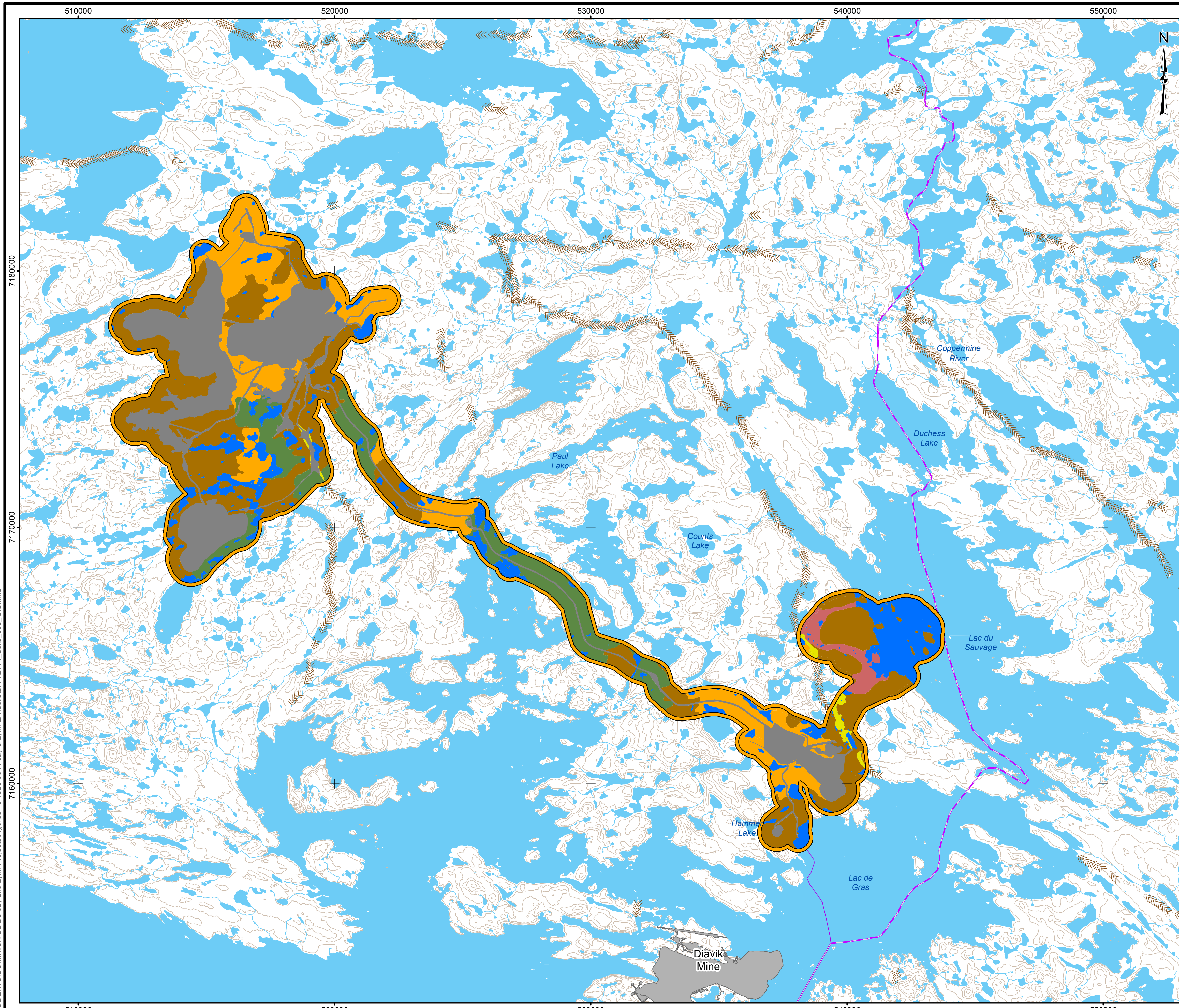
Five soil map units occur in the ESA: Esker Complex (E1), Mineral-1 (M1), Mineral-2 (M2), Mineral-3 (M3), and Mineral-4 (M4) (Table 11A1.2-1, Map 11A1.2-1), all of which capture the range of variability in soil subgroups and terrain present in each unit. All of these map units contain inclusions of wetland (Organic) soils. The Existing Disturbance (EDIS) map unit represents anthropogenic features (e.g., the existing Ekati Mine), and the Open Water (ZW) map unit delineates areas of open or flowing water. The Mineral-1 map unit encompasses the largest proportion of the ESA and covers 4,677 ha (32.1 percent [%]). The Existing Disturbance map unit covers approximately 3,674 ha (25.2%). The Esker Complex map unit covers the smallest area of the ESA (approximately 100 ha or 0.7% of the ESA) (Table 11A1.2-1).

Table 11A1.2-1 Soil Map Units within the Effects Study Area

Map Unit Name	Map Unit Symbol	Area (ha)	Proportion of ESA (%)	Dominant, Co-dominant, and Sub-dominant Soil Subgroups in Map Unit
Esker Complex	E1	100	0.7	Dominantly Orthic Regosols and Orthic Humic Regosols
Mineral-1	M1	4,677	32.1	Co-dominantly Turbic Cryosols (Orthic Dystric and Regosolic) and cryoturbated Orthic Dystric Brunisols
				Sub-dominant exposed bedrock and frost-shattered boulders
Mineral-2	M2	2,301	15.8	Dominantly Turbic Cryosols (Orthic Dystric and Regosolic)
				Sub-dominant exposed bedrock and frost-shattered boulders
Mineral-3	M3	280	1.9	Co-dominantly peaty Gleysolic Static Cryosols, Rego Gleysols, and peaty Orthic Gleysols
				Sub-dominant peaty Gleysolic Turbic Cryosols, Rego Gleysols, and Orthic Gleysols (peaty phase)
Mineral-4	M4	1,585	10.9	Co-dominantly Turbic Cryosols (Orthic Dystric and Regosolic), cryoturbated Orthic Dystric Brunisols, and exposed bedrock or frost-shattered boulders
Existing Disturbance	EDIS	3,674	25.2	N/A
Open Water	ZW	1,942	13.3	N/A
Total	**-**	**14,557**	**100**	**-**

Note: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

Ha = hectare; % = percent; ESA = effects study area; N/A = not applicable.



LEGEND

- EKATI MINE FOOTPRINT
- DIAVIK MINE FOOTPRINT
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (10 m INTERVAL)
- ESKER
- WATERCOURSE
- WATERBODY
- EFFECTS STUDY AREA

SOIL MAP UNIT

- EDIS - EXISTING DISTURBANCE
- E1 - ESKER COMPLEX
- M1 - MINERAL-1
- M2 - MINERAL-2
- M3 - MINERAL-3
- M4 - MINERAL-4
- ZW - OPEN WATER

REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

DEVELOPER'S ASSESSMENT REPORT

3 0 3

SCALE 1:150,000 KILOMETRES

PROJECT

DOMINION DIAMOND

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

SOIL MAP UNITS IN THE EFFECTS STUDY AREA

Golder Associates

PROJECT	13-1328-0041		FILE No. DAR_Soils_003_GIS
DESIGN	DB	14/01/14	SCALE AS SHOWN REV 0
GIS	LMR	07/10/14	MAP 11A1.2-1
CHECK	DB	07/10/14	
REVIEW	DB	07/10/14	

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DOMINION DIAMOND

11A1.2.2.2 Permafrost Potential

The ESA is within the continuous permafrost zone, where permafrost may occupy approximately 90% to 100% of the area (Natural Resources Canada 1995). Permafrost in this area is characterized by having low ice content, indicating the ground ice content in the upper 10 to 20 m of the ground has less than 10% ice content by volume of visible ice (Natural Resources Canada 1995; Annex IV, Section 3). Ice lenses (small bodies of ice in frozen soils) and ice wedges are likely locally present, as indicated by ground conductivity, and by permafrost features such as palsas (mounds of alternating layers of ice and or mineral soils).

Brunisolic and Regosolic soils in the ESA have Low permafrost potential. Cryoturbated Brunisolic and Regosolic soils have Moderate permafrost potential. Gleysolic and Folisolic soils with imperfect to poor drainage have Moderate permafrost potential. Cryosolic soils in the ESA have High potential for permafrost. Imperfectly to poorly drained shallow Organic soils have Moderate to High permafrost potential based on their drainage class, peat and vegetation cover, and potential for increased water content.

11A1.2.2.3 Soil Sensitivity and Quality

11A1.2.2.3.1 Erosion Sensitivities

Water erosion potential for soil types in the ESA is generally Low, based on the dominantly sandy texture associated with upper mineral soil horizons, low percent slope, and a dominant slope length less than 70 m. The Cryosols, Brunisols, and Regosols occurring at upland locations in the ESA have Low sensitivity to water erosion. Gleysolic soils occurring at transition and depressional landscape positions have Low sensitivity to water erosion. At transition and depressional landscape positions, if the organic layer is removed and underlying mineral soil horizons are exposed, peaty Cryosols and Organic soils have Low to Moderate sensitivity to water erosion. Regardless of soil type, if slope percentage or slope length increase, the water erosion potential for soils will also increase.

Wind erosion ratings for soil types in the ESA were generally Medium to High, based on either sandy-textured mineral upper soil horizons, or disturbed, dry Organic (folic and mesic) upper soil horizons. Upland Cryosolic, Brunisolic, and Regosolic soils are most sensitive to wind erosion. Areas containing wetland peaty Cryosolic and Organic soils with fibric organic peat layers have Low sensitivity to wind erosion if they become dry and disturbed. Those with mesic or folic organic peat layers have a Medium sensitivity. If organic surface materials are removed and underlying mineral soil horizons are exposed, the wind erosion ratings will vary according to the upper mineral soil horizon textures.

11A1.2.2.3.2 Sensitivity to Acidification

Upland Brunisolic and Regosolic mineral soils have acidic or low pH and low CEC, and a High sensitivity to acidification. Upland Cryosolic soils have a low pH and moderate CEC, and have a Medium sensitivity to acidification.

Soils associated with wetlands have Low to Medium sensitivity to acidification depending on the associated wetland type. Peaty Cryosolic soils and Folisols were predominantly identified in wetlands considered equivalent to poor fen, and were rated as Medium sensitivity to acidification. Terric Mesisols and Terric Fibrisols were generally identified in sedge wetlands that are considered equivalent to moderate rich fens, and were rated as Low in sensitivity to acidification.

Gleysolic soils generally occur in transitional areas adjacent to wetlands and, in some cases, within wetlands; therefore, pH would be influenced by water associated with the wetland type. In general, these soils would be considered to have a Medium sensitivity to acidification. The mineral materials present in Gleysolic soils may influence this rating because of the low pH and low CEC, which may increase this sensitivity to High.

Overall, in the ESA, upland landscape positions containing well drained, sandy soils are predicted to be most sensitive to acidification, whereas wetlands containing Organic soils have a Low to Medium sensitivity to acidification. Gleysolic soils would generally have a Medium sensitivity, except where there is low pH and low CEC, which would increase the sensitivity rating to High.

11A1.2.2.3.3 Sensitivity to Compaction

Sandy loam and loamy sand-textured upland soils (Cryosols, Brunisols, and Regosols) have a Low sensitivity to compaction under moist soil conditions. Gleysolic soils generally had sandy loam and loamy sand textures in the upper and lower mineral soil horizons, indicating Moderate to High sensitivity to compaction under wet soil conditions. Imperfect to poorly drained peaty phase Cryosolic soils associated with wetlands generally had silt, loam, sandy loam, and loamy sand textured mineral soil horizons, indicating Moderate to Very High sensitivity to compaction under wet soil conditions. Upper organic horizons were not assigned compaction ratings; however, if enough material is present (i.e., organic and peaty phase soils), it can decrease the compaction rating of the lower mineral horizons by one class.

