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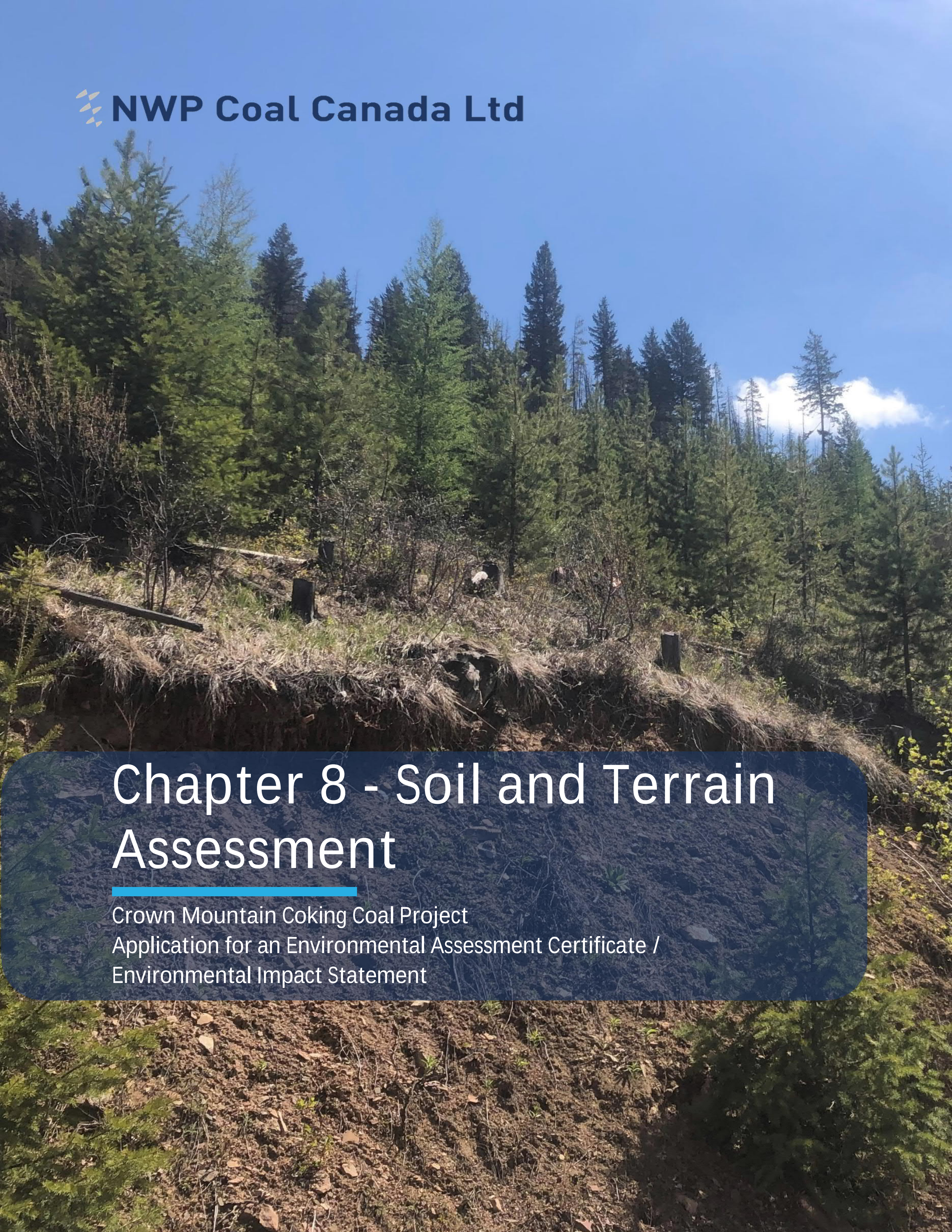

Chapter 8 - Soil and Terrain Assessment

Crown Mountain Coking Coal Project
Application for an Environmental Assessment Certificate /
Environmental Impact Statement

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8. Soil and Terrain Assessment

8.1 Introduction

Existing landforms and the character and distribution of surficial materials result from the interaction of three factors: bedrock geology, glacial history, and climate. Bedrock geology constitutes the foundation of materials and topography in a region. Glaciation and post-glacial activity have affected the morphology of landforms and the horizontal sequence of deposits. Climate has controlled (and continues to control) weathering, erosion, and deposition of mineral materials and the rates at which these processes occur over time.

This chapter discusses the characteristics of soils, landforms, and bedrock in the area of the Project. Soil quantity affects ecological function and quality of vegetation and ecosystems, wildlife habitat, groundwater resources, and associated human and wildlife needs. Soil quality is necessary to maintain the ecological function of ecosystems, has direct influence on wildlife habitat availability, and has the potential to affect the health of Indigenous communities and the public. Terrain refers to the elevation, slope, and orientation (aspect) of landforms. Terrain affects water flow and distribution, sedimentation and erosion, biological diversity, and ecosystem distribution and function. It is important to understand the potential effects of the Project on terrain stability in order to manage the risks associated with geohazards and mitigate the effects through good Project design.

Project activities have the potential to result in changes in terrain stability, soil loss, and changes in soil quality, which can result in the reduction or cessation of local ecosystem functions. Given the complex relationship between soil and terrain and the natural environment, soil quantity, soil quality, and terrain were identified as intermediate valued components (VCs) for the Project in the Application Information Requirements (AIR; Environmental Assessment Office [EAO], 2018) and as components of the physical environment in the Guidelines for the Preparation of an Environmental Impact Statement for the Crown Mountain Coking Coal Project (EIS Guidelines; Canadian Environmental Assessment Agency, 2015). An understanding of soil and terrain characteristics within the Project area is critical to the Project design, engineering, and assessment of potential environmental effects.

Soil quantity and quality and terrain effects have linkages with intermediate and receptor VCs; these effects are primarily assessed in the following chapters:

- Chapter 9: Groundwater Assessment;
- Chapter 11: Surface Water Quality Assessment;
- Chapter 12: Fish and Fish Habitat Assessment;
- Chapter 13: Landscapes and Ecosystems Assessment;
- Chapter 14: Vegetation Assessment;
- Chapter 15: Wildlife and Wildlife Habitat Assessment; and
- Chapter 22: Human and Ecological Health Assessment.

Note that this assessment focuses only on planned activities within the designed scope of the Project related to soil quality, soil quantity, and terrain. Potential effects related to unplanned events such as landslides, slope failures, snow avalanches, and earthquakes are discussed in Chapter 20, and accidents and malfunctions are presented in Chapter 21.

8.1.1 Regulatory and Policy Setting

The British Columbia (B.C.) Ministry of Environment and Climate Change Strategy (ENV) and the Canadian Council for the Ministry of Environment (CCME) have developed threshold limits for comparison to soil quality analytical data. A soil chemistry baseline assessment was conducted by Keefer Ecological Services Ltd. (KES; KES, 2019), which considers the provincial B.C. Contaminated Sites Regulation (CSR, B.C. Reg. 375/96, 2019) and federal Canadian Soil Quality Guidelines (CSQG; CCME, 2010) for comparison. These guidelines and standards provide a comparative basis for identifying soil quality parameters that may have elevated baseline concentrations. Additional applicable provincial and federal legislation and guidance documents related to the management of soil and terrain are summarized in Table 8.1-1.

Table 8.1-1: Regulatory Considerations and Guidance Documents Relevant to Soil and Terrain

Legislation/Guideline Name	Year	Description
Federal Legislation		
Canadian Environmental Protection Act	1999	Provides pollution prevention measures for the protection of human and environmental health, while promoting sustainable development and use of resources in Canada.
Fisheries Act	1985, amended 2019	Provides a legal framework to protect fish habitat. Section 35 establishes requirements for authorization for harmful alteration, disruption, or destruction (HADD) of fish habitat and related offsetting. Section 36 prohibits the release of deleterious substances, including sediments and suspended solids.
Provincial Legislation		
Environmental Management Act	2003	Regulates waste discharge, hazardous waste, pollution, and contaminated sites remediation.

Legislation/Guideline Name	Year	Description
Contaminated Sites Regulation	1996	The Contaminated Sites Regulation (B.C. Reg. 375/96) Schedule 3.1 under the Environmental Management Act (2003) lists soil quality standards for human health and environmental protection. These criteria are used to define if a specific site is contaminated, to determine liability for site remediation, and to assess the effectiveness of remediation and reclamation efforts.
Forest and Range Practices Act (FRPA)	2002	Governs all forestry activities in B.C., including logging, road building, reforestation, and riparian area management. This act applies constraints to when, where, and how forest clearing is undertaken, and regulates construction activities and the use of forest service roads.
Forest Service Road Use Regulation	2004	The FRPA requires that road construction adheres to codes provided in the Forest Service Road Use Regulation (B.C. Reg. 70/2004), which focuses extensively on erosion prevention.
Mines Act	1996	Regulates the stability of stream, river, wetland, and seepage area crossings (Section 9) and requires that the stability of man-made structures (e.g., impoundments, dumps, slopes) are planned in advance, inspected, monitored, and maintained throughout the operations and at the time of project closure (Section 10). It also requires that all surficial soil materials removed for mining purposes be salvaged for use in reclamation (Sections 6, 9, and 10).
Guidelines and Guidance Documents		
Soil Quality Guidelines for the Protection of Environmental and Human Health	2007	The Canadian Council of Ministers of the Environment (CCME) Soil Quality Guidelines for the Protection of Environmental and Human Health (CCME, 2007) provide guidelines for contaminants in soil. These Canada-wide guidelines suggest maximum limits for substances such as pesticides, metals, and hydrocarbons in soil, and apply to residential, agricultural, industrial, and other land uses.
Elk Valley Official Community Plan	2014	Provides local policies and best management practices for the protection of sensitive features on the landscape.
Health, Safety and Reclamation Code for Mines in British Columbia	2021	Provides a foundation for the protection of terrestrial landscapes and ecosystems through requirements that minimize environmental risks associated with mining activities, in addition to providing reclamation requirements for disturbed areas.
Forest Road Engineering Guidebook	2002	Provides guidance for the development of resource roads (British Columbia Ministry of Forests [MOF], 2002).
Field Manual for Describing Terrestrial Ecosystem (2nd Edition)	2010	B.C. Ministry of Forests and Range (MOFR) and B.C Ministry of Environment (B.C. MOE) prepared a guidance manual for the completion of field surveys and field data collection using standardized Ecosystem Field Forms in B.C. Field data include site information, soil, vegetation, mensuration, wildlife habitat assessment, tree attributes for wildlife, and coarse woody debris data.

8.2 Scope of the Assessment

The scope of the assessment includes a review of the Project description and activities associated with the Project, identification of valued components and measurement indicators, discussion of the existing conditions based on baseline studies, identification of key project interactions, and an assessment of the Project effects based on the potential management actions, mitigation and follow-up strategies.

8.2.1 Valued Components and Measurement Indicators

The quantity and quality of soils are important components of terrestrial ecosystems as this is the upper layer of the earth's surface in which plants actively grow. Soil quality can serve as an indicator of the characteristics of soils within an area (e.g., soil microbes as biological indicators within soils). Soil quantity refers to the amount, depth, and distribution of soil and is related to the closure phase of the Project when areas are reclaimed (e.g., using stockpiled soils to reclaim disturbed areas). Soil quality will be considered in the assessment of ecosystems, vegetation, wildlife, and human health. Localized changes in terrain are expected to occur as a result of Project activities such as pit development and extraction. Changes in terrain can potentially impact ecosystem distribution and functioning, wildlife movement, and overall habitat connectivity.

Measurement indicators for soil quantity and quality and terrain are summarized in Table 8.2-1.

Table 8.2-1: Measurement Indicators and Effects Pathways for Soil Quantity and Quality and Terrain

Valued Component	Measurement Indicators	Effects Pathways
Soil Quantity and Quality	• Metal and non-metal concentrations in soil; • Soil type and general soil properties; and • Depth and distribution of soil types.	VCs or VC groups for which soil quantity and quality are effects pathway include: • Groundwater Quality; • Surface Water Quality; • Landscapes and Ecosystems; • Vegetation; • Human Health; and • Wildlife Health.
Terrain	• Terrain type; and • Slope and aspect.	VCs or VC groups for which terrain is an effects pathway include: • Landscapes and Ecosystems; • Vegetation; and • Wildlife and Wildlife Habitat.

8.2.2 Indigenous and Stakeholder Consultation

NWP engaged with Indigenous groups and conducted consultation with Indigenous communities, the public, stakeholders, and regulators. A summary of the consultation and engagement activities undertaken to date is presented in Chapter 4. No specific consultation feedback on soil quantity and quality or terrain was received in the Pre-Application phase.