11A1.2.2.3.4 Soil Metal Chemistry

The evaluation of the soil metal concentrations identified one location where the measured arsenic concentration of 13.6 milligrams per kilogram (mg/kg dry weight [dw]) was over the Canadian Soil Quality Guidelines value of 12 mg/kg dw. This elevated arsenic concentration was observed in the B horizon of a shallow Orthic Dystric Brunisol (30 centimetre [cm] total depth) overlying bedrock.

The elevated arsenic concentration observed during the soil field program is likely a result of naturally occurring arsenic contained within the bedrock. The dominant rock type in the area where this soil was observed is metasedimentary schists (metasediments). Sulphide minerals are present at trace concentrations in metasediments, but occasionally at concentrations of up to 2% and locally, up to 5% sulphides on a centimetre scale. The mineral sulphides class found in these rocks include arsenides, which are made up of arsenic compounds (Dominion Diamond 2013). The shallow soil present at the location of the soil sample was most likely influenced by the parent material (metasediments) on which it has developed. Therefore, the parent material is the likely source of the naturally elevated arsenic levels.

11A1.2.2.3.5 Reclamation Suitability

Reclamation suitability of the surface material in the ESA is generally Poor. All locations were non-saline and non-sodic and pH was considered Good. The surface soil horizons of Upland Cryosolic, Brunisolic, and Regosolic soils are rated as Poor for reclamation due to their limiting sandy textures.

Reclamation suitability of Gleysolic soils are rated as Fair to Poor with constraints of sandy texture and a non-coherent, loose, consistency. The Organic soil and peaty Cryosolic soils in the ESA are not given a rating and are classified simply as Organic. Although soil materials were generally rated as Poor, they are able to sustain the current local vegetation populations and, as such, should be considered appropriate as reclamation material when use is restricted to the environment within the ESA.

11A1.2.2.4 Summary of Local and Traditional Knowledge

Publicly available traditional knowledge and traditional land use information was not specifically identified for soils. However, changes to soil quantity from direct disturbance, and changes to soil quality from air and dust deposition, and water quality are linked to changes in vegetation and are therefore important. Information for five groups of Aboriginal peoples whose traditional lands overlap the Ekati claim block is provided in the Traditional Land Use and Traditional Knowledge Baseline Report (Annex XVII). These groups are the following:

- Yellowknives Dene First Nation;
- Łutselk'e Dene First Nation;
- North Slave Métis Alliance;
- Tłįchǫ Government; and,
- Kitikmeot Inuit Association (EAP 1996).

Eskers in the traditional lands have been identified as important landscape features. Eskers have been used for gravesites and travel routes, and have been identified as important for wildlife habitat, migration routes of caribou, and hunting and trapping (DCI 1995; Weledeh Yellowknives Dene 1997; NSMA 1999; Banci et al. 2006). Traditional knowledge input for Project design and mitigation relating to the esker has included avoiding construction that affects or changes the esker where feasible. Although this approach is not feasible for this Project, design of the Project roads and waste rock storage area (WRSA) limits the extent of disturbance as much as practical.

The Dene have expressed concern about how dust may have cumulative effects on the environment. The North Slave Métis Alliance have expressed concerns about the impacts of dust on the caribou food in the area of the mines. The Yellowknives Dene First Nation are concerned about the effects of dust in and around Ekati. Concerns about the impacts from dust have also been expressed by the Kitikmeot Inuit Association.

Input on Project designs and mitigation related to soil quality have included advice to improve the health and diversity of plant life around the mine. For example, participants in the 2013 vegetation workshop suggested that, for closure, Ekati should make the tailings beaches wavy with little hills so that the plants can grow more easily (Annex XVII).

11A1.3 Pathway Analysis

11A1.3.1 Methods

Pathway analysis identifies and assesses the linkages between Project components or activities, and the correspondent changes to the environment and potential residual effects (after mitigation) to soils and eskers. The first part of the analysis is to identify all potential effects pathways for the Project.
Each pathway is initially considered to have a linkage to potential effects on the VC. Potential pathways through which the Project could affect soils and eskers were identified from the following sources:

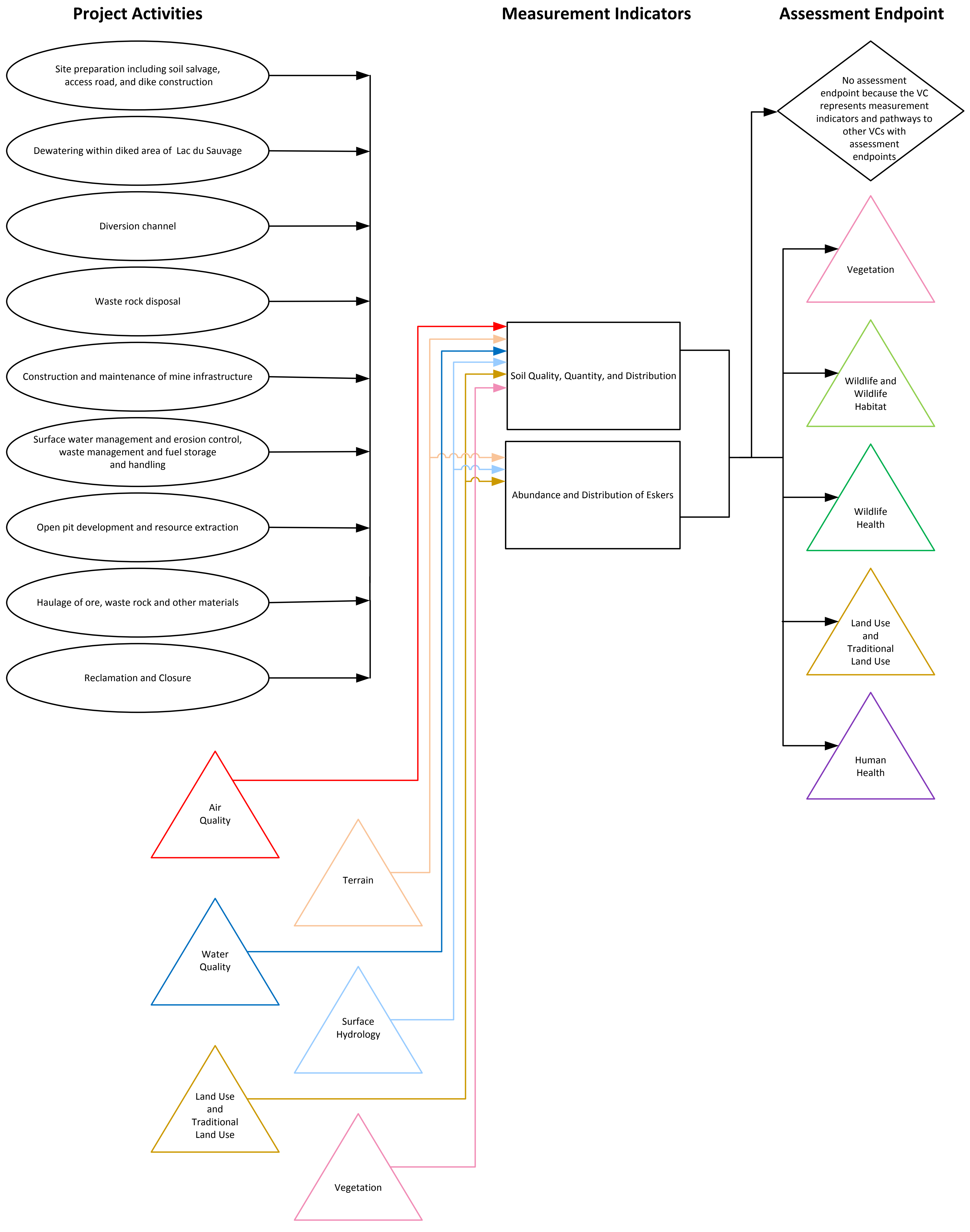
- a review of the Project description and scoping of potential effects by the environmental and engineering teams for the Project;
- information from past and ongoing consultations with Aboriginal communities that are part of the Ekati Mine Community Engagement Programs;.
- local and traditional knowledge obtained from community scoping sessions in Behchokǫ̀, Yellowknife, and Lutsel K'e, and a technical scoping session in Yellowknife (Section 11.2.3);
- scientific knowledge and experience with other mines in the NWT; and,
- consideration of potential effects identified from the TOR.

For an effect to occur there has to be a source (Project component or activity) that results in a measurable change to the environment (pathway or measurement indicator) and a corresponding effect on soils and eskers.

Project Activity → **Change in Environment** → **Effect on Soils and Eskers**

Project components and activities that are linked to changes in measurement indicators are illustrated by ovals in Figure 11A1.3-1. Effects from the Project on other disciplines that can influence measurement indicators for soils and eskers are shown as triangles on the left side of the figure (e.g., air quality, surface hydrology, water quality). Similarly, changes to soils and eskers can affect other disciplines such as land use, traditional land use, vegetation, wildlife, and wildlife habitat (shown as triangles on the right side of Figure 11A1.3-1). There is no assessment endpoint for soils and eskers; instead, the prediction of effects to soils and esker measurement indicators supports the effects analysis of other VCs (e.g., vegetation and wildlife).

Figure 11A1.3-1: Linkage Diagram Identifying Potential Effects on Soils and Eskers



Note: Ovals represent Project activities; rectangles represent measurement indicators: triangles represent connections to and from other disciplines; and the diamond represents the assessment endpoint.

A key aspect of the pathway analysis is to identify environmental design features and mitigation that might reduce or eliminate potential effects of the Project to soils and eskers, and includes appropriate application of the precautionary principle (Section 6.1.2). Environmental design features include engineering design elements, environmental best practices, management policies and procedures, and spill response and emergency contingency plans. Environmental design features and mitigation were developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams to avoid or mitigate adverse effects identified by the pathways analysis.

After applying environmental design features and mitigation, a screening-level analysis is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment, and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on soils and eskers. Pathways are determined to be primary, secondary (minor), or as having no linkage, using scientific, local, and traditional knowledge, and experience with similar developments and environmental design features and mitigation. Each potential pathway is assessed and described as follows:

- **no linkage –** analysis of the potential pathway reveals that there is no linkage or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on soils and eskers relative to the Base Case or guideline values; or,
- **secondary –** pathway could result in a measurable minor environmental change, but would have a negligible residual effect on soils and eskers relative to the Base Case or guideline values and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect; or,
- **primary –** pathway is likely to result in environmental change that could contribute to residual effects on soils and eskers relative to the Base Case or guideline values.

Pathways with no linkage to soils and eskers are not assessed further because environmental design features or mitigation will remove the pathway. Pathways that are assessed to be secondary and demonstrated to have a negligible residual effect on soils and eskers through simple qualitative or semi-quantitative evaluation of the pathway are also not advanced for further assessment.
Primary pathways require further evaluation through more detailed quantitative and qualitative effects analysis (Section 11A1.4).

11A1.3.2 Results

11A1.3.2.1 Review of Mitigation Effectiveness

Mitigation policies and procedures related to soils and eskers that have been implemented at the Ekati Mine will be expanded to include the Project. Mitigation and associated monitoring of mitigation effectiveness has been completed as part of several existing Ekati Mine plans, including:

- the Waste Rock and Ore Storage Management Plan (WROMP);
- the Interim Closure and Reclamation Plan (ICRP), including vegetation trials and monitoring of plant establishment and growth;
- the Spill Contingency Plan; and,
- the Hydrocarbon Impacted Materials Management Plan.

The mitigation for hydrocarbon-affected soils at the Ekati Mine has been outlined in the Hydrocarbon Impacted Materials Management Plan, as approved by the Wek'èezhìi Land and Water Board. This Plan describes isolating affected soils in a landfarm or shipping affected soils off-site. Materials placed in the Landfarm are aerated to enhance the natural breakdown of hydrocarbons. The Landfarm is also used for storage of soils prior to off-site shipment. Once placed and treated in the landfarm, any soil materials removed from the landfarm are considered non-contaminated and acceptable for other uses when final chemical analysis meet the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CCME 2013). All materials added or removed are tracked and reported in the Annual Water Licence Report.

The Ekati Mine Spill Contingency Plan and the Ekati Mine ICRP, both as approved by the Wek'èezhìi Land and Water Board, describe the clean-up and management of soils affected by a spill and the final reclamation of soils and eskers once mining activities have permanently ceased. Also, vegetation trials and progressive reclamation locations are monitored as part of the ICRP.

Existing monitoring and management programs will be applied to the Project to monitor and/or mitigate effects that can change soils and eskers. Further, adaptive management will continue to be implemented to improve effectiveness of mitigations, based on results of monitoring at the Ekati Mine.

11A1.3.2.2 Pathway Screening

Project components and activities, effects pathways, and environmental design features and mitigation are summarized in Table 11A1.3-1. Classification of effects pathways (no linkage, secondary, and primary) to soils and eskers is also summarized in Table 11A1.3-1, and detailed descriptions are provided in the subsequent sections.

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Table 11A1.3-1 Potential Pathways for Effects to Soils and Eskers

Jay Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation Practices	Pathway Classification
• Physical Disturbance from Project Footprint – Construction or development of site access roads, Jay Pit, WRSAs, quarries, support buildings	• Changes to permafrost conditions from the Project footprint can cause changes to soils.	• Design of the Jay Project minimizes the construction of new buildings, roads, pads, or excavations that might affect permafrost by using existing infrastructure. • Soil disturbance will be limited to only those areas required for construction and operation of the Project. • Footprints of the WRSA and other structures will be optimized to limit surface disturbance to the extent practical. • Access roads will be as narrow as feasible, while maintaining safe construction and operation practices. • Buildings will be insulated to minimize heat loss, and will be dismantled as part of reclamation activities. • Drainage around infrastructure will be managed to reduce pooling of water at the surface. • Thaw-sensitive slopes will be insulated. • Quarried granite will be used for road construction to minimize frost effects.	Secondary
	• Direct loss or alteration of local soils and eskers from the Project footprint.	• The Project will maximize the use of the existing infrastructure to reduce the environmental footprint to the extent practical. • The new access roads will be as narrow as feasible, while maintaining safe construction and operation practices. • Footprints of the WRSAs and other structures will be optimized to limit surface disturbance to the extent practical. • A pipe bench will be constructed to accommodate the pipelines, which will follow existing and proposed road alignments to the extent practical to minimize the Project footprint. • Soil disturbance will be limited to only those areas required for construction and operation of the Project. • Siting and construction of the Project will be planned to avoid environmentally sensitive areas to the extent practical (e.g., critical wildlife habitat, rare plants and wildlife species, and wetlands). • Design of the Jay Project minimizes the construction of new buildings, roads, pads, or excavations by using existing infrastructure. • The existing Misery and Lynx Pits will be used for dewatering and minewater management, limiting the requirement for additional areas to be disturbed for minewater management. • Upper soil material, lake bed sediments, and glacial till overburden may be salvaged, to the extent practical, for possible future use in reclamation. • Best management practices already in place at the Ekati Mine will be implemented to control erosion and sediment. • The existing Ekati Mine ICRP will be amended to include the Project and will be reviewed and approved by the Wek'èezhìi Land and Water Board. • Progressive reclamation of the Project will be completed to the extent practical. • Conditions will continue to be monitored over time to evaluate the success of the ICRP.	Primary

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Table 11A1.3-1 Potential Pathways for Effects to Soils and Eskers

Jay Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation Practices	Pathway Classification
• Physical Disturbance from Project Footprint (continued) – Construction or development of site access roads, Jay Pit, WRSAs, quarries, support buildings	• Construction of the Project can cause compaction and erosion to soils, and change soil quality.	• Best management practices already in place at the Ekati Mine will be implemented to control erosion and sediment. • Soil disturbance will be limited to only those areas required for construction and operation of the Project. • Upper soil material, lake bed sediments, and glacial till overburden may be salvaged, to the extent practical, for possible future use in reclamation. • Salvaged soil will be stored on-site and away from areas that could be subject to future disturbances. • Disturbed areas (e.g., access roads and banks) will be reclaimed according to the approved Closure and Reclamation Plan. • Erosion control practices will be applied to salvaged soil to reduce potential erosion and sediment transport off-site such as seeding soil salvage stockpiles. • The height of soil salvage stockpiles will be adjusted so that the size and shape reduces changes to quality, erosion, and loss (e.g., slumping). • The Project will be incorporated into the existing ICRP.	Secondary
	• Soil salvage, stockpiling, and transport can change physical, biological, and/or chemical properties of soils, and increase erosion potential.		Secondary
• General Construction and Operation Activities – Mining of the kimberlite pipe (pit development) – Operation of surface infrastructure and support facilities – Vehicle traffic along the access roads	• Use of explosives can cause changes to soil quality.	• Established Ekati Mine blasting practices will be used in the dewatered portion of Lac du Sauvage and for blasting of quarry rock, including on-going enhancements that may be developed prior to the start of the Project.	No Linkage
	• Air and dust emissions and subsequent deposition can cause chemical changes to the environment, which can alter soil quality.	• Regular maintenance of equipment will continue at the Ekati Mine. • Dust suppression will be applied as appropriate to roads, airstrip, and laydown areas. • Speed limits will continue to be applied to limit fugitive dust. • Salvaged material stockpiles or exposed soils will be seeded, where necessary, to reduce wind erosion.	Secondary
• Mine Rock Management	• Seepage and surface runoff from WRSAs and kimberlite stockpiles can cause changes in groundwater, surface water, and soil quality.	• Metasediment rock mined from the Jay open pit will be encapsulated within a thermally protective cover layer of granite such that metasediment is frozen into permafrost; this continues the approach successfully established at the Ekati Mine. • The existing WROMP, including seepage monitoring, will be expanded to include the Jay WRSA. • Thermistors will be installed within the waste rock piles to monitor the progression of permafrost development. • Mine rock used to construct the dikes will be non-potentially acid generating (non-PAG). • The base of the WRSA and kimberlite stockpile/storage areas will be constructed of granite (i.e., non-PAG) rock.to prevent drainage with low pH.	No Linkage

Table 11A1.3-1 Potential Pathways for Effects to Soils and Eskers

Jay Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation Practices	Pathway Classification
• Site Water Management – Dewatering of diked area of Lac du Sauvage – Diversions	• Changes in surface flows (e.g., isolation and diversion, altered drainage patterns) and water levels from the dewatering of the diked area of Lac du Sauvage may change soils.	• Where practical, natural drainage patterns will be unaltered to reduce the use of ditches or diversion berms. • The diversion channel that will be constructed at the Christine Lake outflow (Sub-Basin B Diversion Channel) will be reclaimed at closure so that water flows through the natural drainage pattern to Lac du Sauvage. • Culverts will be installed along site access roads, as necessary, to maintain drainage. • The road route alignment will minimize stream crossings and limit disturbance to sensitive habitat as feasible. • The Sub-Basin B Diversion Channel will be designed to manage flows and minimize potential for erosion and bank instability. • Dewatering and operational discharges will be monitored for downstream erosion and actions taken to prevent erosion in downstream lakes and channels.	Secondary
	• Changes in surface flows (e.g., isolation and diversion, altered drainage patterns) and changes in water levels may change water quality (e.g., suspended sediments, metals, nutrients) and may cause changes to soils.	• The Sub-Basin B Diversion Channel will be designed to manage flows and minimize potential for suspended sediment generation from bed and bank erosion. • Construction and monitoring of settling/sediment ponds and/or water treatment areas will be part of dewatering and minewater management. • Water quality monitoring for total suspended solids will be completed during the dewatering period. • Standard erosion and sediment control measures (e.g., silt curtains, runoff management) will be used during construction, where appropriate.	No Linkage
• General Closure and Decommissioning Activities – Back-flooding of Jay Pit (back-flooding of dewatered areas, seepage from facilities, groundwater inflows, back-flooded Jay Pit)	• Changes in surface flows (e.g., isolation and diversion, altered drainage patterns) and changes in water levels from the back-flooding of the diked area of Lac du Sauvage may change soils.	• The existing ICRP will be expanded to include the Jay Project. • Dike breaching and re-flooding of the dewatered area will be done in a controlled manner so water levels will be equalized on both sides of the dike and back-flooding will be managed to avoid adverse impacts in source waterbodies and downstream. • Water quality monitoring for total suspended solids will be completed during the back-flooding period. • During excavation of dike breaches, silt curtains and other sediment and turbidity mitigation will be used, as appropriate. • Reclamation of shoreline and shallow areas within the diked area will include localized repair of erosion and revegetation with aquatic and riparian plants, as necessary.	Secondary
	• Long-term seepage from WRSAs may cause local changes to soil quality.	• Following established WRSA practices, potentially acid generating metasediment rock will be encapsulated within a thermally protective cover layer of granite to facilitate permafrost development. • The existing WROMP, including seepage monitoring, will be expanded to include the Jay WRSA. • Thermistors will be installed within the WRSA to monitor the progression of permafrost development.	No Linkage

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Table 11A1.3-1 Potential Pathways for Effects to Soils and Eskers

Jay Project Component/Activity	Effects Pathway	Environmental Design Features and Mitigation Practices	Pathway Classification
• Accidents and Malfunctions	• Chemical spills (i.e., fuels, petroleum products, reagents, pipeline leaks) on site can cause changes to soil quality.	• The existing Spill Contingency Plan is in place and will be expanded to include the Jay Project. • Equipment will be regularly maintained (e.g., regular checks for leaks). • Drip trays and/or absorbent pads will be used during servicing and refuelling. • Hazardous substances will be stored and handled on site in accordance with applicable regulations. • Fuel is stored at a central bulk fuel farm at the Ekati main camp and at satellite fuel farms located at Misery, Fox, and Koala North. Fuel tanks are housed within bermed containment areas. • The Project will follow Ekati's standard policies in the event of a spill; spill response training is provided and updated. • Soil and snow affected by hydrocarbon spills will continue to be handled in accordance with the existing Hydrocarbon-impacted Materials Management Plan and will be remediated in the landfarm or shipped off-site. • Minewater and fine processed kimberlite slurry pipelines will be monitored and inspected throughout construction (i.e., dewatering of diked area), operations, and closure. • Any leaks or spills identified along the pipelines will be addressed immediately and clean-up, if required, will be implemented following the existing Spill Contingency Plan.	No Linkage

WRSA = waste rock storage area; ICRP = Interim Closure and Reclamation Plan; WROMP = Waste Rock and Ore Storage Management Plan; m = metre.

11A1.3.2.2.1 Pathways with No Linkage

A pathway can have no linkage to effects if the activity does not occur (e.g., site runoff is not released), or if the pathway is removed by mitigation and environmental design features so that the Project results in no measurable change in soil quantity and quality. Subsequently, no residual effect is expected. The pathways described in the following bullets are anticipated to have no linkage to effects on soils and eskers, and are not carried through the residual effects analysis (Section 11.4).

- Use of explosives can cause changes to soils quality.

Use of explosives during the Project has potential to change soil quality. Ammonium nitrate fuel oil explosives may be used to remove the glacial till and waste rock from the Jay Pit (Section 3.5.3). This type of explosive has the potential to leave nitrogen residual substances (e.g., ammonia and nitrate) on the blasted material. Blasting activities and the removal of waste rock could also increase dust deposition.

Blasting activities will be managed using current practices applied at the Ekati Mine. These practices have evolved in site-specific efficiency throughout the 15 plus years of operations at the Ekati Mine to provide good blast performance and reduce the potential for enhanced nitrogen loading of soils. Seepage and surface water runoff from the WRSA will be monitored for nitrogen residual substances according to the existing WROMP. Based on site-specific experience, the amount of residue in the waste rock is anticipated to diminish over time and is not expected to result in measurable changes to soil quality. Therefore, the use of explosives was determined to have no linkage to effects on soils.