8.2.3 Assessment Boundaries

8.2.3.1 Spatial Boundaries

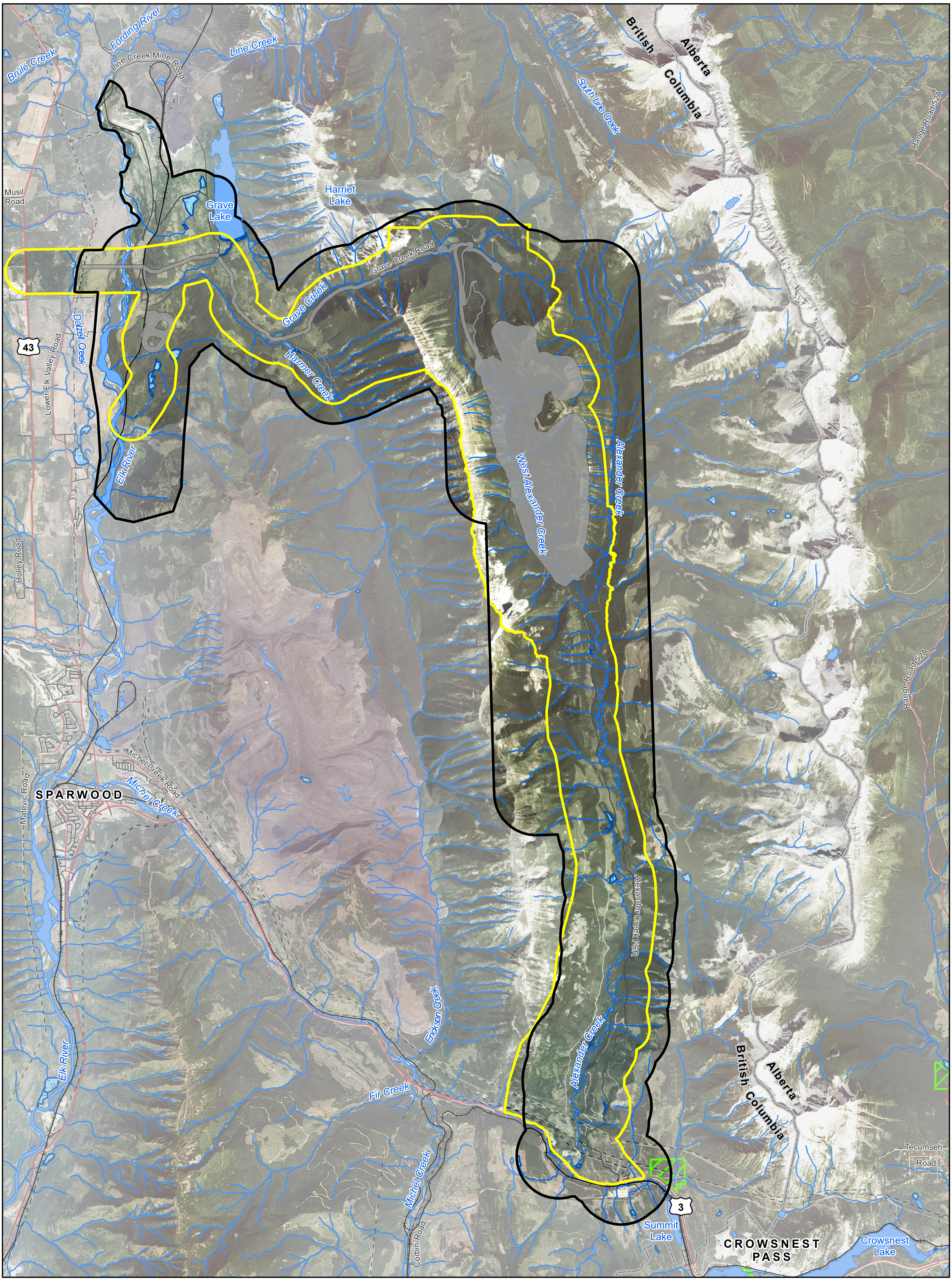
Three spatial boundaries were considered in the soil quantity and quality and terrain assessments: the Project footprint, the Soil Quality and Quantity Local Study Area (LSA) (which incidentally is equivalent to the Landscapes and Ecosystems LSA), and the Terrain LSA. The Soil Quality and Quantity Local Study Area is spatially equivalent to the Regional Study Area (RSA) for the soil quantity and quality and terrain assessments. As detailed in Chapter 5, Table 5.3-2, the spatial boundaries for the soil and terrain VCs have changed from the study areas presented in the AIR. A discussion on the spatial boundaries used in the assessment is provided below.

The Project footprint is the area of physical disturbance associated with the Project and encompasses all anticipated Project components, both temporary and permanent, covering approximately 13 square kilometres (km^2) or 1,283 hectares (ha; Figure 8.2-1). The centre of the Project is positioned approximately 12 km northeast of the District of Sparwood and approximately 5 km west of the provincial boundary between B.C. and Alberta. The Project footprint consists of the proposed surface extraction areas (three pits - North Pit, East Pit, and South Pit); Mine Rock Storage Facility; mine infrastructure and support facilities, including the plant area (raw coal stockpile area and processing plant); clean coal transportation route; rail loadout facility and rail siding; and ancillary facilities (i.e., water supply, power supply, natural gas supply, water, sewage treatment, fuel storage, and explosives storage). The Project footprint is located within portions of two watersheds, Grave Creek and Alexander Creek. The majority of the Project footprint is located within the Alexander Creek watershed, while the access roads leading to the mine are generally located within the Grave Creek watershed.

The Soil Quality and Quantity LSA corresponds to the area assessed during several of the Project baseline studies (e.g., Terrestrial Ecosystem Mapping [TEM], Listed Plants and Ecological Communities, limber pine, whitebark pine, soil quantity and quality). The boundary of the Soil Quality and Quantity LSA corresponds to a 1 km buffer around the Project footprint and coal licenses, covering an area of approximately 12,866 ha. The Soil Quality and Quantity LSA can be thought of as the “zone of influence” of the Project on soil quantity and quality.

The Terrain LSA consists of a minimum 500 metre (m) buffer around the Project footprint, extended to the height of land along Erickson Ridge above the access road and transmission line in the Harmer Creek valley, and above the Mine Rock Storage Facility and the conveyor in the upper Grave Creek and West Alexander Creek drainages (Figure 8.2-1; Figure 8.2-2). The larger mapped area encompasses steep slopes above proposed infrastructure. Mapping to the height of land ensured that geohazards originating on the upper slopes, with potential to impact infrastructure, were considered. A minimum 1 km wide corridor along the Alexander Creek Forest Service Road (FSR) to the south was also included in the Terrain LSA. The Terrain LSA covers an area of approximately 7,900 ha.

The Soil Quality and Quantity RSA and the Terrain RSA is spatially equivalent to the Soil Quantity and Quality LSA. These RSAs provide the spatial boundaries for the cumulative effects assessment.



Crown Mountain Coking Coal Project

Figure 8.2-1
Soil Quality and Quantity Local Study Area and Terrain Local Study Area

LEGEND

- Soil Quality and Quantity Local Study Area
- Terrain Local Study Area
- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- British Columbia/Alberta Border

0 2 4
Kilometres
Scale 1:85,000

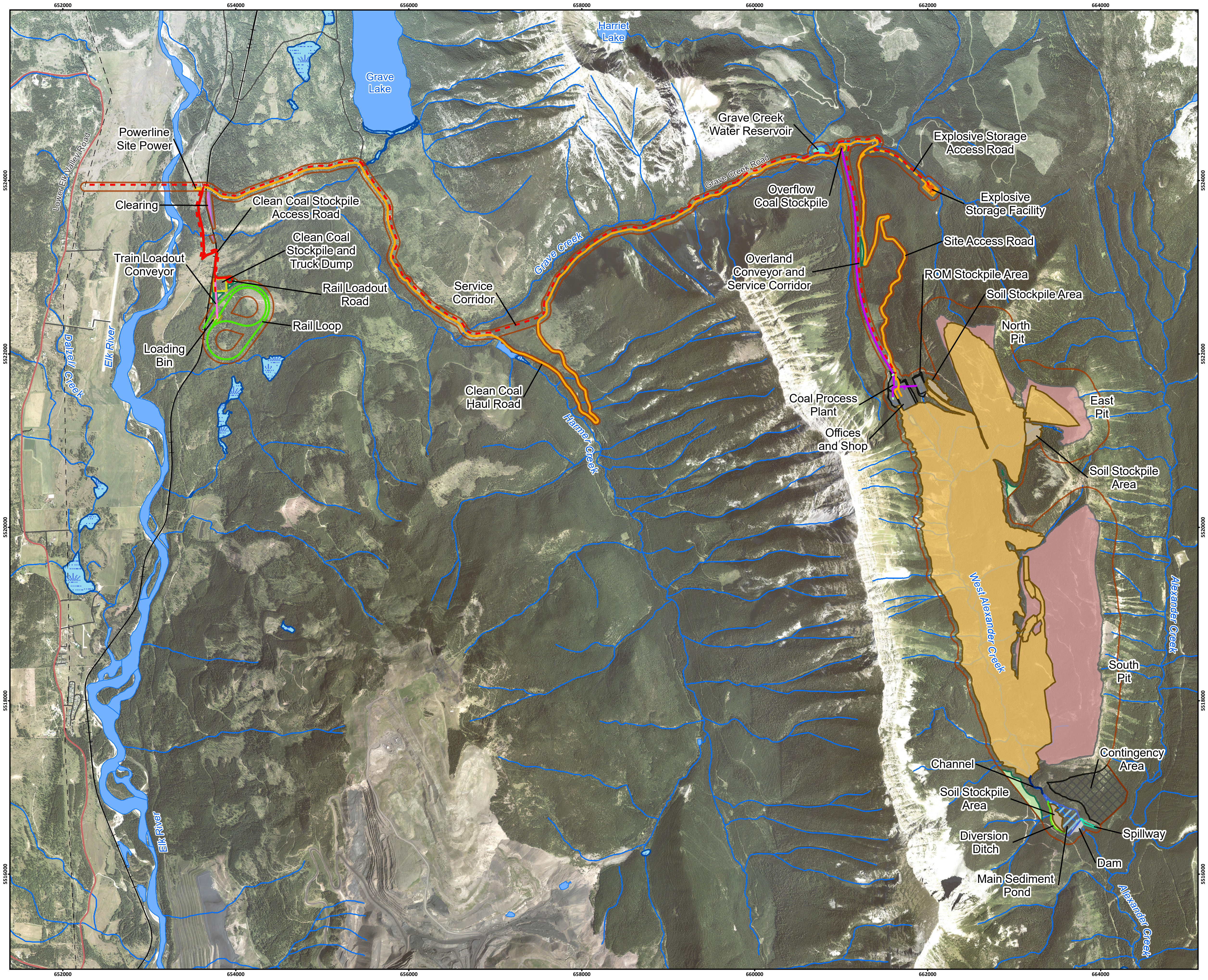
N W E S

Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Keefer Ecological Services Ltd, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada.
Imagery Provided By Landsat 8 (Aug 2018), and GeoBC Ortho Imagery (Aug 2016).

Map Created By: RB
Map Checked By: SK
Map Coordinate System: NAD 1983 UTM Zone 11N

NWP Coal Canada Ltd

Project: 12-6231
Status: FINAL
Date: 2022-01-19



Crown Mountain Coking Coal Project

Figure 8.2-2
Project Footprint Infrastructure

LEGEND

- Project Footprint
- Channel to Ultimate Pond
- Clean Coal Haul Road\Site Access
- Explosive Storage Access\Facility Road
- Rail Loadout Road
- Rail Loop
- Service Corridor
- Coal Process Plant Conveyor
- Coal Process Plant Duct
- Train Loadout Conveyor
- Waste Dump
- Mined Area
- Clean Coal Stockpile and Truck Dump
- Overflow Coal Stockpile
- Soil Stockpile Area
- Explosive Storage Facility\Pad
- Loading Bin
- Plant Site\ROM Stockpile Area
- Powerline-Site Power
- Water Reservoir
- Main Sediment Pond
- Dam
- Spillway
- Diversion Ditch
- Clearing
- Additional Area
- Contingency Area
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- British Columbia/Alberta Border

0 1 2
Kilometres

N E S W

Scale 1:42,000

Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada.
Imagery Provided By GeoBC OrthoImagery (Aug 2016).

Map Created By: RB
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Map Coordinate System: NAD 1983 UTM Zone 11N

NWP Coal Canada Ltd

Project: 12-6231
Status: FINAL
Date: 2022-01-19

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8.2.3.2 Temporal Boundaries

Temporal boundaries include the time periods during which the Project is anticipated to result in potential effects on VCs (British Columbia Environmental Assessment Office [EAO], 2013). The temporal boundaries considered in the assessment include the temporal limits of the Project in terms of its Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases. The temporal boundaries of the Project used in the effects assessment include the timing of Project phases and activities as outlined in Table 8.2-2. Additional details on the Project phases and activities are provided in Chapter 3.

Table 8.2-2: Temporal Boundaries for the Soil Quantity and Quality and Terrain Effects Assessment

Phase	Project Year	Length of Phase (Years)
Construction and Pre-Production	1 – 2	2
Operations	3 - 17	15
Reclamation and Closure	18 – 19	2
Post-Closure	20 – 34	15

Onset of Project effects is expected during the Construction and Pre-Production phase and gradually increase to their maximum towards the end of the Operations phase. Changes to soil quantity and terrain are anticipated to result based on the Reclamation and Closure and Post-Closure designs; however, risk will be managed and adverse effects will be mitigated through good Project and Reclamation designs.

8.2.3.3 Administrative Boundaries

Administrative boundaries refer to the limitations imposed on the assessment by political, economic, or social constraints and consider the jurisdiction in which the Project is located. In addition to the applicable regulatory and policy framework as outlined in Table 8.1-1, the Soil Quality and Quantity LSA and Terrain LSA occur within the resource management area boundaries of Fisheries and Oceans Canada (DFO's) Pacific Region, the B.C. Ministry of Forests, Lands, Natural Resources Operations and Rural Development (FLNRORD) Rocky Mountain District in Kootenay-Boundary Region, Ministry of Environment and Climate Change Strategy Kootenay Region 4, and Ministry of Energy, Mines and Low Carbon Innovation Southeast Region.