- Seepage and surface runoff from WRSAs and kimberlite stockpiles can cause changes in groundwater, surface water, and soil quality.
- Long-term seepage from WRSAs may cause local changes to soil quality.

Surface runoff, seepage, and long-term seepage from waste rock can change groundwater and surface water. Changes to groundwater and surface water can affect soil quality. Acid rock drainage and metal leaching can result from chemical weathering of minerals present in rock exposed during construction and mining. Metasedimentary and diabase rock are considered potentially acid generating because they contain trace amounts of sulphide minerals. Approximately 25% of waste rock from the Jay Pit will be metasedimentary, with minor amounts of diabase (Section 3.3.2). The remaining 75% of waste rock from the Jay Pit will be granite, which is non-PAG and non-metal leaching.

Waste rock from the Jay Pit will be stored in the new Jay WRSA. The existing Ekati WROMP will be expanded to incorporate the Jay WRSA. Seepage quality will be monitored and reported to the Wek'èezhìi Land and Water Board as part of the requirements set out in the Water Licence. The Jay WRSA will be constructed following existing WRSA practices to facilitate permafrost development. Any potentially acid-generating waste rock removed from the Jay Pit will be encapsulated for closure within a thermally-protective cover of non-PAG material (in this case 5 metres [m] of granite rock). The WRSA will then be monitored for long-term thermal performance as part of existing monitoring programs under the WROMP and ICRP.

Processing of the Jay kimberlite is expected to generate processed kimberlite. The Panda and Koala open pits are the primary deposition locations for processed kimberlite resulting from the Project (Section 3.5.6). The use of mined-out open pits for processed kimberlite deposition has generally been acknowledged as a preferred approach as outlined in the original Environmental Assessment in 1995 (Section 3.5.6).

The Jay WRSA will be stabilized according to the methods described in the Ekati Mine ICRP and will focus on providing a thermally protective surface cover over potentially acid-generating materials and providing a relatively flat upper surface that discourages snow accumulation.

Changes to groundwater and surface water from surface runoff, seepage, and long-term seepage from leaching of potentially acid-generating mine rock in the WRSA and from the kimberlite storage facilities is expected to be limited through the use of mitigation and environmental design features. No change to soil quality is predicted. Consequently, this pathway was determined to have no linkage to effects on soils.

- Changes in surface flows (e.g., isolation and diversion, altered drainage patterns) and changes in water levels may change water quality (e.g., suspended sediments, metals, nutrients) and may cause changes to soils.

Construction and operation of the Project may change surface flows and lake levels, which can change the water quality directly through altered chemistry or indirectly through change in biogeochemical processes. Water quality changes from changes in surface flows and lake levels may lead to the deposition and accumulation of sediments, metals, and nutrients onto soils adjacent to receiving waterbodies thereby changing soil quality. Changes in soil quality can influence soil nutrient cycling, microbial communities, and the bioavailability of metals for plant uptake (Ewing and Singer 2012; Pan 2012; Violante et al. 2012).

Runoff and surface flows will be managed as part of dewatering and minewater management in the Mine Water Management Plan to limit introduction of sediment into receiving waterbodies. Where practical, natural drainage courses will be used to reduce the need for constructed ditches and diversion berms. Existing erosion and sediment control practices (e.g., silt curtains) already in place at the Ekati Mine will be implemented to limit the generation of sediments, metals, and nutrients from changes in surface water. To reduce the potential for erosion in channels or backwatering due to higher than normal water flows and levels, natural drainage courses will be surveyed to evaluate capacity, and then modified, if required. Water quality monitoring will occur during the Project and water will not be released to the surrounding environment unless it meets discharge criteria. Areas of exposed soils may require localized repair of erosion and re-vegetation to stabilize and prevent erosion (BHP Billiton 2011). This work will be based on experience gained through operations and closure of other areas of the Ekati Mine, and is summarized in the ICRP.

It is anticipated that implementing environmental design features and mitigation will result in minor changes to water quality and would cause minor and local changes to soil quality. Therefore, this pathway was considered to have no linkage to residual effects on soil.

- Chemical spills (i.e., fuels, petroleum products, reagents, pipeline leaks) on site can cause changes to soil quality.

Spills during construction, operations, or decommissioning and reclamation activities have the potential to change soil quality. Spills that occur in high enough concentrations could contaminate soils and water and cause direct toxicity to aquatic organisms, soil organisms, and vegetation. Spills are generally local in nature.

Mitigation identified in the existing Ekati Mine Spill Contingency Plan and environmental design features will be in place to limit the frequency and minimize the extent of spills that have potential to occur during Project activities. Hazardous materials and fuel will be stored, transported and handled according to regulatory requirements to protect the environment and workers. Bulk fuel storage for the Project is within bermed containment areas. Emergency spill kits will be provided wherever hazardous materials or fuel are stored and transferred.

Hydrocarbon-impacted soil with average particle size less than 4 cm will be contained in the existing landfarm. Hydrocarbon-impacted soil that is unsuitable for on-site treatment will be temporarily stored in the landfarm until it is shipped off site for proper disposal (Section 3.4.1.8.5). Hydrocarbon-impacted snow and ice will be contained in the contaminated snow containment facility (Section 3.4.1.8.6). Individuals working on site and handling hazardous materials will be trained in spill response as per the Spill Contingency Plan.

Failure of minewater and fine-processed kimberlite slurry pipelines could result in the release of non-compliant water to the surrounding environment. During operations, minewater that may be non-compliant with the Water Licence will be pumped from the Jay Pit and surface minewater sumps to the Misery Pit. Additionally, fine-processed kimberlite slurry will be pumped from the processing plant to the mined-out Panda and Koala open pits. The fine-processed kimberlite slurry pipelines will lie within the catchments of the Ekati camp and open pit collection systems such that spills would be contained in these areas.

Mitigations and management identified in the existing Wastewater and Processed Kimberlite Management Plan and environmental design features will be in place to limit the potential for pipeline failure. The integrity and performance of the pumping and pipeline systems will be monitored throughout the Project construction and operations phases to prevent the unintentional release of minewater to the environment. If any leaks and spills occur from the pipeline, clean-up will follow existing procedures in place at the Ekati Mine.

The implementation of existing mitigations outlined in the Spill Contingency Plan and environmental design features are anticipated to reduce the likelihood and extent of the release of spills and hazardous materials on-site, and mitigate the unintentional release of minewater from pipelines to the environment. Therefore, spills occurring from Project construction and operations are not expected to result in a change to soil quality, and this pathway was determined to have no linkage to effects on soil.

11A1.3.2.2.2 Secondary Pathways

In some cases, both a source and a pathway exist, but the Project is anticipated to result in a minor environmental change, and would have a negligible residual effect on soils relative to Base Case or guideline values. The pathways described in the following bullets are expected to be secondary and is not carried through the residual effects analysis (Section 11.4).

- Changes to permafrost conditions from the Project footprint can cause changes to soils.

Loss and alteration of permafrost from the Project footprint has the potential to affect surface hydrology, soils, vegetation, and land use. Freeze-induced displacement of soil (i.e., frost jacking) and thaw-induced displacement (i.e., subsidence) of soil are the main issues related to permafrost degradation. Changes to thaw penetration and thickness of the active layer can influence surface stability through thaw settlement, frost heave, and bearing capacity, as well as slope stability (Tarnocai et al. 2004). Changes can also affect hydrology, soil moisture, and nutrient availability, thereby influencing the ecology of an area.

Numerous factors determine the magnitude of changes to permafrost areas and influence recovery of an area following disturbance: type of construction activities, site infrastructure, vegetation, soil type, soil texture, soil density, water content, and snow depth (Lawson 1986; Nolte et al. 1998; Jorgenson et al. 2010). Thaw settlement caused by disturbance and subsequent melting of permafrost can initially lead to water impoundment, decreased albedo, and an increase in heat flux, which in turn causes more thaw settlement (Jorgenson et al. 2010). Thaw settlement can result in a change in surface hydrology that shifts recovery patterns towards new plant communities, further influencing permafrost. The depth of the active layer may continue to increase as a result of disturbance (Burgess and Harry 1990; Burn and Smith 1993; Hayhoe and Tarnocai 1993).

The ESA is within the continuous permafrost zone, where permafrost may occupy approximately 90% to 100% of the area (Section 11A1.2.2.2). The permafrost in this area is characterized by having low ice content, which indicates the ground ice content in the upper 10 to 20 m of the ground has less than 10% ice content by volume of visible ice (Section 11A1.2.2.2).

The amount of ground ice present in permafrost is important for assessing the response of permafrost to clearing, construction, and subsequent recovery of ice conditions following disturbance (Jorgenson et al. 2010). Areas with high ground ice content (i.e., terrain with abundant ice wedges) should be avoided where feasible. These areas are more sensitive to thaw settlement and can result in longer-term changes in terrain, soils, and surface hydrology (Jorgenson et al. 2010). Conversely, areas with small volumes of ground ice are not as sensitive to thaw settlement (Lawson 1986). Soil present in the ESA ranged from having Low potential for permafrost (rapidly drained Brunisolic and Regosolic soils) to High (rapidly drained Cryosolic soils and imperfect to poorly drained Cryosolic and Organic soils). Within the ESA, permafrost, when present, would likely have low ground ice content (Section 11A1.2.2.2).

The 1995 Environmental Impact Statement for the Ekati Mine predicted that local disturbance of the permafrost layer would occur due to mine activities such as the digging of open pits, storage of waste rock, and construction of roads and the Long Lake Containment Facility. The disturbances were predicted to be local in nature and restricted to the mine footprint (BHP and Dia Met 1995). These predictions have been verified by results of permafrost monitoring undertaken to support the original approval of the Ekati Mine (BHP Billiton 2009, 2012). The low relief of the Ekati claim block and the implementation of appropriate engineering design and construction practices specific to Arctic areas typically mitigate most of the mine effects on permafrost. Permafrost will also form within the WRSAs as they cool.

Key mitigation and environmental design features to reduce the potential for permafrost melting are:

- design of the Project minimizes the construction of new buildings, roads, pads, or excavations that might have an effect on permafrost;
- footprints of the WRSAs and other structures will be optimized to limit surface disturbance to the extent practical;
- soil disturbance will be limited to only those areas required for construction and operation of the Project; and,
- buildings will be insulated to minimize heat loss, and will be dismantled as part of reclamation activities, which will allow for a return to stable permafrost conditions.

By implementing mitigation practices and based on site-specific experience, minor local changes to permafrost and soils relative to the Base Case conditions within the Project footprint are anticipated. Consequently, this pathway was determined to have a negligible residual effect on soils.

- Construction of the Project can cause compaction and erosion to soils, and change soil quality.
- Soil salvage, stockpiling and transport can change physical, biological, and/or chemical properties of soils, and increase erosion potential.

Project activities are expected to result in direct and indirect changes to soil quality. In the absence of mitigation, project activities have the potential to directly cause soil compaction and erosion, which can cause changes to the physical, chemical and biological properties of soil. With no mitigation, in areas where soil materials may be affected by Project construction, it would be predicted to cause gradual, negative changes to soil quality. The extent of changes to soil quality varies depending on existing soil conditions (Abdul-Kareem and McRae 1984).

Changes to soil quality can influence the ability of soil to support other VCs (e.g., vegetation).
Soil disturbances have potential to occur during the construction phase of the Project. Growth materials currently salvaged at the Ekati mine include surface tundra soils (including the organic layers [e.g., plant litter, mosses]), glacial till and lake sediment, where available, and are stockpiled for future use in site reclamation. The salvaged growth materials from other areas of the Ekati Mine have been placed during progressive reclamation activities (Martens 2003, 2005, 2006, 2009, 2010, 2011, 2012, 2013) and would be used in critical areas during reclamation of the Project, if required.