8.2.3.4 Technical Boundaries

Technical boundaries represent constraints imposed on the assessment due to limitations in the ability to predict the effects of the Project (EAO, 2013). The assessment of soil and terrain was based on data collected through review of existing literature and mapping, field surveys, soil sampling and analyses, and interpretation of available air photography and remote sensing data (i.e., LiDAR).

The accuracy of the terrain stability mapping conducted for the Project was limited by air photo quality, photo scale, and the presence of shadows in forested and high relief terrain, although the level of detail and interpretation was greater where LiDAR was available (BGC Engineering Inc. [BGC], 2019). The following factors were not taken into account by the terrain baseline studies: subsurface conditions (e.g., groundwater conditions) not detectable by air photo interpretation or surface observations, events whose time of occurrence and severity cannot be predicted with available data (e.g., storm events), management practices, and land use (BGC, 2019). The effects of the Project on the terrain VC are, therefore, limited by the data available for the terrain stability and geohazards mapping completed to-date and this is reflected in the confidence in the effects assessment for this VC. Note that this assessment focuses only on planned activities within the designed scope of the Project related to soil quality, soil quantity, and terrain. Potential effects related to unplanned events such as landslides, slope failures, snow avalanches and earthquakes are discussed in Chapter 20, and accidents and malfunctions are presented in Chapter 21. More detailed geohazard and risk assessment studies will be required at later Project stages.

8.3 Regional and Local Overview

Current land uses within the Soil Quality and Quantity LSA and Terrain LSA include: residential; recreational (e.g., hunting, all-terrain vehicle [ATV] trails, fishing, hiking, etc.); exploration; resource; industrial; transportation; rangeland; agriculture; and forestry. Forestry, agriculture, and mining in the East Kootenay have been ongoing for well over a century, with coal being the dominant resource extracted in the area. Fire suppression is practiced in the Elk Valley and there have not been any large fires in the last several years (Tourism Fernie, 2020; B.C. Wildlife Service, 2020). Controlled burning projects have been carried out to improve wildlife habitat and increase available forage in the Elk Valley, funded through the Fish and Wildlife Compensation Program (e.g., FLNRORD, 2020). Additional information on past and present land uses is provided in Chapter 1, Section 1.3.2.

Historical and current mining, forestry, and agricultural activities in the Elk Valley have resulted in removal and contamination of soils and intensive modification of existing terrain. Other sources of soil and terrain impacts in the Elk Valley include development of local municipalities, off-road vehicle use, natural and anthropogenic air emissions, natural processes, and climate change.

8.3.1 Topography

The Project is located in the Elk Valley within the front ranges of the southern Rocky Mountains in southeastern B.C. The Elk Valley stretches more than 180 km from the mouth of the Elk River at Lake Koocanusa in the south, and north to its headwaters in Elk Lakes Provincial Park near the Continental Divide along the B.C.-Alberta border (Elk Valley Cumulative Effects Management Framework Working Group, 2018; George et al., 1987). The Elk Valley forms part of the Continental Ranges of the Rocky Mountains. Elevations in the Soil Quality and Quantity LSA range from 1,170 m above mean sea level (m amsl) along the Elk River west of Grave Lake up to above 2,700 m amsl along the Continental Divide at the northeast corner of the Soil Quality and Quantity LSA. Erickson Ridge (2,480 m amsl) is a major north-south limestone ridgeline from the Kootenay Group within the Soil Quality and Quantity LSA that separates the Project from Teck’s Elkview Operations to the southwest. Immediately north of Erickson Ridge, across the east-west flowing Grave Creek is Sheep Mountain (2,460 m amsl), of the same geologic origin. Sheep Mountain parallels Grave Lake as its western shore and is connected via a north-south ridgeline to Mount Salter (2,530 m amsl) immediately south of the east-west Line Creek valley.

8.3.2 Climate and Hydrology

A review of available meteorological data (i.e., climate normals for temperature and precipitation from 1981-2010) available from Environment and Climate Change Canada (ECCC) was conducted for three climate stations in the regional area to compare data from the Crown Mountain climate station with past meteorological averages; however, given that the Crown Mountain climate station was situated at a higher elevation on mountainous terrain, recorded climate data may not be directly comparable to long-term local and regional trends near the Project site and the local and/or regional weather stations. Thus, it is important to consider both proximity and elevation of ECCC climate stations relative to the Crown Mountain station. Existing local and regional meteorological data were compiled from three ECCC climate stations: Sparwood (ID: 1157630; 1,138 m amsl), Fernie (ID: 1152850; 1,001 m amsl), and Fording River Cominco (ID: 1152899; 1,585 m amsl (Table 8.3-1), supplemented by an on-site climate station. Details on the locations and instruments installed at each of these climate stations are provided in the Meteorology Baseline Report (Chapter 6, Appendix 6-B).

The annual total and mean monthly precipitation data from the three ECCC climate stations are provided in Table 8.3-1.

Table 8.3-1: Regional Mean Monthly and Annual Precipitation (mm)

Summary Statistic	1981-2010 Climate Normals								
	SPARWOOD Station 1157630 (1,138 m amsl)			FERNIE Station 1152850 (1,001 m amsl)			FORDING RIVER COMINCO Station 1152899 (1,585 m amsl)		
	Rain	Snow	Total	Rain	Snow	Total	Rain	Snow	Total
Annual Total	411.2	264.0	613.5	902.2	325.0	1,226.9	339.8	277.3	617.1
Monthly Minimum	12.4	0.0	34.9	39.0	0.0	51.9	3.1	0.1	33.9
Monthly Average	34.3	22.0	51.1	75.2	27.1	102.2	28.3	23.1	51.4
Monthly Maximum	67.7	54.2	72.1	123.0	83.5	179.1	82.1	44.7	85.7

The mean monthly precipitation data indicate that higher amounts of precipitation occur in the late fall and early winter months (predominately as snowfall) and lower amounts of precipitation in summer and early fall months (predominately as rainfall). A notable difference exists in the amount, type, and distribution of precipitation between the Fernie climate station, which is located further south and lower in elevation, compared to the Sparwood and Fording River Cominco climate stations that are further north and at higher elevations. Similarly, mean annual rainfall, snowfall, and total precipitation appeared to be influenced by elevation and latitude, with the highest amounts recorded at the Fernie climate station, the most southerly station at the lowest elevation. Mean annual snowfall and total precipitation were the lowest at the Sparwood climate station.

Precipitation data were collected at the Crown Mountain climate station between January 2014 and May 2016; however, due to a malfunction of the precipitation gauge caused by high winds, some of the data were deemed to be inaccurate. As such, precipitation conditions for the Project footprint were characterized using a regression analysis of data collected at nearby climate stations. The Sparwood (11557630) and Natal Harmer Ridge (1155402) climate stations were selected for the analysis given their proximity to the Crown Mountain climate station, elevation, and available period of record. For the purpose of the analysis, only the data for the common period of record (1980 to 1990) for the two stations were utilized for the regression analysis of the climate station data.

The results of the regression analysis indicate that the mean summer precipitation at the Crown Mountain climate station (1,920 m amsl) is 14.9 millimetres (mm) higher than at the Sparwood climate station (1,138 m amsl), and the mean winter precipitation is 23.9 mm lower than at the Sparwood climate station. The seasonal relationships for mean summer and winter precipitation were applied to derive the monthly precipitation for the Project footprint. The monthly mean precipitation varied throughout the assessment period, with the lowest values generally corresponding to the summer months (a lowest mean of 35.4 mm in August) and higher precipitation in the early winter months (a highest mean of 89.6 mm in November). The maximum monthly precipitation was 268.6 mm in December and the minimum monthly precipitation was 2.9 mm in February. The total annual precipitation from January 2014 to May 2016 was approximately 760 mm in 2014 and 700 mm in 2015 (Appendix 6-B).

Long-term meteorological data available from ECCC (2019) for the Sparwood, Fernie, and Fording River Cominco stations were collected to describe temperature normals for the region and compare data from the Crown Mountain climate station with past meteorological averages. Similar to precipitation, recorded climate data may not be directly comparable to long-term local and regional trends near the Project site and the local and/or regional weather stations, given that the Crown Mountain climate station was situated at a higher elevation on mountainous terrain.

Air temperatures in the region are variable and influenced by various factors including elevation, latitude, and local topography. Air temperatures were lowest at Fording River Cominco (1,585 m amsl) and highest at Fernie (1,001 m amsl), respectively. The Crown Mountain climate station air temperature data is most closely aligned with the corresponding data for Fording River Cominco, which is the station that is nearest in elevation. Mean monthly air temperature ranges at each regional station between 1981 and 2010 included the following:

- At Sparwood, mean monthly air temperatures ranged from -7.3°C in December to 15.8°C in July, with an annual average of 4.4°C;
- At Fernie, mean monthly air temperatures ranged from -6.1°C in December to 16.8°C in July, with an annual average of 5.3°C; and
- At Fording River Cominco, mean monthly air temperatures ranged from -11.3°C in December to 12.6°C in July, with an annual average of 0.9°C.

Air temperature data were collected at the Crown Mountain climate station between January 2014 and May 2016. During this monitoring period, the mean monthly air temperatures ranged from -8.1°C in December to 14.9°C in July, with an annual average of 1.2°C. The extreme minimum temperature at the Crown Mountain climate station was -32.3°C on March 1, 2014 and the extreme maximum temperature was 35.2°C on June 7, 2015 (Appendix 6-B).

Of the three climate stations in the region from which long-term meteorological data were reviewed (ECCC 2019), only the Sparwood station collected data for wind speed and direction in the 1981 to 2010 climate normal data. During this period, the maximum recorded hourly wind speed was 83 km/h on February 23, 1994. The most frequent wind direction was traveling westerly (i.e., from the east).

Wind speeds between 2 and 6 km/h were most frequently recorded during the monitoring period from January 2014 to May 2016. Wind speeds below 3.6 km/h or 1 m/s (i.e., calm winds) occurred 33.6% of the time, and wind speeds over 21.6 km/h or 6 m/s (i.e., strong winds) occurred 1.4% of the time. The maximum instantaneous wind speed was 58.4 km/h on February 6, 2016. The most frequent wind direction was traveling west-northwesterly (i.e., from the south-east), at approximately 22.9% of the recorded entries (Appendix 6-B).

Key watercourses in the Soil Quality and Quantity LSA and the Terrain LSA include the Elk River, Michel Creek, Alexander Creek, West Alexander Creek, Harmer Creek, and Grave Creek. Waterbodies in the immediate vicinity include Grave Lake, Harriet Lake, Mite Lake, and Barren Lake. The Alexander Creek watershed is the largest drainage basin within the LSAs and covers a watershed area of approximately 18,490 ha, which is oriented in a north to south direction. Alexander Creek flows in a southerly direction from its headwaters to its confluence with Michel Creek, approximately 10.7 km southeast of Sparwood. Michel Creek flows north-westerly along Highway 3 and ultimately discharges to the Elk River near Sparwood. The total length of Alexander Creek is approximately 25 km. Alexander Creek has numerous tributaries that generally consist of high-gradient mountain streams, with the most significant tributary being West Alexander Creek. Additional information on watersheds and watercourses is provided in Chapter 10.

Additional meteorological and climate results, including pressure, precipitation, relative humidity, wind speed, and wind direction, are provided in Chapter 6 and Appendix 6-B. Potential effects related to extreme weather events, including extreme precipitation events, extreme temperatures, extreme wind events, extreme hydrological events, and climate change are discussed in Chapter 20.

8.4 Existing Conditions

This section describes the existing soil quantity and quality and terrain conditions based on the findings of field and baseline studies conducted for the Project footprint, Soil Quality and Quantity LSA, and the Terrain LSA. The existing conditions are described in sufficient detail to enable the potential effects of the Project on these VCs to be identified, understood, and assessed.

8.4.1 Existing Regional and Local Information

Existing soil and terrain mapping products were reviewed to provide regional context and an overview of surficial and bedrock geology. The Terrestrial Ecosystem Information (TEI) Data Warehouse, Ecocat, and the British Columbia Surficial Geology Map Index (Arnold and Ferbey, 2020) were queried to find any soils, terrain, and geology mapping that existed for the Soil Quality and Quantity LSA and the Terrain LSA. Products that covered all or most of the Soil Quality and Quantity LSA and the Terrain LSA at a useful map scale included:

- Biophysical Resources of the East Kootenay Area: Soils (Lacelle, 1990);
- Soil Landscapes of British Columbia (British Columbia Ministry of Environment [B.C. MOE], 1986);
- Provincial biogeoclimatic ecosystem classification (BEC) mapping products (FLNRORD, 2016);
- Terrain Resource Information Management (TRIM) contour lines and water features, active roads from Digital Road Atlas (FLNRORD, 2017);
- An American badger survey in the Landscapes and Ecosystems LSA (Klafki, 2015);
- Soil and terrain mapping (Lacelle, 1988), 1:100,000 scale;
- Terrain of the East Kootenay Area (Ryder, 1981), 1:50,000 scale;
- Bedrock geology mapping (Massey et al., 2005), 1:50,000 to 1:100,000 scale; and
- Price et al., 1992 (covers the north half of the Soil Quantity and Quality LSA only), 1:50,000 scale.