The definition of soil quality encompasses physical, chemical, and biological characteristics that are used to determine overall soil health (Ewing and Singer 2012). Stripping and stockpiling upper soil materials can to cause physical changes to soil such as disturbing soil structure. Loss of soil structure may result in a reduction in the amount of soil organic matter and soil organic carbon present within the soil and influences the bulk density, pore size distribution, microbial community structure and resistance of soil to erosion (Wick et al. 2009). However, by salvaging the upper soil horizons where possible, it can maintain the soil organic materials, which is important for maintaining soil quality because it plays an important role in determining the overall resilience of an ecosystem to disturbance (Baldock and Broos 2012). Growth medium materials use currently employed at the Ekati Mine include spreading stockpiled organic materials in localized areas to enhance site conditions for natural colonization of vegetation (Martens 2013).

Soil compaction decreases soil quality and occurs primarily from heavy equipment or repeated passes of equipment across the soil surface. Reclamation research at the Ekati Mine has found that surface compaction appears to be a major factor limiting plant establishment and growth, especially in mixtures containing a high proportion of lake sediment because of the high fines content (Martens 2005). This is because soil compaction increases soil density and reduces soil porosity, influences drainage and structure, alters soil strength, water content and temperature (Corns 1988; Tuttle et al. 1988; Busse et al. 2006; Blouin et al. 2008). At the Ekati Mine, areas most prone to compaction in the ESA are low-lying, poorly drained areas with fine-textured soils (e.g., wetlands). However, the organic layer present in these areas is sometimes fibric, which can reduce the compaction sensitivity. Current studies have assessed methods and procedures that optimize benefits from the salvaged growth materials that include best equipment to use and placement techniques (Martens 2010). By employing mitigations that avoid or minimize compaction on soil surfaces not required for the Project and that alleviate soil compaction following closure (e.g., deep ripping), soil quality degradation due to compaction are expected to be mitigated and reversible.

Soil erosion can adversely affect quality of stockpiled growth materials that may have future value for reclamation. Soil quality can be adversely affected by erosion through the removal of fine soil particles and organic materials, which can reduce the overall nutrient content and soil water holding capacity. As such, it has been suggested that existing and future salvaged materials that may have future value for reclamation be allowed to freeze and remain frozen until needed to slow microbial processes that change soil quality (i.e., immobilization of soil nutrients), thereby maintaining the quality of salvaged materials (Martens 2005). In addition, based on previous management of salvaged materials, it is expected that stockpiles will be stabilized and the material will be used for site-specific applications of reclamation in critical areas (BHP Billiton 2011).

Overall, construction of the Project will result in changes to soil quality relative to Base Case conditions. With appropriate mitigations as described in this assessment, the changes to soil quality are predicted to be local and minor. Therefore, these pathways were determined to have a negligible residual effect to soil.

- Air and dust emissions and subsequent deposition can cause chemical changes to the environment, which can change soil quality.

Construction and operation of the Project will generate air emissions such as carbon monoxide (CO), oxides of sulphur (SO_x includes sulphur dioxide [SO_2]), oxides of nitrogen (NO_x), particulate matter ($PM_{2.5}$), and total suspended particulates (TSP). Air emissions such as SO_x and NO_x can result from the use of fossil fuels in generators, vehicles, machinery, and the use of explosives for the Project. Transportation routes that are used to access the Project and the dewatered diked area in Lac du Sauvage are the main source of dust ($PM_{2.5}$ and TSP) due to the re-suspension of soil and sediment particles (Farmer 1993; Harrison et al. 2003; Peachey et al. 2009; Liu et al. 2011).

The deposition of air and dust emissions can lead to changes in soil quality by altering soil pH and nutrient content, and soil fauna composition (Rusek and Marshall 2000; Jung et al. 2011). The related changes to soil from atmospheric inputs is determined by complex geochemical factors, which include nutrient uptake by plants, decomposition of vegetation, cation and anion exchange in soil, soil sensitivity to acidification, and duration and quantity of atmospheric inputs (Turchenek et al. 1998; Jung et al. 2011). Changes in soil fauna can lead to alterations in rates of organic matter decomposition and nutrient cycling (Rusek and Marshall 2000).

Changes to soil from atmospheric inputs of SO_x and NO_x and potential for acidification depend on the buffering capacity of the soil and the vegetation cover present in the receiving environment (Bobbink et al. 1998; Barton et al. 2002; Jung et al. 2011, 2013). Brunisolic and Regosolic soils in the ESA were rated as having a High sensitivity to acidification (Section 11A1.2.2.3.2). Cryosolic soils were rated as having a Medium sensitivity. Organic, Gleysolic, and peaty phase wetland soils, and the associated wetlands have a Low to Medium sensitivity, and is dependent on wetland type (i.e., soil in Sedge Wetland is rated as Low and Tussock/Hummock is rated as Medium).

In addition to changes from the deposition of SO_x and NO_x chemical changes can occur from the deposition of dust. Rates of dust deposition and accumulation are dependent on the rate of supply from the source, wind speed, precipitation events, topography, and vegetation cover (Rusek and Marshall 2000; Liu et al. 2011). Changes in soil quality depend on the chemical composition of dust and its source (e.g., dried lake bed sediments) (Grantz et al. 2003). Dust deposition can also cause chemical loading in soils if dust emissions include elevated concentrations of metal particles. Metal particle deposition can also affect soil biota composition (Grantz et al. 2003), which could change soil quality. Particle size of the sediments in Lac du Sauvage was predominantly silt (Water and Sediment Quality Baseline Report, Annex XI, Section 5.1). Total metals concentrations were generally below sediment quality guidelines, with the exception of arsenic, chromium, and copper (Annex XI, Section 5.1).

In addition to metals, dust can contain other cations and anions. The presence of cations such as calcium in dust emissions can reduce the acid-generating potential of the SO_2 and NO_x because they tend to react with bases (e.g., carbonates) found in dust (McNaughton et al. 2009). When cations (e.g., ammonium) are deposited into an ecosystem, the vegetation present can take up the cation; however, other cations, usually hydrogen [H^+], can be released into the environment and decrease soil pH (Turchenek et al. 1998). When anions (e.g., chloride) are deposited into an ecosystem, anions such as hydroxide [OH^-] can be released. Although OH^- increases pH, cation and anion uptake has generally been shown to result in a net production of acidity. The net effect is acidification because the cations are generally retained in the plant biomass and are therefore not mineralized. Ultimately, the concentration and duration of air and dust emissions and the sensitivity of the ecosystems determine the overall influence that emission deposition will have on soils (Bobbink et al. 1998).

Air quality modelling was completed to predict the spatial extent of air and dust emissions and deposition from the Project (Section 7.4). Air quality modelling was completed for the Base Case and Application Case. The Base Case includes emissions from the existing Ekati Mine and the Diavik Diamond Mine (Section 7.4.1). The Application Case includes the Base Case plus emissions during worst case operations year and provides the maximum potential effects from the Project. Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates.

Results of the air quality modelling indicated that the maximum ground-level concentrations of CO and SO_x, are below the Northwest Territories Ambient Air Quality Standards (GNWT-ENR 2014; Section 7.4.2.2). The maximum 1-hour and annual NO_2 concentrations are above the NWT standard in both the Base Case and Application Case. The maximum 24-hour NO_2 concentrations in the Base Case are below the NWT standard but above the standard in the Application Case. All predictions exceeding the NWT standards are confined to small areas within a few hundred metres from the edge of the Diavik Mine or Jay Pit. These higher predictions are primarily a result of mine fleet exhaust along the haul roads at the perimeters of the mine sites. The predictions decrease sharply with distance from the edge of the mine sites.

Modelling results indicate that the maximum annual potential acidic input is 1.46 kiloequivalents per hectare per year (keq/ha/yr), and is associated with the boundary of the Jay Pit. The Project's maximum annual potential acidic input outside of the Project footprint is predicted to be between 0.17 keq/ha/yr to 0.5 keq/ha/yr, with values dropping below 0.17 keq/ha/yr within 1 km of the Project.

The maximum annual $PM_{2.5}$ emissions resulting from the Project is 39.4 micrograms per cubic metre ($\mu g/m^3$), which is above the NWT air quality standard of 10 $\mu g/m^3$. The maximum annual TSP emissions resulting from the Project is 607 $\mu g/m^3$, which is above the annual NWT air quality standard of 60 $\mu g/m^3$. However, the maximum annual totals are predicted to be confined to the boundaries of the existing Ekati Mine, the Jay Pit and the Diavik Mine. The area with $PM_{2.5}$ and TSP above the annual NWT air quality standards extends no further than approximately 1 km beyond the sources. This is to be expected, as in general the majority of TSP tends to settle out within 1 km of ground-level sources (Everett 1980; Walker and Everett 1987; Watson et al. 1996; Meininger and Spatt 1988; Grantz et al. 2003). In addition, because of the conservatism used for the air quality modelling, it is expected that the actual $PM_{2.5}$ and TSP concentrations at the Project will be lower than predicted, closer to the concentrations measured currently at the Ekati Mine. Dust production is expected to be higher during the non-winter period and would be reduced during wet conditions.

Overall, air and dust emissions and subsequent deposition are expected to result in minor and local changes to soil quality relative to Base Case conditions. Therefore, this pathway was determined to have a negligible residual effect on soils.

- Changes in surface flows (e.g., isolation and diversion, altered drainage patterns) and changes in water levels from the dewatering of the diked area of Lac du Sauvage may change soils.
- Changes in surface flows (e.g., isolation and diversion, altered drainage patterns) and changes in lake levels from the back-flooding of the diked area of Lac du Sauvage may change soils.

Dewatering of the diked area of Lac du Sauvage and diversion of flows from tributaries that flow into this area are required for the Project. The location of the proposed Jay Pit currently receives runoff from Sub-Basin B and a small portion of the Lac du Sauvage main watershed. To divert water away from the proposed Jay Pit, the Sub-Basin B Diversion Channel will be constructed to divert water to Lac du Sauvage outside the dewatered area. Changes in water levels in Lac du Sauvage beyond the natural range of variation could lead to a loss of soils through erosion. In addition to changes in lake water levels, alteration of inflows and outflows (e.g., drainage patterns, flow velocities) could change soils downstream.

Dewatering of the diked area to Lac du Sauvage is expected to temporarily redistribute the lake water storage and increase the lake water level and outflow. During construction, the largest changes to Lac du Sauvage would result from dewatering discharge. The dewatering phase modelling predicts an increase of up to 0.05 m in the water level in Lac du Sauvage compared to median baseline conditions, and an increase in the 2-year daily peak flood discharge of approximately 10% compared to baseline conditions (Section 8.5.3.2). Discharge flow rates will be managed to reduce the potential for soil loss through erosion.

At closure, the back-flooding of the Jay Pit is predicted to result in a decrease in Lac du Sauvage water levels of up to 0.06 m (Section 8.5.3.2). back-flooding will be managed to minimize adverse effects in source waterbodies and downstream. Following back-flooding of the Jay Pit, baseline water levels in Lac du Sauvage are anticipated to be re-established. The riparian (shoreline) and littoral (shallow) areas around the perimeter of Lac du Sauvage at the re-established water elevation will be reclaimed where necessary to limit loss of soil through erosion. The reclamation work is expected to include localized repair of erosion, and re-vegetation of select areas with aquatic and riparian plants. This work will be based on experience gained through operations and closure of other areas of the Ekati Mine.

The cumulative effects from overlapping activities for the Ekati and Diavik mines are within the Lac de Gras watershed downstream of the Lac du Sauvage sub-basin. Negligible effects to surface hydrology from Ekati Mine closure and Diavik Mine operational and closure activities are expected for Lac du Sauvage. Based on modelling results, the maximum annual change to the average Lac du Sauvage mean discharge is predicted to be less than 0.02% and the maximum annual change to the Lac du Sauvage mean water levels are predicted to be less than 0.001 m for the period of 2016 to 2037 (Section 8.5.3.3).

The largest cumulative increase in Lac de Gras outlet flows predicted is during Project dewatering and the back-flooding of the Fox Pit, and Diavik operational activities during 2019. Modelling results predicted a less than 1% cumulative increase in the mean annual discharge and a 0.001 m cumulative increase in the mean annual water levels as compared to baseline conditions (Section 8.5.3.3). The largest cumulative decrease in Lac de Gras outlet flows is predicted to occur during the back-flooding of the diked area in Lac du Sauvage in 2032. Modelling results predicted a 5% cumulative reduction in the mean annual discharge and a 0.04 m cumulative reduction in the mean annual water levels as compared to baseline conditions (Section 8.5.3.3). Cumulative effects to Lac de Gras outlet flows and water levels in an average climate year are within the range of natural variability.

Environmental design features and mitigation have been included to limit loss of soils through erosion from dewatering and back-flooding the diked area in Lac du Sauvage. Lac du Sauvage water levels and Lac du Sauvage outflow discharges will be monitored, and pit back-flooding rates may be adjusted during low water years. Cumulative changes in Lac du Sauvage and Lac de Gras are predicted to be temporary and within the range of natural variability. Minor and local changes in the distribution of soils are predicted relative to the Base Case conditions. Therefore, these pathways were determined to have a negligible residual effect on soils.

11A1.3.2.2.3 Primary Pathway

The following primary pathway is assessed in detail in the residual effects analysis.

- Direct loss or alteration of local soils and eskers from the Project footprint.

11A1.4 Residual Effects Analysis

11A1.4.1 General Approach

11A1.4.1.1 Project Phases

The analysis is completed for the soils and eskers VCs. The Project phases include construction, operation, and closure. Final closure of the Project generally occurs after the completion of reclamation.

The effects analysis encompasses the following Project phases:

- construction (2016 to 2019);
- operations (2019 to 2029); and,
- closure (2030 to 2033).

The above timeframes are intended to be sufficiently flexible to capture the effects of the Project on soils and eskers. Effects to soils and eskers begin during the construction phase with the removal and alteration of material, and continue through the operation phase and for a period of time after the closure phase (unless determined to be permanent). Therefore, effects to soils and eskers were analyzed from Project construction through closure. This approach generates the maximum potential spatial and temporal extent of changes to the abundance and distribution of soils and eskers, which provides confident and ecologically relevant effects predictions.

11A1.4.1.2 Assessment Cases

For most VCs, the effects assessment consists of three cases: Base Case, Application Case, and the Reasonably Foreseeable Development (RFD) Case (if applicable; Table 11A1.4-1). Cumulative effects could occur in all three cases because of past, existing, and future mining and reclamation activities. The objective of the DAR is to assess cumulative effects for VCs where Project effects could contribute to a cumulative effect.

Table 11A1.4-1 Contents of Each Assessment Case

Base Case	Application Case	Reasonably Foreseeable Development Case
Range of conditions from little or no development to previous and existing developments[a] before the Project	Base Case plus the Project	Application Case plus reasonably foreseeable developments

a) Includes approved projects.

Base Case represents a range of conditions over time within the effects assessment (study) area (ESA) before application of the Project. Environmental conditions on the landscape before industrial development represent reference conditions. The Base Case also describes the existing environment before the application of the Project to provide an understanding of the current conditions that may be influenced by the Project. Existing conditions include the cumulative effects from all previous and existing developments and activities that are planned and approved, and are either under construction or not yet initiated in the ESA (e.g., Lynx Project). Current (baseline studies) and effects from ongoing projects that are approved (e.g., mining and reclamation at the Ekati mine) are also included.

The Base Case describes the range of existing conditions before Project development, which includes the reference condition and 2014 baseline condition. However, a reference condition was not included in the Base Case because historic data are not available to describe soil conditions at a measurable scale in the ESA that would generate ecologically relevant and robust effects predictions. For example, the original 1995 Environmental Impact Statement for the Ekati Mine (BHP and Dia Met 1995) briefly discusses soils in the context of terrain and permafrost, but provides no explicit soil survey or mapping data. Further, no historical government soil survey (CanSIS 2014) has occurred within close proximity to the ESA, and soil surveys that have been completed in the Arctic are generally not at a precise enough scale to establish a suitable reference condition.

The use of existing historic data to define a reference condition for soils would have provided incompatible reference values for the 2014 baseline condition (existing environment), constrained the usability of the data collected for the baseline, and created a high degree of uncertainty for the effects assessment. Therefore, for soils and eskers, the 2014 Base Case reflects only the 2014 baseline condition and describes existing environment conditions in the ESA before application of the Project (i.e., includes existing and approved projects). A reference condition is determined for the vegetation Base Case (Section 11.4.1.2), which considers the relationship among soils, eskers, and vegetation.

Application Case represents predictions of the cumulative effects of the developments in the Base Case combined with the effects from the Project. Physical disturbance to soils is expected to occur at the beginning of construction, and the effects from the Project are expected to be strongest during construction and the initial period of mining operation. The main components of the Project footprint are the proposed infrastructure (Jay WRSA, Ore Stockpile and Transfer Pad, Sub-Basin B Diversion Channel, and dike alignment) and Jay access roads, pipeline, and power line. The effects to soils are considered permanent because the time required to reverse the effect is uncertain.

The Application Case for soils and eskers will determine the incremental changes from the Project that are predicted to occur between the 2014 Base Case and Application Case. Incremental changes to soil and esker measurement indicators are characterized in terms of magnitude, duration, and geographic extent. Because soils are linked to vegetation (and wildlife habitat) the prediction of changes to soils and eskers will support the cumulative effects assessment for vegetation (Section 11.6) and other VCs. The results are provided to other VCs with assessment endpoints (e.g., vegetation and wildlife) for inclusion in the analysis and evaluation of significance of residual effects from the Project and other developments.

Reasonably Foreseeable Development (RFD) Case represents the Application Case and reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities. The RFDs are defined as projects that meet the following criteria:

- are currently under regulatory review or have officially entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project, or may be induced by the Project; and,
- have the potential to change the Project or the effects predictions.

None of the reasonably foreseeable developments identified in Section 6.5.2.4 are located within the ESA. The closest reasonably foreseeable development is the Courageous Lake Project, which is located approximately 73 km to the southwest of the Project and is outside of the ESA selected for soils and eskers. Therefore, the RFD case is not included in this section of the DAR.

11A1.4.2 Effects on Soils and Eskers

The residual effects analysis is focused on thoroughly evaluating the primary pathway associated with the Project on soils and eskers. The residual effects assessment is completed by calculating and estimating changes to measurement indicators of soils and eskers. These measurement indicators are:

- quantity of soils (i.e., abundance and distribution of soil map units); and,
- distribution of the Esker Complex soil map unit.

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11A1.4.2.1 Methods

Development of the Project is expected to change soil quantity and distribution and the distribution of eskers. These changes can affect other VCs (e.g., vegetation and wildlife). The proposed infrastructure was buffered by 200 m and the access roads and adjacent pipeline and power line were buffered by 100 m (200 m right-of-way) so that a maximum possible extent of disturbance was used in the assessment of effects to soils. Thus, the effects analysis results represent a conservative estimate of residual effects to soil quantity and distribution and the distribution of eskers. The proposed infrastructure that was buffered for the Application Case also includes the expanded WRSA constructed for Lynx (included in Base Case) as it is expected that it will also be used for the Project as an Ore Stockpile and Transfer Pad area.

A Geographic Information System (GIS) platform was used to calculate the absolute changes in soil map units within the ESA caused by the Project footprint (Application Case) relative to the 2014 Base Case (i.e., Applicate Case value minus 2014 Base Case value). Following closure of the Project, there will be a net change to these soil map units relative to the ESA, but it is unknown what soil map units these areas will become in the future. As such, the changes from the Project are considered permanent.

11A1.4.2.2 Results

During the 2014 Base Case, the soils ESA is dominated by the Mineral-1 map unit (4,677 ha; 32.1% of the ESA; Section 11A1.2.2.1, Map 11A1.2-1). Existing disturbance on the landscape covers 3,674 ha, and represents anthropogenic features including the existing Ekati Mine and the approved Lynx Project. Although mapped as disturbance in the Base Case, progressive reclamation has been completed at locations no longer needed for operations. Reclamation projects have included exploration camps, exploration drill and adit sites, slope stabilization at the Panda Diversion Channel, Panda open pit, and the Airport Esker quarry site (BHP Billiton 2012). The Esker Complex covers 100 ha (0.7% of the ESA).

Changes from the Project on soil quantity and distribution and the distribution of eskers will be confined to the Project footprint. The predicted Project footprint is estimated to be 1,132 ha (7.8% of the ESA; Map 11A1.4-1). The soil map unit that will likely experience the greatest change during construction is the Mineral-1 map unit, representing dominantly Turbic Cryosol and cryoturbated Orthic Dystric Brunisol upland soil types (Table 11A1.4-2; Map 11A1.4-1). A total of 459 ha of the Mineral-1 soil map unit will be disturbed. The dewatering within the diked area of Lac du Sauvage will decrease the Open Water map unit by 404 ha, and the existing disturbance map unit will increase by 1,101 ha. The Jay footprint overlaps a portion of this existing disturbance map unit during the Application Case. The resulting increase in disturbance appears smaller than the actual Project footprint because the existing disturbance map unit is overestimated in the Base Case, a result of the mapping process. Approximately 11 ha of the Esker Complex will be disturbed (0.1% of the ESA) and represents the disturbance associated with the single crossing location of the Jay access road, pipelines, and power line. Wetland soils represent inclusions (i.e., less than 15% of a mapped polygon) in all soil map units.

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Table 11A1.4-2 Comparison of Soil Map Unit Distribution Between the 2014 Base Case and Application Case in the Effects Study Area

Map Unit Name	Map Unit Symbol	2014 Base Case (ha)	Application Case (ha)	Change from Base Case to Application Case (ha)	Change Following Closure (ha)
Esker Complex	E1	100	89	-11	-11
Mineral-1	M1	4,677	4,218	-458	-458
Mineral-2	M2	2,301	2,239	-62	-62
Mineral-3	M3	280	114	-166	-166
Mineral-4	M4	1,585	1,585	0	0
Existing Disturbance	EDIS	3,674	4,775	1101	32
Open Water	ZW	1,942	1,538	-404	-404
Project Footprint	N/A	0	0	0	1,132