8.4.1.1 Physiographic and Geological Setting

The Project straddles the Fernie Basin and Front Ranges, which are subdivisions of the Rocky Mountains Physiographic Region (Holland, 1976). The Front Ranges are roughly north-south trending, rugged mountains that are structurally controlled (Ryder, 1981). Both areas are underlain by Mesozoic to Paleozoic-aged limestone, sandstone, shale, and coal (Price et al., 1992; Massey et al., 2005). The Fernie Basin is centered along the Elk River Valley and consists of bedrock that is more erodible, resulting in a more subdued landscape than the Front Ranges (Ryder, 1981). Within the Soil Quality and Quantity LSA and the Terrain LSA, summit elevations are approximately 2,400 m amsl along the Erickson Range west of the proposed plant site and 2,237 m amsl at the peak of Crown Mountain. The Elk River floodplain elevations range from 1,200 m to 1,100 m amsl and makes up the lowest elevations in the Soil Quality and Quantity LSA and the Terrain LSA.

The Soil Quality and Quantity LSA and the Terrain LSA are underlain by a sequence of numerous sedimentary rock formations ranging in age from Jurassic to Lower Carboniferous. Due to folding and thrust faults and subsequent millennia of erosion, many of these layers outcrop within the Soil Quality and Quantity LSA and the Terrain LSA. In general, the Grave Prairie, Upper Grave Creek, West Alexander Creek, and Alexander Creek drainages are largely underlain by Jurassic-aged sandstone, shale, and limestone of the Fernie Formation (Massey et al., 2005; Price et al., 1992). The spine of Erickson Ridge consists of Carboniferous-aged dolomite, limestone, and chert of the Rundle Group (Etherington, Mount Head, and Livingstone Formations). Outcrops of dolomitic siltstone, sandy dolomite, orthoquartzite and limestone of the Rocky Mountain Group flank the Rundle Group rocks. In turn, shale, sandstone, and limestone of the Spray River Group are located between the Fernie Formation and the Rocky Mountain Group. Sandstone, siltstone, and coal of the Kootenay group outcrop along the Crown Mountain ridge top (Massey et al., 2005; Price et al., 1992).

8.4.1.2 Landscape Evolution

Most of the surficial materials that are of significance with regards to terrain and terrain stability originate from the most recent major glacial episode (Fraser Glaciation) and subsequent erosion by gravity and water (Ryder, 1981).

At the beginning of the Fraser Glaciation about 29,000 years before present, ice accumulated in cirques at high elevations. These gradually expanded and merged until the valleys were filled and all but the highest mountain peaks were covered. About 17,000 years ago, when the ice sheet was its thickest and most extensive in the area, the ice was about 1,000 m thick in the valleys and the ice sheet flowed generally from north to south (Ferbey et al., 2013). Ryder (1981) states that elevations lower than about 2,400 m amsl were overridden by ice at this time.

Deglaciation commenced about 15,000 years ago (Ryder, 1981). Deglaciation took place by thinning of the glacial ice due to melt so that the uplands emerged from ice first, while tongues of ice remained in the valley bottoms. Downwasting ice often forms characteristic subglacial and ice-marginal landforms on gentler surfaces, such as kames and ice-dammed lakes. Basal till was deposited beneath glaciers both during advance and retreat phases.

During the post-glacial period, natural processes have re-worked some glacial sediments and weathered bedrock to redistribute them as colluvium and fluvial sediments. Streams and rivers have graded to the present-day river level of the Elk River, downcutting into glacial deposits and bedrock creating gullies, terraces, benches, and steep-sided scarps. Glaciofluvial terraces, glaciolacustrine deposits, and till blankets are located along the lower slopes of the Soil Quality and Quantity LSA and the Terrain LSA. Alluvial fans have formed at the mouths of the major creeks. Colluvium is present on many of the steep slopes in the Soil Quality and Quantity LSA and the Terrain LSA and is usually mapped near bedrock outcrops.

8.4.1.3 Stream Network

The Project is located within the Grave Creek and Alexander Creek watershed units. Grave Creek and its tributary Harmer Creek drain the northern portion of the Soil Quality and Quantity LSA and the Terrain LSA westwards into the Elk River. The reach of the Elk River that flows through the Soil Quality and Quantity LSA and the Terrain LSA at the confluence with Grave Creek is characterized as an irregularly wandering river with frequent active gravel bars, as well as forested gravel bars. Alexander Creek and its tributary West Alexander Creek drain the rest of the Soil Quality and Quantity LSA and the Terrain LSA flowing southwards to Highway 3 and the confluence with Summit Creek. Outside of the Soil Quality and Quantity LSA and the Terrain LSA, Summit Creek flows westwards to the Elk River at Sparwood via Michel Creek.

8.4.2 Baseline Programs

8.4.2.1 Methods

Baseline data collection was conducted for the soil and terrain VCs by KES with support from BGC for terrain stability and geohazards mapping. The following subsections summarize the methodology of the data collected through the baseline programs and analysis of results, to support the effects assessment on the soil quantity and quality and terrain VCs. No important data gaps were identified during the review of existing conditions.

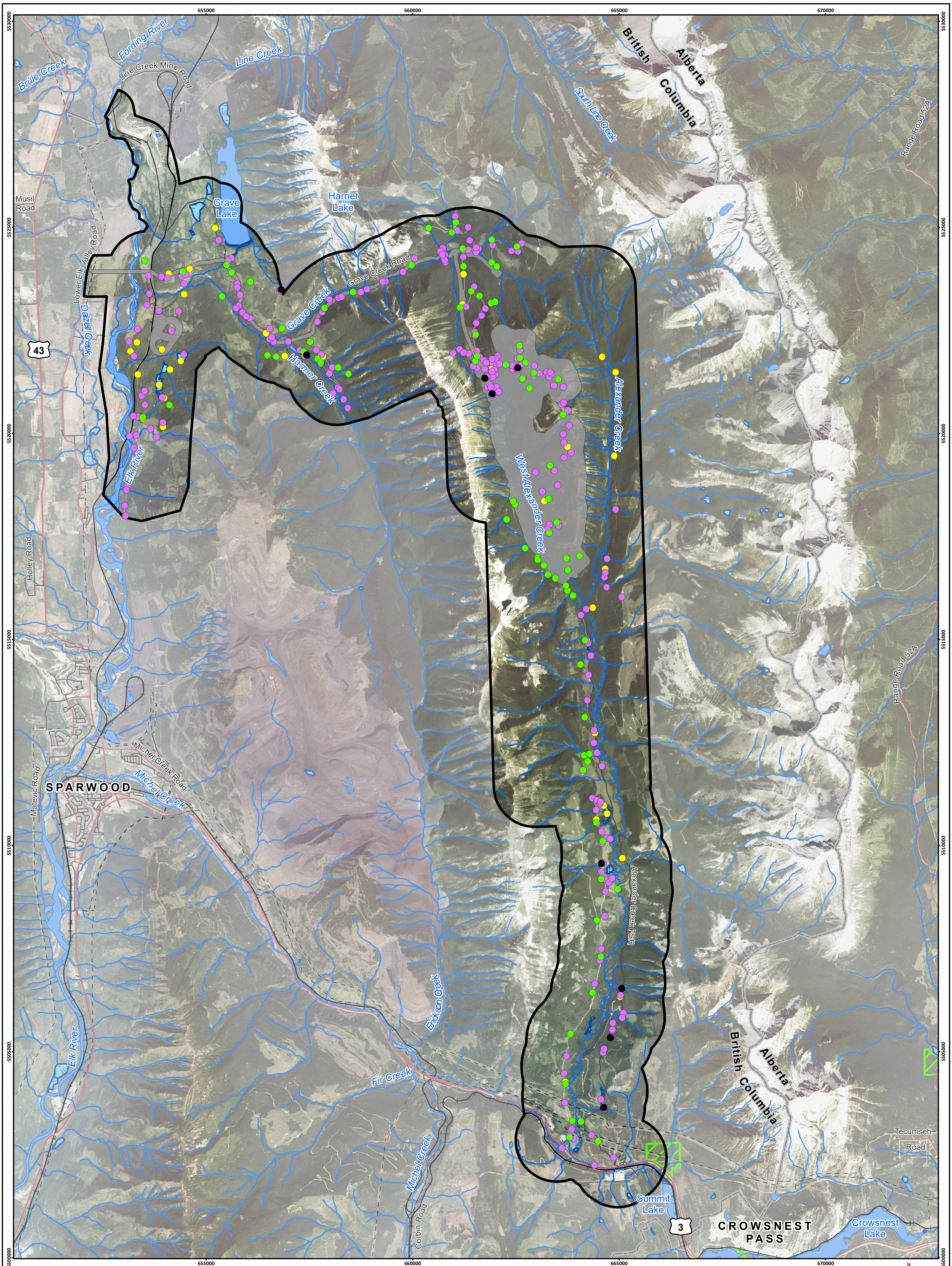
The Baseline Soils Report (KES, 2020) and Baseline Soil and Vegetation Chemistry Report (KES, 2019) for the Project can be found in Appendix 8-A and Appendix 8-B, respectively. BGC (2019) produced a Terrain Stability and Geohazards Mapping report, which can be found in Appendix 8-C. Slope mapping is provided by KES, and was processed by Dillon using ArcGIS.

8.4.2.1.1 Soil Quantity and Quality

Soil samples were collected during each stage of the soil quantity and quality and terrain baseline assessments. Soil sample locations are illustrated in Figure 8.4-1.

Soil Mapping

In 2017, a total of 101 detailed soil pits, with full horizon descriptions and classification, contributed to the creation of the interpretive soil map by KES for the Soil Quality and Quantity LSA. In addition, 108 visual plots (which include notes on basic site, terrain, and soil classification) helped to confirm Soil Map Units (SMUs) and to refine soil type polygon boundaries. In October 2017, KES completed further work including soil descriptions in nine additional locations within the proposed rail loop infrastructure area (Grave Prairie). This area has special significance to the Ktunaxa Nation and requires permission to excavate soils. Thirteen additional soil descriptions were completed in 2018 in other infrastructure sites



Crown Mountain Coking Coal Project

Figure 8.4-1
Soil Sample Locations

LEGEND

- Soil Sample Location (KES, 2020)
- Soil Baseline Chemistry (KES, 2019)
- Soil PAH Sample (KES, 2019)
- Terrain Plot (KES, 2020)
- Soil Quality and Quantity Local Study Area
- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- British Columbia/Alberta Border

0 2 4
Kilometres

Scale 1:85,000

Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Keefer Ecological Services Ltd, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada.
Imagery Provided By Landsat 8 (Aug 2018), and GeoBC Ortho Imagery (Aug 2016).

Map Created By: RB
Map Checked By: SK
Map Coordinate System: NAD 1983 UTM Zone 11N

NWP Coal Canada Ltd

Project: 12-6231
Status: FINAL
Date: 2022-01-19

not previously captured, specifically relating to the 2018 mineral exploration program and aimed to capture deeper soil information at 13 drill pads across the Crown Mountain ridge. In 2019, an additional 50 observations were made comprising 8 detailed plots and 42 visual observations. Detailed soil, environment, and vegetation data were entered into VENUS (B.C. MOE, 2004) in 2017, with additional field plots from 2018 and 2019 added in 2019.

The primary objective of the soil survey was to develop a soil inventory map at a detailed level (survey intensity level 2; Resources Inventory Committee, 1995) within the proposed infrastructure area and a reconnaissance level (survey intensity level 3) over the entire Soil Quality and Quantity LSA. In addition, the findings of the survey were used to provide physical and chemical data to verify field identification as well as for land use interpretations such as soil salvage and erosion potential.

Prior to the field investigation, probable soil plot locations were identified by analyzing data from a combination of sources including publicly-available mapping, previous surveys and mine plan information, Google Earth, and existing orthoimagery (dated 2014). The priority areas for the survey included the proposed mine infrastructure components (e.g., mine pits, plant site, conveyor line, utility corridors and mine tock storage facility), including sampling from each of the representative forest ecosystems spanning all biogeoclimatic (BGC) variants/subzones.

The TEM was used to provide an initial stratification for the soils mapping. The TEM polygons were then modified to capture relatively consistent areas of SMUs, and then attributed to proportion of SMU within each polygon. Universal Transverse Mercator (UTM) coordinates (NAD 1983, Zone 11N) of each plot location described in the field were recorded for mapping purposes and to easily relocate the sample sites in the future. In addition to the field observations carried out specifically for the soil mapping, many field observations were recorded for the terrain baseline mapping for the Project (BGC, 2019).

In total, 276 soil plots were examined, of which 138 were considered visual in nature (i.e., contain less detailed descriptions and often are not associated with an excavation). Soil inspections were focused on areas largely inside or near planned infrastructure areas and along planned transportation corridor options. The minimum target to achieve a detailed level sample intensity (SIL2) within the Project footprint was attained, with 123 plots being assessed, while the target was 97. For the remainder of the Soil Quality and Quantity LSA, a minimum target of 52 plots to attain a reconnaissance level sample intensity (SIL3) was also exceeded, as 153 plots were assessed in the remainder of the Soil Quality and Quantity LSA. This translates to one inspection for every 2 to 20 hectares for SIL2 and one inspection for every 20 to 200 hectares for SIL3. SIL2 is appropriate for creating a soil map at a scale between 1:5,000 to 1:40,000 that provides enough information for local planning of projects (Resources Inventory Committee, 1995). The final map provides reliable information on soil properties for a given soil polygon. Based on a Project footprint area of 1,238 ha, a minimum target of 77 plots was planned for to meet the requirement of one inspection for every 20 ha or less. For the Soil Quality and Quantity LSA outside the Project footprint, a minimum target of 54 additional plots was planned for to meet the Soil Inventory Methods suggestions for SIL3. This level of detail is adequate for describing simple and compound SMUs and is useful for planning, construction, and operation phases of mine development.

Terrain mapping conducted in 2017 (BGC, 2019) also provided valuable data to aid soil mapping (e.g., terrain classification, soil texture, and coarse fragment content). A total of 38 additional samples were submitted to ALS Environmental for the chemistry baseline assessment. The methods of the soil chemical baseline and terrain baseline programs are provided in the following sections.

Detailed (i.e., excavation) and visual (i.e., no excavation) site, soil, and vegetation descriptions were completed at soil pit locations using the methods outlined in the "Field Manual for Describing Terrestrial Ecosystems" (MOFR and B.C. MOE, 2010) and recorded on "Ecosystem and Soil Description Field Forms" (FS882 Form) or "Site Visit Forms" (FS 1333). Soils were classified to the subgroup level according to the Canadian System of Soil Classification (Agriculture and Agri-Food Canada, 1998).

Each detailed plot entailed excavation and examination of soil material to depth of approximately 0.75 m to 1 m, or lithic contact, whichever came first. A pit was excavated and described for soil classification and physical features in order to characterize representative soil conditions. Where practicable, soil pits were described along existing access roads (i.e., using road cuts or forested sites near the road edge) within the Soil Quality and Quantity LSA, as road cuts can provide a deeper and wider inspection of the type of parent material present than is possible using hand excavation methods. Visual descriptions of terrain and soil type were also completed where no pit was excavated or in cases where it was unsafe to visit a certain location. In such situations, soil and terrain materials were assessed from a short distance away.

The required information was collected at each site (Resources Inventory Committee [RIC], 1995) including, but not limited to the following:

- Horizon depth, colour, texture, coarse fragment volume (%) and size;
- Soil structure of each horizon;
- Main rooting zone depth;
- Depth to root restricting layer;
- Depth of seepage;
- Drainage class;
- Terrain classification;
- Canadian Soil Classification;
- Humus form classification and depth of organic horizons; and
- Depth of A horizons (Ah and Ae) to assist in fertility interpretation.

Biophysical attributes can also impact soil development and the supply of soil nutrient and moisture resources. Standard ecological (biogeoclimatic) site information (MacKillop et al., 2018) was collected at each soil plot location, including:

- Biogeoclimatic Ecosystem Classification (BEC) to the site series level;
- Moisture and nutrient regimes;
- Slope gradient (%) and aspect;
- Meso slope position;
- Structural stage;
- Surface topography; and
- Evidence of soil instability (e.g., erosion, tension cracks, buttressed trees).

Soil pH and alkalinity were measured in the field using pH test kits, as well as a visual effervescence field test for the presence of carbonates using 0.1N hydrochloric acid (HCl). Twelve soil samples were also analyzed for particle size. These samples were collected in areas that could be viewed as sensitive to soil erosion, often being adjacent to water features or in areas where unstable surficial materials were evident. Soil type changes or unusual soil features, such as roadside slumps or mineral licks, were also noted. Soil and site field data were entered into a database using the VENUS data capture application (B.C. MOE, 2004).

Following field data collection, draft SMUs were defined once a pattern of major soil types in the Soil Quality and Quantity LSA was established from examination of imagery and existing local information (Ryder, 1981; Yole and Lau, 2017). SMUs are repeatable soil types on the landscape and have soil characteristics that could have significant management implications for construction and reclamation activities. Simple (single SMU) and complex (two or three SMUs) soil map units were assigned to each polygon as appropriate. Proportions of soil components are displayed using slashes separating components (modified from Newfoundland and Labrador Geological Survey, 2014). For example, a soil polygon label of SMU 1a/SMU 2a has between 60 to 80% soil characterized by the SMU 1a type and 20 to 40% soil characterized by the SMU 2a type.

A total of 17 SMUs were described, and were finalized once a pattern of main soil types in the Soil Quality and Quantity LSA was established through field sampling and image analysis. SMU descriptions characterize the most common soil characteristics such as parent material, soil texture, drainage, soil nutrient and moisture regime, depth to water table or seepage, soil colour, percent coarse fragment volume (%), slope gradient (%), soil classification, and slope position. Soil classification common to each SMU follows the Canadian System of Soil Classification (Agriculture and Agri-Food Canada, 1998). Where field plots were not available, imagery interpretation was relied upon to determine the most appropriate SMU. Additionally, linework from the terrain mapping (BGC, 2019) was used to assist in interpreting landforms.

Soil Erosion Potential

Soil erosion potential (SEP) refers to the displacement of soil particles primarily due to the action of surface water and, to a lesser extent, wind. Conditions that influence surface runoff, such as precipitation/climate, slope steepness, slope morphology, slope length, and material type and texture, form the criteria used to assess SEP. Soil erosion can have negative consequences to soil, water, and air quality, and aquatic ecosystems. SEP is represented by a categorical value that indicates the erosional hazard associated with a soil type. These categorical values range from Low (L) to Very High (VH) and are determined by considering several factors including: topography (slope gradient), depth to restricting layer, texture (surface and subsurface soils), and coarse fragment content. In addition to those variables assessed above, SEP rating was increased for polygons subject to avalanching and adjacent to creeks or rivers. SEP was assessed for each SMU; as numerous polygons contain more than one SMU component and/or site variation within an SMU, the SEP rating often contains a range (e.g., L-M).

The method for assigning SEP followed the Provincial standard used in the forest industry (MOF, 1999). SEP classes range from Class VL (very low) to Class VH (very high), and refer to in situ, non-vegetated surficial materials that are exposed as a result of development activities (Table 8.4-1). The ratings do not apply to undisturbed, vegetated terrain, and they do not apply to future development-related deposits such as stockpiles, tailings, and mine rock.

Table 8.4-1: Management Implications of Soil Erosion Potential Class (B.C. Ministry of Forests, 1999)

Class	Rating	Implication
L	Low	Expect minor erosion of fines from bare soil.
M	Moderate	Except moderate erosion when water is channeled onto bare surfaces.
H	High	Significant erosion problems can be created when water is channeled onto or over exposed soil on these sites.
VH	Very High	Severe surface and gully erosion problems can be created when water is channeled onto or over these sites.

The criteria used for rating SEP are provided in Table 8.4-2.

Table 8.4-2: Guidelines for the Assessment of Soil Erosion Potential Classes

Surficial Material Characteristics		Dominant Gradient Range		
		0-40%	> 40%	> 30-40%
Dominant Texture (in approximate order of decreasing erodibility)	Typical Surficial Material	Gentle to Moderate Gradient Slopes; Irregular, Benched, Terraced	Moderately Steep and Steep Slopes	Dissected Slopes
Matrix supported fine sand, silt	Glaciolacustrine, till, eolian, some fluvial and glaciofluvial	H	VH	VH
Matrix supported soils, coarse sand, clay (cohesive)	Glaciofluvial, colluvium, till, fluvial, glaciofluvial, some glaciolacustrine	M	H, VH	VH
Consolidated till	Till	L	M, H	VH
Clast supported soils	Fluvial, glaciofluvial, colluvium, till	L	M	H
Resistant bedrock, talus slopes	Bedrock and talus slopes	L	L	L
Organics (peat bogs)	Organic	L	-	-

Note: The classes indicate the likelihood of soil erosion resulting from mine development activities that expose in situ surficial materials.
Source: KES (2020).

Soil Salvage Potential

Soil salvage potential (SSP) is also represented by a categorical value that indicates the potential suitability of a soil for salvage. These categorical values range from Very Low (VL) to High (H) and are determined by considering several factors including, organic matter, texture, coarse fragment content, pH, effervescence, and consistency (i.e., friability). SSP was assessed for each SMU; as numerous polygons contain more than one SMU component and/or site variation within an SMU, the SSP rating often contains a range as well. A critical factor assessed in determining soil salvage potential was slope steepness. Slope gradients >45% are impractical and unsafe to salvage soil from (Teck, 2015). So, regardless of other factors, polygons with slope gradients >45% were considered to have very low soil salvage potential. Soil salvage potential was reduced for sites that were >30% slope gradient from that determined from assessing factors. Soils were also assessed for organic carbon content, soil pH level, and free carbonates, soil texture, and coarse fragment content for the purpose of evaluating SEP and SSP. For both SEP and SSP, a value of 'N/A' was assigned to anthropogenic soils. Additional information regarding the classification of SEP and SSP is provided in the Baseline Soils Report (KES, 2020) in Appendix 8-A.

Soil Quality

Laboratory analyses performed by ALS Environmental (ALS), an accredited laboratory located in Burnaby and Saskatoon, include soil fertility parameters such as available cations (calcium (Ca), magnesium (Mg), sodium (Na)), available N, P, K and S, pH (2:1 water:soil to determine soil acidity) and total Kjeldahl nitrogen (%; TotN), as well as particle size analysis. One hundred and five soil samples were analyzed for pH. Ninety-one samples were analyzed for nutrient status (including total Kjeldahl nitrogen and other available nutrients). Twenty-six samples were analyzed for particle size (i.e., soil texture).

No soil samples were collected for laboratory analysis in the rail loadout area proposed prior to October 2019 (Grave Prairie Access Management Area) as this area falls within in a high value area (Ktunaxa Nation, personal communication, 2018) for significant archaeological features of importance to the Ktunaxa Nation. In addition, some soil samples were collected in representative soil types throughout the Soil Quality and Quantity LSA that are not expected to be disturbed during mining operations. These samples located away from planned infrastructure provide a record of undisturbed baseline conditions for long-term soil monitoring and characterization of soil materials well away from possible sources of disturbance.

Soil sampling in support of the baseline soil quality assessment at Crown Mountain was completed over two broad periods, first between August and September 2017, and in July 2019. Baseline soil samples were collected at vegetation sampling locations, for the sake of efficiency, for use in the development TEM for the site. Results of the vegetation sampling and TEM results are summarized in Chapter 13 and Chapter 14.

The baseline sampling program was developed in general accordance with the British Columbia Field Sampling Manual (British Columbia Ministry of Water, Land and Air Protection, 2013) and a Health Canada guidance document for including country foods in human health risk assessments (Health Canada, 2017). Soil analytical results were compared to the provincial B.C. CSR Schedule 3.1 Numerical Soil Standards for wildlands natural land use, and the federal CCME CSQGs for the Protection of Environmental and Human Health (CCME, 2006) for agricultural, residential/parkland, commercial, and industrial land use. Comparison to numerical standards and guidelines enable the assessment of baseline soil quality with respect to the intended land use, and the evaluation of the consequences of development associated with the Project. As the Project falls within both provincial and federal jurisdiction, both provincial and federal comparison criteria were considered in the assessment of soil quality.

Sampling locations were selected based on the distribution of plant species throughout the Project area for the soil and vegetation baseline chemical assessment. The soil and terrain baseline study program aimed to collect samples in proximity to and within the Project footprint. Other samples were collected in sensitive areas (e.g., wetlands). A total of 63 soil samples were collected during the baseline chemistry survey.

Soil samples were collected between 0 and 30 cm in depth from the soil surface, as the top 30 cm of soil typically contains the greatest rooting density. Soil was collected using a stainless-steel shovel to dig into the soil to a depth of approximately 50 cm. A plastic trowel was then used to scrape away soil exposed to the shovel to reduce the risk of contamination. An additional plastic trowel was used to collect soil for analysis. The shovel and plastic trowels were cleaned using distilled water between samples. Clean, single-use latex or nitrile gloves were worn to reduce the risk of sample contamination. One, 125 mL composite soil sample per sample location was collected. Observations of soil texture, coarse fragment content, soil drainage, and the primary vegetation community were recorded at each sampling location. Samples were stored in coolers with ice packs and immediately shipped for analysis to the ALS analytical laboratory in Burnaby, B.C. following sample collection.

Baseline chemistry samples were submitted to ALS for analysis moisture content, pH, and metal analyses. In addition, select samples were analysed for polycyclic aromatic hydrocarbons (PAHs). The benzo(a)pyrene (B[a]P) total potency equivalence (TPE) represents the sum of estimated cancer potency relative to B(a)P for potentially carcinogenic PAH parameters (i.e., Benz(a)anthracene, Benzo(a)pyrene, Benzo(b+j+k)fluoranthene, Benzo(g,h,i)perylene, Chrysene, Dibenz(a,h)anthracene and Indeno{1,2,3-c,d)pyrene). B(a)P TPE for each soil sample is calculated by multiplying the concentration of each PAH in the sample by its corresponding B(a)P potency equivalence factor. The IACR assesses potential threats to potable groundwater water quality from leaching carcinogenic PAH mixtures from soil. The Index of Additive Cancer Risk (IACR) is calculated by dividing the soil concentration of each carcinogenic PAH by its soil quality guideline of potable water component value, which are then added together (CCME, 2006).

Microsoft Excel was used to assess soil sample quality to individually highlight which samples exhibited metal and/or PAH concentration exceedances in exceedance of the provincial (B.C. CSR standards) and federal guidelines (CCME CSQG's). Statistical analysis including the Rosners Outlier Test and histogram graphs were conducted using software program ProUCL version 5.1.002. ProUCL is a statistical analysis software for environmental applications. Non-detect observations were taken as equivalent to the laboratory reportable detection limit for the purpose of the statistical tests.

8.4.2.1.2 Terrain

Baseline studies were undertaken to address the terrain measurement indicators in the AIR (terrain type, slope, aspect; EAO, 2018) and EIS Guidelines (terrain stability and geohazards; Canadian Environmental Assessment Agency, 2015).

The terrain stability and geohazard baseline study was completed in 2017 and included the assessment and mapping of terrain stability, hazards, and constraints (refer to Appendix 8-C). The work involved the review of background information, preliminary mapping, field surveys, production of final maps, and preparation of an assessment report.