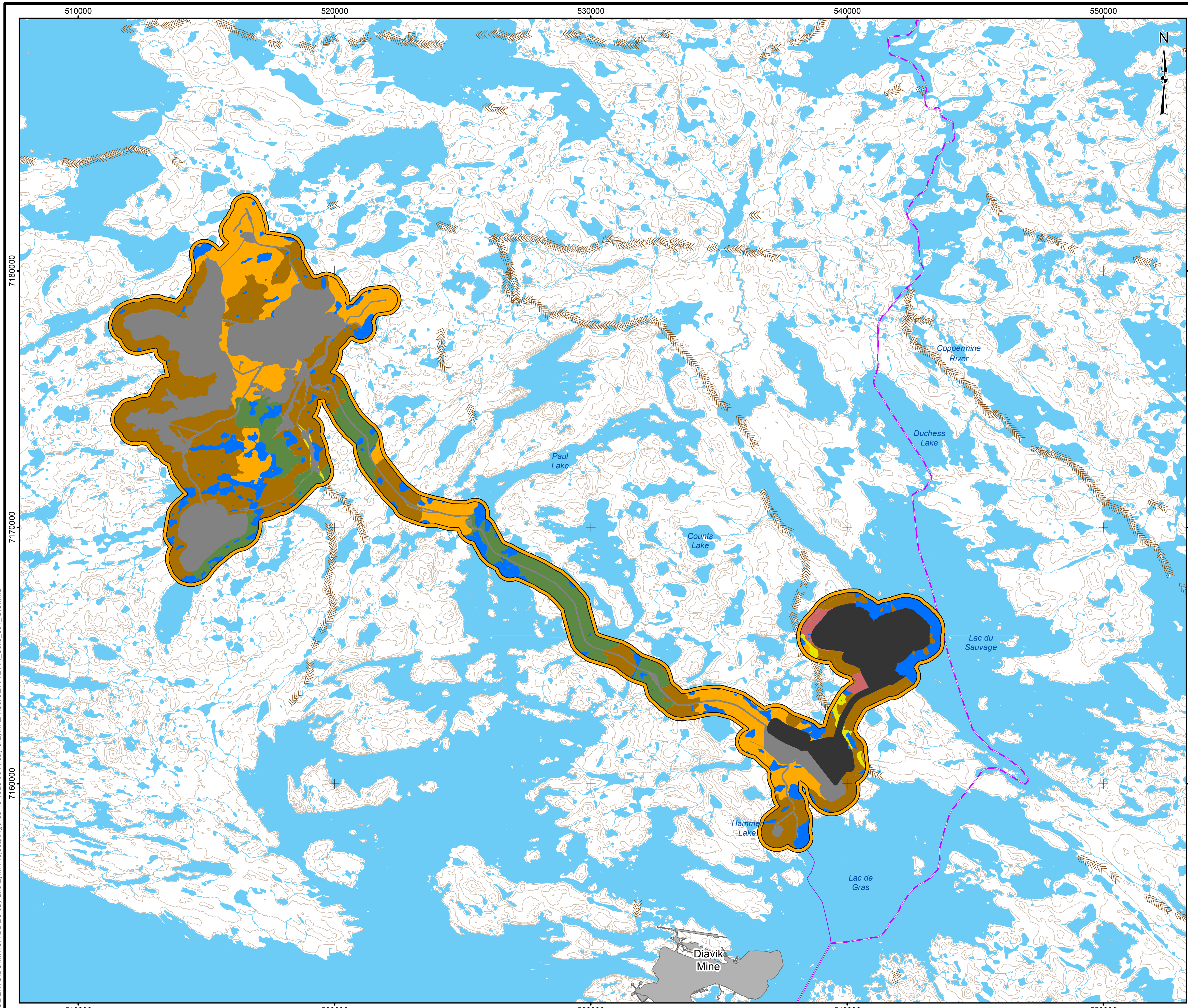
Note:

The total area of the effects study area is 14,557 ha.

Negative numbers indicate a reduction or change in that soil map unit. Positive numbers indicate an increase or gain in that soil map unit.

The existing disturbance map unit is overestimated in the Base Case, a result of the mapping process and the footprint overlaps some of this map unit during the Application Case.

ha = hectare; % = percent; N/A = not applicable.



LEGEND

- EKATI MINE FOOTPRINT
- DIAVIK MINE FOOTPRINT
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (10 m INTERVAL)
- ESKER
- WATERCOURSE
- WATERBODY
- EFFECTS STUDY AREA

SOIL MAP UNIT

- EDIS - EXISTING DISTURBANCE
- E1 - ESKER COMPLEX
- M1 - MINERAL-1
- M2 - MINERAL-2
- M3 - MINERAL-3
- M4 - MINERAL-4
- ZW - OPEN WATER
- PROPOSED PROJECT FOOTPRINT

REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

DEVELOPER'S ASSESSMENT REPORT

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
SOIL DISTRIBUTION DURING THE APPLICATION CASE

Golder Associates

PROJECT	13-1328-0041		FILE No. DAR_Soils_004_GIS
DESIGN	DB	14/01/14	SCALE AS SHOWN REV 0
GIS	LMR	07/10/14	
CHECK	JF	07/10/14	MAP 11A1.4-1
REVIEW	CD	07/10/14	

G:\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Soils\DAR\DAR_Soils_004_GIS.mxd

11A1.5 Prediction Confidence and Uncertainty

There is a high degree of confidence that surficial materials will be moved, excavated, and re-contoured, and soil will be disturbed within the Project footprint. During the closure phase of the Project, soils will be reclaimed where appropriate and feasible according to the Ekati Mine ICRP and additional Project-specific measures described herein.

A degree of uncertainty is associated with the baseline soil mapping. Soil mapping was completed by correlating reconnaissance level soil survey data with mapped ELC map units. The reconnaissance level soil survey focused more on the types and capabilities of the limited number of soils encountered than on locating the exact boundaries of the soil types. There is uncertainty with the ELC mapping because it was developed using satellite imagery with limited field ground-truthing to generate the ELC.

Several aspects of soil quality were examined. The changes from soil salvage and stockpiling and other Project activities on soils were assessed. Minor changes in quality due to these processes are expected with moderate certainty, and effects are expected to be localized. Prediction of a minor change is based on appropriate stockpile design.

Uncertainty was addressed in the assessment by incorporating information from available and applicable literature, using past experience in similar areas, and results of the Ekati Mine monitoring and research programs. In addition, the application of environmental design features and mitigation during construction, operation, and closure, and the ICRP will be implemented to mitigate changes to soils and the esker. Finally, a conservative approach was used when information was limited so that effects are typically overestimated. The proposed infrastructure was buffered by 200 m and the access roads and adjacent pipeline and power line were buffered by 100 m (200 m right-of-way) so that a maximum possible extent of disturbance was used in the assessment of effects to soils. Therefore, the results presented in this section represent a conservative estimate of residual effects to soil quantity and the distribution of eskers.

11A1.6 Follow-Up and Monitoring

Monitoring programs implemented during the Project include a combination of environmental monitoring to track conditions and implement further mitigation as required (e.g., monitoring for soil erosion during construction), and follow-up monitoring to verify the accuracy of effect predictions and adaptively manage and implement further mitigation as required.

Dewatering Plans that will be developed prior to dewatering under the Water Licence will include a description of specific operational erosion monitoring and mitigation programs that will be applied. A soils investigation will be completed for the Sub-Basin B Diversion Channel to verify the nature and ice content of soils to be excavated, which will enable an appropriate mitigation-design approach.

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11A1.7 References

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11A1.8 Glossary

Term	Description
Acidification	The process of becoming acid or being converted into an acid.
Active layer	In permafrost environments, it is the top layer of soil that thaws in the summer and freezes again in the fall.
Adit	A horizontal tunnel driven into the side of a hill at a mine site for the purpose of exploration.
Admixing	Mixing of the upper soil materials (e.g., topsoil) with the generally nutrient deficient lower soil materials (e.g., subsoil, parent material, C horizon) to cause a dilution of texture, nutrients, and/or organic matter found in the upper lift.
Albedo	The ratio of reflected solar radiation to the total incoming solar radiation received at the surface.
All-season road	A road that can be driven all year by the prevailing means of rural transport.
Anthropogenic	Human-related, often referring to an activity, development, or disturbance on the landscape.
Application case	Predictions of the cumulative effects of the developments in the Base Case combined with the effects from the Project.
Assessment endpoint	Assessment endpoints are qualitative expressions used to determine the significance of effects on valued components (VCs) and represent the key properties of VCs that should be protected for future human generations (i.e., incorporate sustainability).
Base case	Represents a range of conditions over time within the effects assessment area before application of the Project.
Baseline	A surveyed or predicted condition that serves as a reference point to which later surveys are coordinated or correlated.
Baseline study area (BSA)	The area where direct effects and small-scale indirect effects from the Project are expected to occur.
Bedrock	The body of rock that underlies gravel, soil, or other material.
Bioavailability	A measure of the amount of a chemical that is absorbed and retained within the body.
Blanket	Unconsolidated soil material thick enough to cover/mask minor irregularities in the underlying material but still integrating the generally underlying topography.
Bog	A peatland with weakly to moderately decomposed sphagnum and forest peat material formed in oligotrophic environments. The bog surface is acidic and low in nutrients due to the slightly raised peat surfaces disassociating it from underlying and surrounding mineral rich soil waters.
Brunisolic soil	Boreal forest soils that primarily develop in sandy glacial sediments. These soils have undergone very limited soil formation.
Buffering capacity	The ability of a soil to resist changes in pH.
Cation	An ion carrying a positive charge of electricity. The common soil cations are calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and hydrogen (H).
Cation exchange capacity	The maximum quantity of total cations that a soil is capable of holding, at a given pH value. Cation exchange capacity is used as a measure of fertility and nutrient retention capacity.
Canadian Council of Ministers of the Environment (CCME)	National Canadian body that sets ambient guidelines for air, water, soil, and contaminants.
Cation exchange capacity	The sum total of exchangeable cations that a soil can adsorb; usually expressed in milliequivalents per 100 grams of soil.
Classification, soil	The systematic arrangement of soils into categories according to their inherent characteristics, or on interpretation of those properties for various uses. Broad groupings are made on the basis of general characteristics, and subdivisions according to more detailed differences in specific properties.
Climate	The prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine, cloudiness, and winds, throughout the year, averaged over a series of years.
Compaction	An increase in soil density and a loss of soil pore space because of weight or pressure being placed on soil.

Term	Description
Conductivity	A measure of the capacity of water to conduct an electrical current. It is the reciprocal of resistance. This measurement provides an estimate of the total concentration of dissolved ions in the water.
Consistence	Soils degree of cohesion and adhesion and a soil's resistance to deformation or rupture.
Cryosolic soil	Cryosolic soils have horizons with permafrost. In some soils the frost action causes considerable mixing of soil horizons, which is termed cryoturbation. In these soils the permafrost layer must be within 2 m of the surface. If no strong cryoturbation has occurred the permafrost layer must be within 1 m of the surface.
Cryoturbated phase, soil	Any non-permafrost soil having one or more cryoturbated (mixed) horizons.
Disturbed soils	Soil that has experienced disturbance, usually as a result of human activity or natural processes such as erosion or annual freeze and thaw cycles.
Ecological landscape classification (ELC)	An ecological mapping process that involves the integration of site, soil, and vegetation information.
Ecoregion	Relatively homogeneous subdivisions of an ecozone, which are characterized by distinctive climatic zones or regional landforms.
Ecosystem	A relatively homogeneous area of organisms interacting with their environment.
Electrical conductivity	The ability of soil to conduct electrical current as expressed in decisiemens per metre (dS/m) and typically used to measure salinity (e.g., of soil, water).
Emission	The act of releasing or discharging air contaminants into the ambient air from any source.
Erosion	(i) The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. (ii) Detachment and movement of soil or rock by water, wind, ice, or gravity.
Esker	A long, narrow ridge of stratified gravel and sand, which forms from glacial processes.
Fen	A fen is a peat-covered or peat-filled wetland with a high water table, which is not hydrologically isolated and receives water from streams and/or groundwater.
Fen, poor	An ecosite that is transitional between the fen and bog. A poor fen is intermediate in nutrient regime and has a similar floristic composition to fen and bog. Sedges and peat moss, golden and brown mosses compose the majority of the organic matter content.
Fen, rich	A peatland with moderate to well-decomposed sedge, grass, and reed peat material from eutrophic environments. Mineral-rich waters are at or are just above the fen surface.
Fibric material	Materials (primarily mosses, rushes, and woody materials) that are readily identifiable as to botanical origin.
Folisolic soil	Composed of upland organic (folic) materials, generally of forest origin that are either 40 cm or more in thickness, or are at least 10 cm thick if overlying bedrock or fragmental material.
Footprint	The proposed development area that directly affects the soil and vegetation components of the landscape.
Geochemistry	The chemistry of the composition and alterations of solid matter such as sediments or soil.
Geographic information system	Computer software designed to develop, manage, analyze, and display spatially referenced data.
Geology	The study of the Earth's crust, its structure, the chemical composition and the physical properties of its components.
Geomorphology	The science of surface landforms and their interpretation on the basis of geology and climate. That branch of science that deals with the form of the Earth, the general configurations of its surface and the changes that take place in the evolution of landforms.
Glaciofluvial	Sediments or landforms produced by melt waters originating from glaciers or ice sheets. Glaciofluvial deposits commonly contain rounded cobbles arranged in bedded layers.
Gleysolic soil	Gleysolic soils are associated with prolonged water saturation of the soil profile. Water saturation leads to depletion of oxygen and the development of soil features associated with oxygen-depleted conditions: blue-gray colours and reddish specks (called mottles) within the soil profile. These features are the diagnostic criteria for Gleysolic soils and occur within 50 cm of the soil surface.