The surficial geology and terrain stability mapping followed the current Provincial guidelines and standards, including:

- The Terrain Mapping Classification System for British Columbia (B.C. MOE, 1997);
- The Guidelines and Standards for Terrain Mapping in British Columbia (RIC, 1996);
- The Mapping and Assessing Terrain Stability Guidebook (MOF, 1999); and
- Terrestrial Ecosystem Information Digital Data Submission Standard – Draft for Field Testing (B.C. Ministry of Environment [B.C. MOE], 2010).

Terrain Stability

Terrain mapping is a method of dividing the landscape into polygons based on surficial material type, surficial material depth, landforms, and processes acting on the polygon. A specialized form of terrain mapping called "terrain stability" (TS) was completed for this Project as well. Additional criteria used for polygon delineation to create terrain stability mapping included:

- Soil drainage;
- Surficial material texture;
- Slope steepness;
- Slope breaks;
- Slope position;
- Geomorphological processes (which include landslides); and
- Surface expression and slope morphology (e.g., concave, or convex and slope length).

The TS mapping completed for the Project provides good quality and reliable inventory of terrain type, geomorphology, terrain stability class, soil erosion potential class, subsidence, and landslides; however, there are some limitations due to scale and availability of imagery used and access for field ground-truthing. In addition, 1:30,000 scale, year 2005 air photos were used in 3D mapping software (DA/TEM Summit Evolution). The mapping can be used at 1:5,000 scale where LiDAR was available and at 1:20,000 where LiDAR was not available. Landslides that occurred after the dates of the imagery used for the mapping may not have been identified. Deep-seated landslides may be missed or inaccurately delineated in the areas not covered by LiDAR. Reliability of the mapping is greater in areas where access to enable field ground-truthing was possible, and areas without reasonable access in 2017 were not field checked.

The baseline report (BGC, 2019; Appendix 8-C) describes methods and results of the TS and geohazards mapping of the current topography and includes discussion on the distribution of terrain type (geomorphology), topography (landform), TS class (geotechnical characteristics of areas proposed for construction of major Project components), and landslides in the Terrain LSA. In addition to the existing soils, terrain, and bedrock geology mapping for the Project area, the following resources were used to create the TS and soil erosion potential mapping for the Project:

- 1:30,000 scale, colour, 2005 air photos (viewed in DA/TEM Summit Evolution [3D mapping software]);
- LiDAR (year 2012) and derivative products including a hillshade from bare earth LiDAR and slope percent (LiDAR covered mine site area and northern end of the Alexander Creek FSR);
- Field observations collected during fall 2017, including surficial material characteristics, soil drainage, evidence, and descriptions of geomorphic processes (natural hazards); and

- Soils field data collected by the KES soils mapping team in the summer and fall of 2017 were reviewed and used to help confirm the surficial geology, but it did not provide geohazard or TS information.

The terrain mapping was completed on year 2005, colour, 1:30,000 scale air photos using 3D mapping software called DA/TEM Summit Evolution and 2012 LiDAR, where coverage was available. Once the polygon boundaries were defined, the following terrain attributes were identified for each polygon: surficial material type, surface expression (landform), material texture, geomorphic processes, soil drainage class, and TS class. Attributes such as surficial material type, surface expression, material texture, geomorphic processes, and soil draining class were later verified using field data. In total, 833 polygons were delineated across the Terrain LSA with an average polygon size of 9.47 ha. Depending on the complexity of terrain, up to three surficial materials can be assigned to a polygon and deciles are added to indicate the spatial extent of each material.

TS relates to landslides (i.e., slumps, slides, debris flows, and earthflows). The method for assigning TS classes followed the Provincial standard used in the forest industry (MOF, 1999) for detailed TS mapping. Each polygon was assigned one of five classes, TS Class I to TS Class III (stable), TS Class IV (potentially unstable), and TS Class V. The classes indicate the likelihood of instability resulting from resource development activities that occur in the upper few metres of the land surface within in situ surficial materials and bedrock. These ratings do not apply to future development-related deposits such as stockpiles, tailings, and mine rock, and they do not apply to deep excavations such as open pits. Class IV polygons are expected to contain areas with a moderate likelihood of landslide initiation following mine development activity. Class V polygons are expected to contain areas with a high likelihood of landslide initiation following mine development activities. The general guidelines used to determine terrain stability class ratings are shown in Table 8.4-3.

Table 8.4-3: Criteria Used to Assign Terrain Stability Classes (adapted from B.C. Ministry of Forests, 1999)

Dominant Texture	Typical Surficial Material	Terrain Stability Class					
		I	II	III	IV: Dissected Slopes (-V)	IV: Uniform Slopes	V
Silt, clay, mixed silt and clay	Glaciolacustrine	< 10%	10-25%	25-40%	> 35%	> 40%	Materials and landforms that are currently unstable. For example, polygons containing active slumping and the head scarps of debris slides, debris flows and rockfall.
Sand, silt, mixed sand and silt, may contain coarse fragments, coal, disintegrated shale	Glaciolacustrine, Till	< 15%	15-30%	30-55%	> 45%	> 55%	
Predominately sandy soils with coarse fragments	Till, Fluvial, Glaciofluvial, Colluvium	< 20%	20-40%	40-60%	> 50%	> 60%	
Sedimentary bedrock with slaty cleavage		< 20%	20-40%	40-60%	> 50%	> 60%	

Dominant Texture	Typical Surficial Material	Terrain Stability Class					
		I	II	III	IV Dissected Slopes (-V)	IV Uniform Slopes	V
a, b, resistant bedrock	Colluvium, Bedrock	< 10%	10-25%	25-40%	> 35%	> 40%	

Note: Numerical ranges in the table refer to the dominant range of hillslope gradients. The classes indicate the likelihood of instability resulting from mine development activities that occur in the upper few metres of the land surface in in situ surficial materials and bedrock.

Polygons with existing active landslides, including rockfall, are automatically assigned TS Class V ratings. For larger active landslides, TS Class V ratings are typically assigned to the head scarp areas, while the runout area is assigned a stability class based on its slope and morphology.

Slope and Aspect

A slope gradient map and aspect map were developed as part of the terrain assessment based on slope data provided by KES and processed by Dillon in ArcGIS. The maps were produced from LiDAR data (year 2010) with 1 m x 1 m resolution. Slope classes were based on standard terrain classification categories (B.C. MOE, 1997) with an additional class of greater than 100% slopes. Aspect classes were derived from the cardinal compass directions.

8.4.2.2 Baseline Program Results

8.4.2.2.1 Soil Quantity and Quality

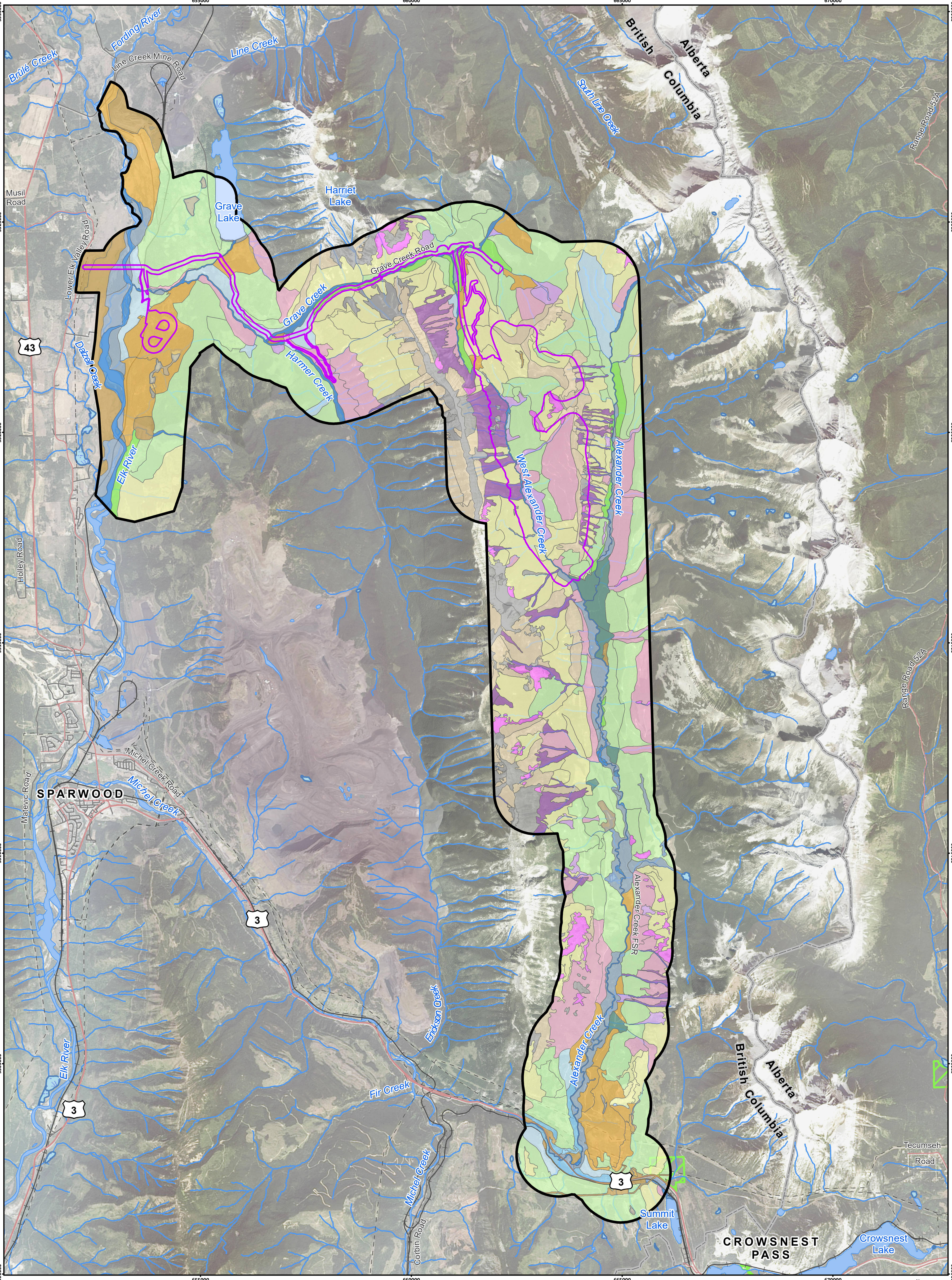
Soil Mapping

A total of 17 SMUs were described, and were finalized once a pattern of main soil types in the Soil Quality and Quantity LSA was established through field sampling and image analysis. SMU are illustrated in Figure 8.4-2, and a summary of the SMUs and percentage contribution to the Soil Quality and Quantity LSA and Project footprint is provided in Table 8.4-4. Refer to Appendix 8-A (KES, 2020) for complete descriptions of the SMU identified within the Soil Quality and Quantity LSA.

Soil Erosion Potential

Maps displaying erosion potential and the SEP interpretation in simplified hazard classes are illustrated in Figure 8.4-3, and a summary of the percentage contribution to the Soil Quality and Quantity LSA and Project footprint per SEP class is provided in Table 8.4-5. Note that for both SEP and SSP, a value of N/A was assigned to anthropogenic soils.

The erosion potential was classified into four classes based on a combination of slope gradient, slope length, soil texture, and depth to water restricting layer. The areas with the highest potential for erosion are found in association with fine-sand and silt-containing materials and/or near creeks where active creek bank erosion is occurring. Other areas with elevated erosion potential are moderately sloping ground with fine textured materials (SMU 3) and steep ground (>60 % gradient), especially if prone to snow avalanching (SMU 4d).



Crown Mountain Coking Coal Project

Figure 8.4-2
Soil Map Units

LEGEND

Soil Map Units (SMU)

- 1a - Circum-mesic till
- 1b - Lower slope till (& Colluvium)
- 2a - Moderately shallow soil
- 2b - Very shallow soils
- 3 - Fine-textured soils
- 4a - Deep Colluvium
- 4b - Soils with evidence of mass movement or erosion
- 4c - Talus
- 4d - Avalanche track
- 5a - Glaciofluvial, gentle slopes
- 5b - Glaciofluvial terrace scarps
- 6a - Mid-bench fluvial
- 6b - Low-bench and active fluvial
- 6c - Fluvial and Colluvial fans
- 7 - Wetland soils
- A - Anthropogenic
- OW - Open Water
- RO - Rock Outcrop
- Soil Quality and Quantity Local Study Area

- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- British Columbia/Alberta Border

0 2 4
Kilometres

Scale 1:85,000

Map Drawing Information:
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Table 8.4-4: Summary of Soil Map Units across the Soil Quality and Quantity LSA and Project Footprint

SMU		Soils Quality and Quantity LSA Area (ha)	% of Soil Quality and Quantity LSA	Project Footprint Area (ha)	% of Project Footprint
1a	Circum-mesic Till	3,691.9	28.7%	286.2	22.3%
1b	Lower Slope Till (Colluvium)	168.1	1.3%	17.9	1.4%
2a	Moderately Shallow Soil	2,533.8	19.7%	326.6	25.5%
2b	Very Shallow Soils	968.0	7.5%	152.2	11.9%
3	Fine-textured Soils	906.9	7.0%	72.8	5.7%
4a	Deep Colluvium	1,300.1	10.1%	177.6	13.8%
4b	Soils with evidence of mass movement or erosion	149.4	1.2%	61.4	4.8%
4c	Talus	203.6	1.6%	7.8	0.6%
4d	Avalanche Track	500.1	3.9%	89.0	6.9%
5a	Glaciofluvial, gentle slope	394.7	3.1%	30.8	2.4%
5b	Glaciofluvial, terrace scarps	67.3	0.5%	0.0	0.0%
6a	Mid-bench Fluvial	542.8	4.2%	10.5	0.8%
6b	Low-bench and Active Fluvial	294.7	2.3%	21.7	1.7%
6c	Fluvial and Colluvial Fans	119.9	0.9%	1.8	0.1%
7	Wetland Soils	58.2	0.5%	0.6	0.0%
A	Anthropogenic	378.0	2.9%	11.8	0.9%
OW	Open Water	77.8	0.6%	0.7	0.1%
RO	Rock Outcrop	530.7	4.1%	13.6	1.1%
	Total	12,886.0	100%	1,283.0	100%

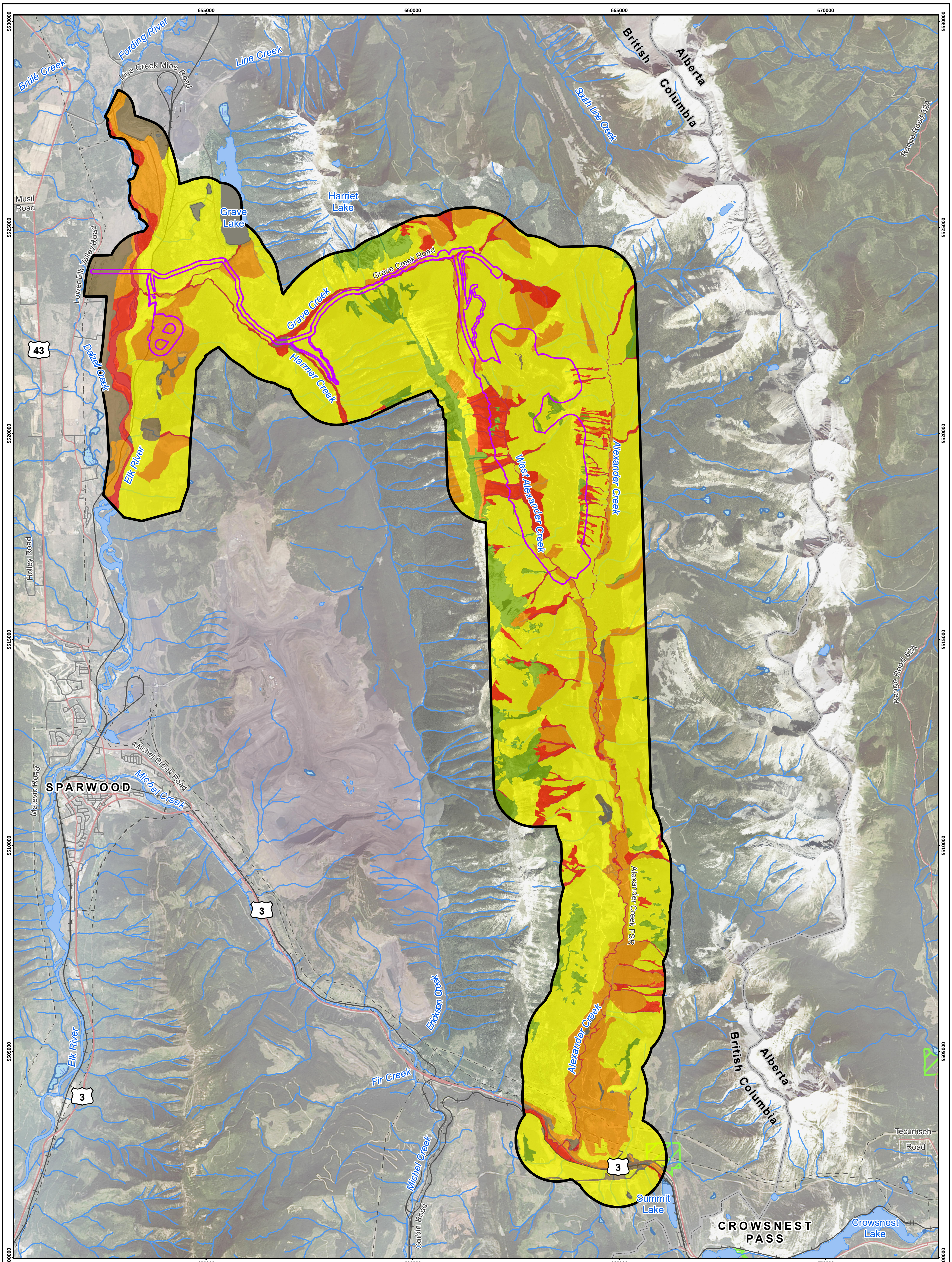

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Figure 8.4-3
Soil Erosion Potential

LEGEND

Soil Erosion Potential (SEP)
- Very High (vh)
- High (h)
- Medium (m)
- Low (l)
- N/A
- Soil Quality and Quantity Local Study Area
- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- British Columbia/Alberta Border

0 2 4
Kilometres

Scale 1:85,000

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Table 8.4-5: Summary of Soil Erosion Potential and Hazard Classes across the Soil Quality and Quantity LSA and Project Footprint

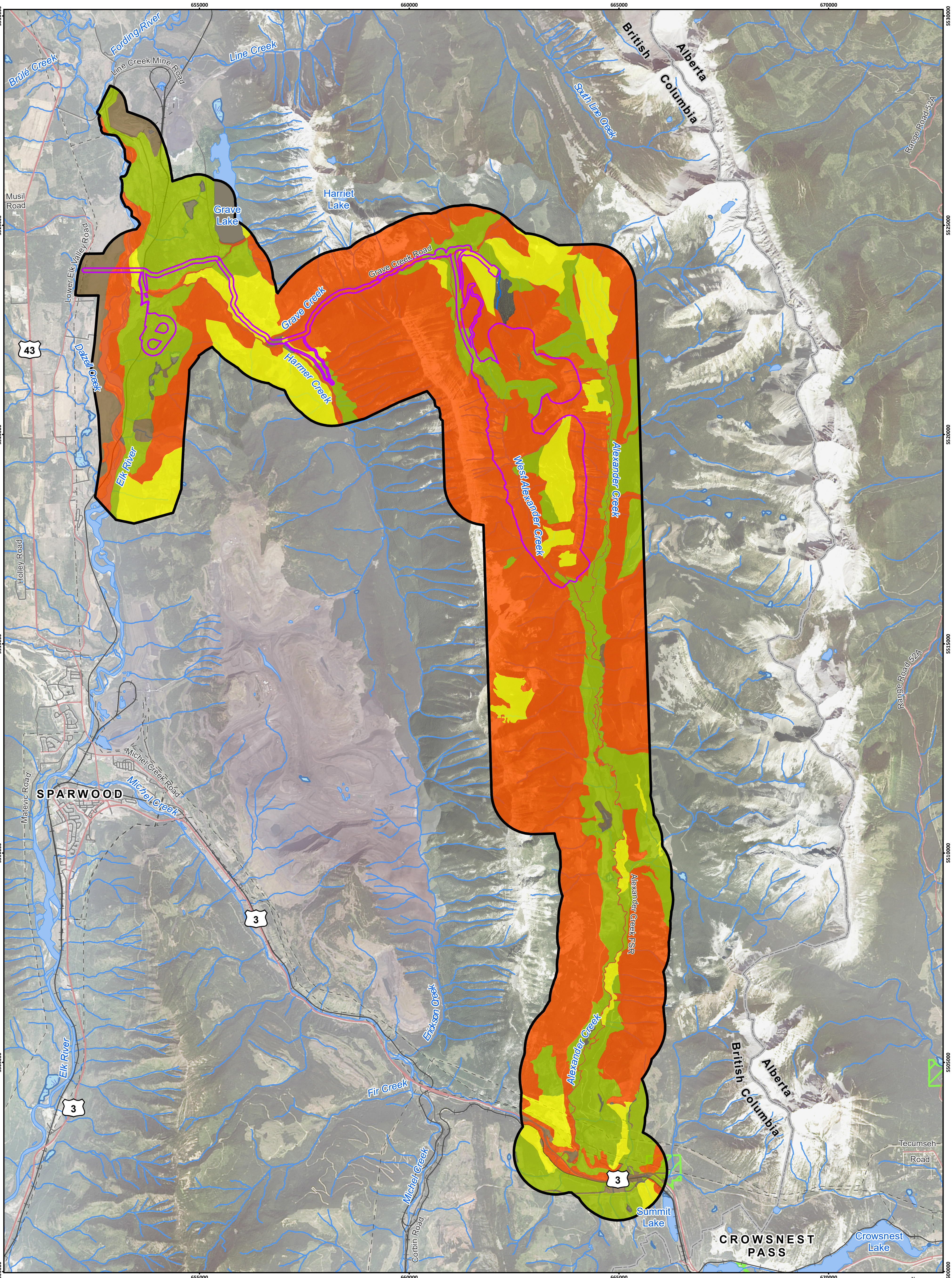
SEP Category	Soil Quality and Quantity LSA Area (ha)	% of Soil Quality and Quantity LSA	Project Footprint Area (ha)	% of Project Footprint	Hazard Class
H-VH	127.7	1.0%	0.0	0.0%	Very High
VH	557.9	4.3%	72.5	5.6%	
VH-H	78.0	0.6%	42.4	3.3%	
VH-M	251.2	1.9%	71.4	5.6%	
H	1,186.4	9.2%	72.9	5.7%	High
H-M	338.5	2.6%	29.7	2.3%	
M-VH	434.6	3.4%	44.6	3.5%	
L-VH	85.4	0.7%	0.1	0.0%	Moderate
M	3,755.3	29.1%	437.7	34.1%	
M-H	3,912.1	30.4%	351.9	27.4%	
M-L	861.9	6.7%	125.4	9.8%	
L	662.8	5.1%	21.3	1.7%	Low
L-H	26.4	0.2%	0.0	0.0%	
L-M	96.9	0.8%	0.0	0.0%	
n/a	510.9	4.0%	13.1	1.0%	n/a
Total	12,886.0	100%	1,283.0	100%	-

High erosion potential was identified along watercourses and on steep slopes throughout the Soil Quality and Quantity LSA. Soils with finer textures have also been identified as having high erosion potential; while fine textured soils with significant clay content are resistant to erosion, there is variation in texture of glaciolacustrine deposits with silty inclusions being very prone to erosion.

It is expected that surface soil erosion will occur when mineral soil exposed areas are not protected. Erosion is reduced when the disturbed cleared surfaces are covered with rough, loose materials, coarse woody debris, coarse rocky material, or vegetation cover, to better control soil displacement and retention of displaced soil particles.

Soil Salvage Potential

SSP across the Soil Quality and Quantity LSA is illustrated in Figure 8.4-4, which has been simplified into good, fair, and unsuitable classes. SEP classes and percent coverage of the Soil Quality and Quantity LSA and Project footprint are summarized in Table 8.4-6. Soils with good potential to be salvaged for rehabilitation purposes (i.e., m, m-h, m-l classes) cover 22% of the Project footprint. Another 17% of the Project footprint has fair potential for soil salvage.



Crown Mountain Coking Coal Project

Figure 8.4-4
Soil Salvage Potential

LEGEND

Soil Salvage Potential (SSP)
- Good Salvage Potential
- Fair Salvage Potential
- Unsuitable
- N/A

- Soil Quality and Quantity Local Study Area
- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- British Columbia/Alberta Border

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Kilometres

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As with the assessment of SEP, SSP had many instances where a range of potentials were assigned to a polygon as either the polygon exhibited multiple SMUs or although comprised of one SMU, factors important to SSP varied over the polygon. Mapped SSP may differ from that experienced on the ground for a variety of reasons, such as difficulty in assessing soil fertility or depth from imagery, inherent variability within an SMU, or unmappable scale of variation. Several of the factors cited in assessing soil salvage potential, in particular, soil pH and calcareous subsurface, varied within an SMU and are impossible to assess from imagery. Key factors in determining SSP will need to be further assessed on the ground as salvage operations are planned for and carried out. The mapping of SSP should be thought of as an indication of relative likelihood of finding salvageable soil in order to focus ground assessments.

Table 8.4-6: Summary of Soil Salvage Potential and Hazard Classes across the Soil Quality and Quantity LSA and Project Footprint

SSP Category	Soil Quality and Quantity LSA Area (ha)	% of Soil Quality and Quantity LSA	Project Footprint Area (ha)	% of Project Footprint	Suitability Class
h	11.2	0.1%	0.1	0.0%	Good Salvage Potential
m-vh	40.4	0.3%	0.8	0.1%	
m	1,515.7	11.8%	130.7	10.2%	
m-h	907.6	7.0%	95.7	7.5%	
m-l	933.6	7.2%	56.9	4.4%	
m-vl	402.6	3.1%	12.7	1.0%	Fair Salvage Potential
l-m	1,179.4	9.2%	206.9	16.1%	
l-vl	222.7	1.7%	59.6	4.6%	Unsuitable
l	1,128.4	8.8%	80.7	6.3%	
vl	4,918.6	38.2%	487.4	38.0%	
vl-l	262.6	2.0%	47.2	3.7%	
vl-m	852.2	6.6%	91.2	7.1%	
n/a	510.9	4.0%	13.1	1.0%	n/a
Total	12,886.0	100%	1,283.0	100%	-

Soil Quality

Chemical analysis revealed large amounts of variation within SMUs for some parameters, as is expected with large polygons with multiple SMUs attributed. For example, pH varies from 4.6 to 8.1, very strongly acidic to moderately alkaline in SMU 1a, as is similar in SMUs 3, 4a and 6c. A summary of the analytical results for soil samples tested for pH, nitrate, potassium, sulphate, calcium, magnesium, potassium, and sodium by SMU, and soil nutrient and particle size analysis, is provided in the Baseline Soil Report (KES, 2020; Appendix 8-A). A summary of the results is provided below.