Term	Description
Groundwater	Water that is passing through or standing in the soil and the underlying strata in the zone of saturation.
Habitat	The physical location or type of environment in which an organism or biological population lives or occurs.
Hydrology	Science that deals with the waters above the land surfaces of the Earth, their occurrence, circulation and distribution, both in time and space, their biological, chemical, and physical properties, their reaction with their environment, including their relation to living beings.
Infiltration	The process by which water on the ground surface enters the soil.
Kame	Ice contact deposits associated with the concurrent processes of melting ice and flowing meltwater.
Kimberlite	An igneous rock that can contain diamonds.
Kimberlite pipe	Vertical structures on which kimberlites occur in the Earth's crust.
Landform	A particular type of land formation.
Landscape	A heterogeneous land area with interacting ecosystems that are repeated in similar form throughout. From a wildlife perspective, a landscape is an area of land containing a mosaic of habitat patches within which a particular "focal" or "target" habitat patch is embedded.
Laydown area	An area that has been cleared for the temporary storage of equipment and supplies. Laydown areas are usually covered with rock and/or gravel for accessibility and safe manoeuvrability for transport and off-loading of vehicles.
Leaching	The removal, by water, of soluble matter from any solid material lying on top of bedrock (e.g., soil, alluvium or bedrock).
LiDAR	A remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth.
Litter	Organic layers developed primarily from leaves, twigs, and wood materials with minor components of mosses.
Map unit	A combination of kinds of soil, terrain, or other features that can be shown at a specified scale of mapping for the defined purpose and objectives of a particular survey.
Measurement indicator	Measurement indicators represent properties or attributes of the environment and VCs that, when changed, could result in, or contribute to, an effect on assessment endpoints. Measurement indicators may be quantitative (e.g., concentrations of metals in surface water) or qualitative (e.g., movement and behaviour of wildlife from disturbance to habitat and travel corridors).
Mesisolic soil	Mesisolic soils are at a stage of decomposition intermediate between Fibrisols and Humisols; dominantly composed of mesic organic materials.
Metasediment	Sedimentary rocks that have been modified by metamorphic processes.
Mineral soil	Soils containing relatively low concentrations of organic matter. Soils that have evolved on fluvial, glaciofluvial, lacustrine, and morainal parent material.
Moisture regime	The relative moisture supply at a site available for plant growth.
No linkage pathway	The potential pathway has no linkage or is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on soils relative to the Base Case or guideline values.
Non-sorted circles	A type of patterned ground where alternating freeze and thaw of soils develop geometric circular patterns surrounded by a circular margin of vegetation. Consists of unsorted mineral material.
Nutrients	Environmental substances (elements or compounds) such as nitrogen or phosphorus, which are necessary for the growth and development of plants and animals.
Organic matter	Plant and animal materials that are in various stages of decomposition.
Organic soil	Organic soils are composed of organic materials. They include most of the soils commonly known as peat, or bog/fen soils. Most Organic soils are saturated with water for prolonged periods. These soils occur widely in poorly and very poorly drained depressions and level areas and are derived from vegetation that grows in such sites. The organic layer is greater than 60-cm thick (if fibric) or 40-cm thick (if mesic or humic).

Term	Description
Outwash deposit	Deposits of sand and gravel by running water from the melting ice of a glacier.
Overburden	Materials of any nature, consolidated or unconsolidated, that overlie a deposit of useful materials. In the present situation, overburden refers to the soil and rock strata that overlie kimberlite deposits.
Parameter	A particular physical, chemical, or biological property that is being measured.
Parent material	Underlying bedrock or drift deposit on which soil horizons form and are made up of consolidated or unconsolidated mineral material that has undergone physical or chemical weathering.
Particulate matter	A mixture of small particles and liquid droplets, often including a number of chemicals, dust, and soil particles.
Pathway analysis	Identifies and assesses the linkages between Project components or activities, and the correspondent changes to the environment and potential residual effects after mitigation.
Peaty phase, soil	Any mineral soil having a surface horizon of 15 to 60 cm of fibric and 15 to 40 cm of mesic or humic organic material.
Peat polygon (polygonal peat plateau)	A perennially frozen bog, rising approximately 1 m above the surrounding fen. The surface is relatively flat, scored by a polygonal pattern of trenches that developed over ice wedges. The permafrost and ice wedges developed in peat originally deposited in a non-permafrost environment. Polygonal peat plateaus are commonly found near the boundary between the zones of discontinuous and continuous permafrost.
Permafrost	Permanently frozen soil or rock and incorporated ice and organic material that remain at or below 0°C for a minimum of two years due to natural climatic factors. The occurrence of permafrost increases with latitude (i.e., more northern areas permafrost is continuous, and more southern areas patches of permafrost alternate with unfrozen ground).
Ph	The degree of acidity (or alkalinity) of soil or solution. The pH scale is generally presented from 1 (most acidic) to 14 (most alkaline). A difference of one pH unit represents a ten-fold change in hydrogen ion concentration.
Polygon	A map delineation that represents a tract of land with certain landform, soil, hydrologic, and vegetation features. The smallest polygon on a 1:50,000 scale map is approximately 0.5 cm^2 and represents a tract of approximately 12.5 ha.
Primary pathway	A primary pathway is likely to result in environmental change that could contribute to residual effects relative to the Base Case or guideline values.
Rare plants	A native plant species found in restricted areas, at the edge of its range or in low numbers within a province, state, territory or country.
Reasonably foreseeable development (RFD) case	The RFD case represents the Application Case and reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities.
Reclamation	The process of reconverting disturbed land to its former or other productive uses.
Redox	Shorthand for reduction-oxidation. Describes all chemical reactions in which atoms have their oxidation number (oxidation state) changed, most commonly through the transfer of electrons.
Regosolic soil	Regosolic soils lack significant soil formation and occur on very young surfaces (e.g., sand dunes or river floodplains) or unstable surfaces (e.g., upper slope positions that experience high rates of soil erosion).
Riparian	(i) The interface between an upland area and a river or stream. (ii) The floodplain portion of a river or stream corridor.
Runoff	The process by which water flows over the ground surface because of excess water from rain, meltwater, or other sources.
Saline	Salty.
Secondary pathway	A secondary pathway could result in a measurable minor environmental change, but would have a negligible residual effect relative to the Base Case or guideline values and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect.

Term	Description
Sedge	A grass-like plant with a triangular stem often growing in wet areas. Sedge wetland habitats are typically wet sedge meadows and other sedge associations of non-tussock plant species. Sedge species such as *Carex aquatilis* and *C. bigelowii*, and cotton grass (*Eriophorum angustifolium*) are the dominant vegetation types. Plant species occupy wet, low lying sites where standing water is present throughout much of the growing season.
Sediment	Solid particles of material that have been derived from rock weathering. They are transported and deposited from water, ice, or air as layers at the Earth's surface.
Seepage	Slow water movement in subsurface. Flow of water from man-made retaining structures. A spot or zone, where water oozes from the ground, often forming the source of a small spring.
Soil	The naturally occurring, unconsolidated mineral or organic material that occurs at the Earth's surface and is capable of supporting plant growth.
Soil great group	Used in the classification of soil and is the next division of the soil order. Differentiated based on characteristics that reflect the differences in the strengths of the dominant processes or a major contribution of an additional process.
Soil horizon	A layer of mineral or organic soil material approximately parallel to the land surface that has characteristics altered by processes of soil formation. It differs from adjacent horizons in properties such as colour, structure, texture, and consistence and in chemical, biological, or mineralogical composition.
Soil macro-organisms	Invertebrates that live in the soil and are generally visible to the naked eye. Many benefit the soil by helping to break down minerals, soil particles, and nutrients. Examples include beetles, earthworms, and nematodes.
Soil micro-organisms	Any organism in soil, which requires a microscope to observe. These organisms include bacteria, fungi, algae, and protozoa. Soil micro-organisms are responsible for the breakdown of organic matter, conversion of inorganic compounds from one form to another, and the production of humus.
Soil order	Used in the classification of soil and include Brunisolic, Regosolic, Organic, Cryosolic, and Gleysolic Orders. At this level, soils are differentiated on the basis of characteristics of the soils that reflect the nature of the total soil environment and the effects of the dominant soil forming processes.
Soil structure	Refers to the accumulation of soil particles into compound particles that are classified in terms of grade (weak, moderate, strong), class or size (fine, medium, coarse), and type (platy, granular, prismatic, blocky).
Soil subgroup	The third level of classification of soils formed by subdividing each larger grouping. Subgroups are differentiated on the basis of the kind and arrangement of horizons that reflect 1) similarity to the central concept of the larger group, 2) intergrading towards soils of another order, 3) additional features within the control section. A control section is the vertical section of soil upon which classification is based.
Soil texture	A soil property used to describe the relative proportion of different grain sizes of mineral particles in a soil.
Subsoil material	The layer of soil under the topsoil on the surface of the ground, the layer of soil under the topsoil on the surface of the ground.
Talik	A large volume of unfrozen ground in the permafrost region. It originates mainly under deep lakes, rivers, and other places where the mean annual soil temperature is above zero.
Terms of Reference	The Terms of Reference identify the information required by government agencies for an Environmental Impact Assessment.
Terrain	The landscape or lay of the land. This term is considered to comprise specific aspects of the landscape, namely genetic material, material composition, landform (or surface expression), active and inactive processes that modify material and form, slope, aspect, and drainage conditions. Terrain analysis is the identification of the above land surface features, to a more or less defined depth and determining their areal extent. The identification of special features such as permafrost, erosion, and landforms indicating subsurface structures is included in such analyses.
Thermistor	A device whose electrical resistance, or ability to conduct electricity, is controlled by temperature. Used to measure temperature in soil, bedrock, or various media.

Term	Description
Till	An unstratified, unconsolidated mass of boulders, pebbles, sand, and mud deposited by the movement or melting of a glacier.
Topography	The surface features of a region, such as hills, valleys, or rivers.
Topsoil	Uppermost layer of soil, usually the top 5 to 20 cm. It has the highest concentration of organic matter and microorganisms and is where most of the biological activity occurs. Plants generally concentrate their roots in and obtain most of their nutrients from this layer.
Total dissolved solids	The total concentration of all dissolved compounds solids found in a water sample.
Total suspended solids	The amount of suspended substances in a water sample. Solids, found in wastewater or in a stream, which can be removed by filtration. The origin of suspended matter may be anthropogenic or natural.
Traditional knowledge	The knowledge, innovations, and practices of indigenous people; refers to the matured long-standing traditions and practices of certain regional, indigenous, or local communities.
Traditional land use	The practices and traditions of land use and resource harvesting by regional, indigenous, and local communities.
Treeline	An area of transition between the tundra and boreal forest to the south.
Tundra	An area between the polar ice cap and taiga that is characterized by a lack of trees and permanently frozen subsoil.
Turbidity	The degree of clarity in the water column typically reflected as the amount of suspended particulate matter in a waterbody.
Upland	Areas that have typical ground slopes of 1% to 3%, have better drainage, and are not wetlands.
Valued Component (VCs)	Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important by society.
Veneer	Unconsolidated soil material too thin to cover the minor irregularities of the underlying material. Ranges from 10 to 100 cm in thickness.
Vegetation	A term to describe all of the plants or plant life of an area.
Waste rock	Rock moved and discarded in order to access resources.
Waterbody	An area of water such as a river, stream, lake or sea.
Watercourse	Riverine systems such as creeks, brooks, streams and rivers.
Wetlands	Areas with ground slopes of less than 0.5% or depressions and typically poorly drained.
Wildlife	A term to describe all undomesticated animals living in the wild.
Winter road	Roads that are built over frozen lakes and tundra. Compacted snow and/or ice is used for embankment construction.