Generally, each SMU varies in soil pH (e.g., from very strongly acidic to moderately alkaline). This is expected as the majority of SMUs delineated in the Soil Quality and Quantity LSA are large and often contain more than one variation of soil materials (e.g., 2a/1a/4a) from more than one type of parent material (e.g., till or colluvium). The pH ranges and average pH level for each SMU are presented in Table 8.4-7.

Table 8.4-7: Summary of Soil pH Levels by SMU

Leading SMU (number of samples)		Minimum pH	Maximum pH	Average pH
1a (20)	Circum-mesic Till	4.63	8.07	6.48
1b (2)	Lower Slope Till (Colluvium)	5.31	7.14	6.23
2a (23)	Moderately Shallow Soils	3.96	7.99* (6.42)	5.20 (5.08)
2b (5)	Very Shallow Soils	4.51	5.19	4.84
3 (14)	Fine-textured Soils	4.62	8.13	6.63
4a (9)	Deep Colluvium	4.65	8.00	6.09
4b (4)	Soils with evidence of mass movement or erosion	5.13	6.33	5.68
4c (0)	Talus	Talus SMU (non-soil)		
4d (1)	Avalanche Track	5.49	5.49	5.49
5a (4)	Glaciofluvial, gentle slope	6.48	8.08	7.40
5b (4)	Glaciofluvial, terrace scarps	5.47	8.04	6.87
6a (3)	Mid-bench Fluvial	7.25	7.62	7.37
6b (4)	Low-bench and Active Fluvial	5.33	7.56	6.49
6c (3)	Fluvial and Colluvial Fans	4.95	7.93	6.05
7 (7)	Wetland Soils	5.92	7.36	6.71

Soil pH varies seasonally and is affected by factors such as moisture, temperature, plant growth, and microbial activity. The typical pH range for forest soils is approximately 3.5 to 6.5 (extremely acidic to slightly acidic) while the typical pH range for calcareous soils is approximately 7 to 8.5 (neutral to strongly alkaline; Brady and Weil, 2004). The effects of parent material and ecosystem type on soil pH is reflected in the range of pH values found throughout the Soil Quality and Quantity LSA.

A total of 55 soil samples were collected in association with the vegetation baseline chemical surveys, and 63 soil samples were collected in association with the baseline soil classification and surveys in 2017. Soil sample locations where concentrations of metals in soil were identified are illustrated in Figure 8.4-5. Overall, concentrations of metals detected in the soil samples analyzed during the baseline chemical surveys were found to be below the B.C. CSR standards and CCME CSQGs, with the following exceptions:

- Aluminum
  - Soil sample collected from sample location DY6 from a depth of 0-15 cm within a forested slope south of the Branch C Road, was found to contain concentrations of aluminum (40,010 milligrams/kilograms [mg/kg]) slightly in exceedance of the B.C. CSR wildlands natural standard for the protection of human health (40,000 mg/kg).
- Arsenic
  - Sample 48, ROSA-06, collected from a forested site east of Valley Service Road approximately 2 km south of the intersection with Harmer Road, and a subsoil sample (350+ cm depth) collected at drill pad 18-22 (sample 18-22-IIC) on the west-facing slope of the Crown Mountain ridge, were found to contain concentrations of arsenic (12.7 and 15.2 mg/kg, respectively) in exceedance of the CCME guidelines for each land use (12 mg/kg).

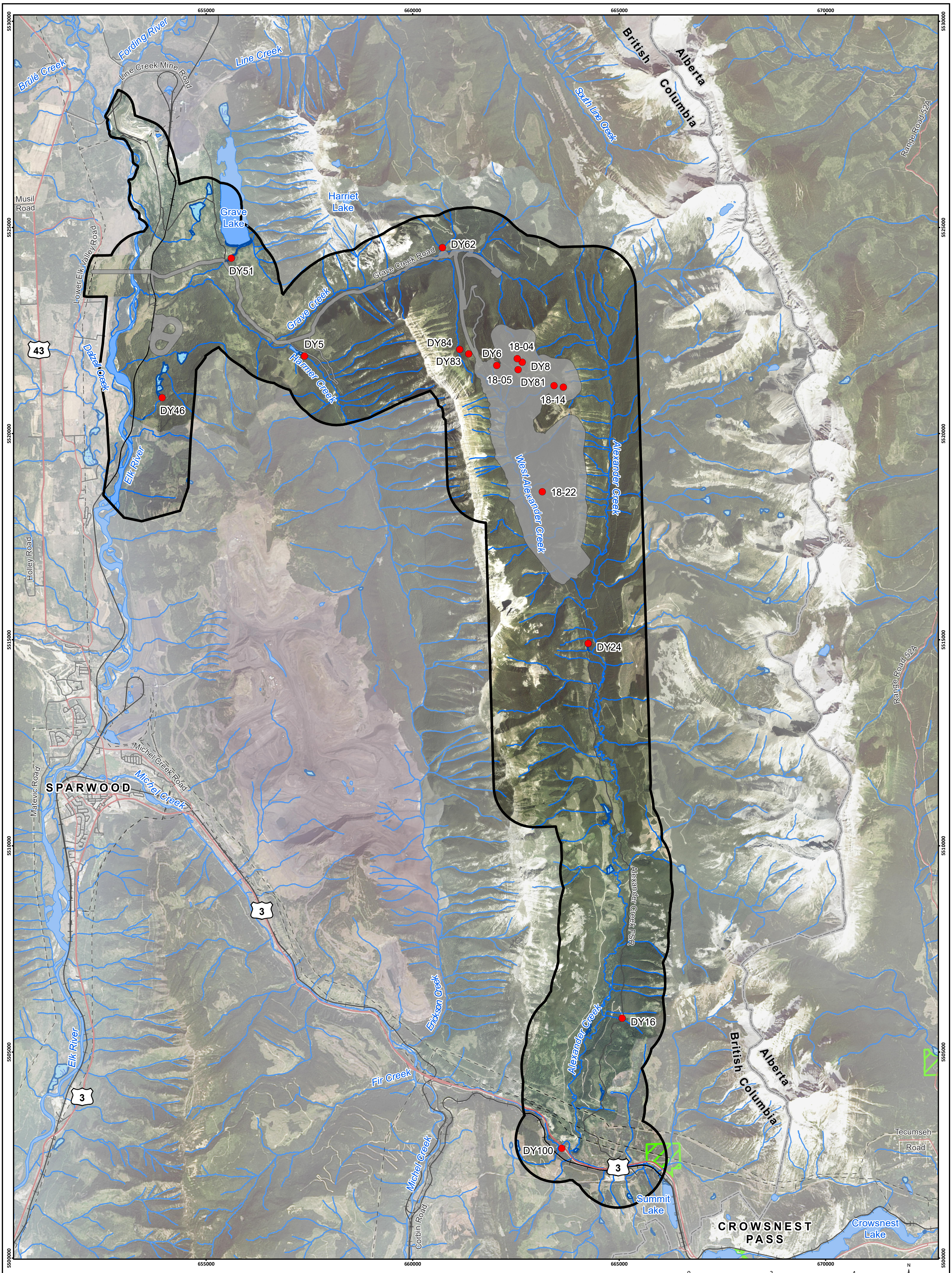

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Figure 8.4-5
Soil Sample Quality Results

LEGEND

- Soil Metal Exceedances
- Soil Quality and Quantity Local Study Area
- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- British Columbia/Alberta Border

Note: Soil locations found to contain metal concentrations above federal and/or provincial guidelines.

Scale 1:85,000

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- Barium
  - Sample 25 (CAREX-02), collected from an open water wetland at the base of Gaff Peak, and sample 11 (SHEPCAN-02), collected immediately east and uphill of the reclaimed Teck land in the west of the Soil Quality and Quantity LSA, exhibited concentrations of barium (503 mg/kg and 601 mg/kg, respectively) in exceedance of the CCME CSQG for residential/parkland (500 mg/kg) land use and B.C. CSR wildlands natural guideline for the protection of ecological health (350 mg/kg). In addition, soil samples DY6, DY8, and DY81 were found to contain concentrations of barium (547, 508, and 656 mg/kg, respectively) in exceedance of the CCME CSQG and B.C. CSR standard.
  - Sample 31 (CAREX-03/EQUIARV-05), collected from a wetland south of the confluence of West Alexander and Alexander Creeks, was found to contain concentrations of barium (401 mg/kg) in exceedance of the B.C. CSR wildlands natural guideline for the protection of ecological health (350 mg/kg). Soil samples DY16 (401 mg/kg) and DY45 (477 mg/kg). The subsoil sample 18-22-IIC, collected from the west-facing slope of the Crown Mountain ridge, was found to contain concentrations of barium (455 mg/kg) above the B.C. CSR standard.
- Cobalt
  - Sample 4, SALIX-01/POPUBAL-01, was found to contain a cobalt concentration (45 mg/kg) in exceedance of the B.C. CSR wildlands natural guideline for the protection of human and ecological health (25 mg/kg).
- Manganese
  - Soil sample DY88, collected from a forested east-facing slope above the Branch C road, was found to contain concentrations of manganese (4,230 mg/kg) in exceedance of the B.C. CSR standard for the protection of ecological health (2,000 mg/kg).
- Nickel
  - Sample 48, ROSA-06, collected from a forested site east of Valley Service Road approximately 2 km south of the intersection with Harmer Road, and subsoil sample 18-22-IIC were found to contain concentrations of nickel (50.6 mg/kg and 84.7 mg/kg, respectively) in exceedance of the CCME CSQG for agricultural and residential/parkland land use (45 mg/kg).
- Selenium
  - Of a total of 118 soil samples submitted for laboratory analysis of selenium during the baseline soil assessments (KES, 2019; KES, 2020), 26 samples were found to contain concentrations of selenium in soil in exceedance of one or both of the CCME CSQG for agricultural and residential/parkland (1.0 mg/kg), and the B.C. CSR standard for environmental protection (1.5 mg/kg). These samples include the following (Table 8.4-8):

Table 8.4-8: Summary of Exceedances of Selenium in Soil

Sample Name	Selenium Concentration (mg/kg)	Most Stringent CCME CSQG (mg/kg)	Most Stringent B.C. CSR Standard (mg/kg)
Sample 4 (SALIX-01/POPUBAL-01)	5.66	1.0	1.5
Sample 5 (POPUBAL-02)	1.17		
Sample 8 (SALIX-03)	3.04		
Sample 25 (CAREX-02)	1.39		

Sample Name	Selenium Concentration (mg/kg)	Most Stringent CCME CSQG (mg/kg)	Most Stringent B.C. CSR Standard (mg/kg)
Sample 31 (CAREX-03/EQUIARV-05)	2.85		
Sample 34 (CAREX-04)	1.28		
Sample 37 (CAREX-05)	2.10		
Sample 42 (CAREX-07)	3.05		
Sample 43 (CAREX-08)	2.95		
Sample 44 (SALIX-06)	22.5		
Sample 45 (CAREX-09)	3.93		
Sample 54 (SALIX-07)	3.58		
Sample 55 (CAREX-10)	4.00		
DY5	2.65		
DY8	1.51		
DY16	1.98		
DY24	2.80		
DY46	2.44		
DY51	2.60		
DY62	2.19		
DY81	1.65		
DY84	1.06		
DY100	1.43		
18-04	1.20		
18-14	1.00		
18-5	1.21		

Note: Most stringent CCME CSQG is for agricultural and residential/parkland use. Most stringent B.C. CSR standard is for environmental protection (toxicity to invertebrates and plants).

- Thallium
  - Soil sample DY46, collected from an upland area adjacent to a wetland in the west of the Soil Quality and Quantity LSA, was found to contain concentrations of thallium (1.22 mg/kg) in exceedance of the CCME CSQG (1.0 mg/kg).
- Zinc
  - Sample DY46 was found to contain concentrations of zinc (257 mg/kg) in exceedance of the CCME CSQG (250 mg/kg). The subsoil sample 18-22-IIC was also found to contain concentrations of zinc (320 mg/kg) above the CCME CSQG.

Of the parameters listed above, the highest detected concentrations for each were identified as statistical outliers from the population. For parameters with numerous exceedances (i.e., selenium and barium), histogram graphs were used to assess whether the datasets represent one or more populations. Histograms indicating a single population suggest that the identified exceedances are likely associated with naturally elevated concentrations of a given metal in soil. If two distinct populations are identifiable in the histogram, anthropogenic or external contamination may be the source of elevated concentrations of metals in soil.

Histogram graphs for barium and selenium concentrations each indicated the datasets represent a single population. This suggests that the identified exceedances of selenium and barium in soil likely represent naturally elevated background concentrations, which may be attributed to local geology, rather than local land use activities (i.e., mining). Selenium is a metalloid that occurs naturally in coal (CCME, 2009). Both anthropogenic and natural sources of selenium contribute to its ubiquitous presence in the environment; a major anthropogenic source locally is through the extraction of coal, while the major natural sources include the weathering of rocks, minerals, and soils (e.g., shale parent materials). Selenium is taken up by terrestrial plants in its soluble forms and translocated to all parts of the plant; thus, selenium concentrations in animal tissue tend to reflect dietary selenium concentrations (CCME, 2009).

In total, seven soil samples were submitted for PAH analysis. Of the 18 PAH parameters analyzed, 14 of the parameters exhibited concentrations below the detection limits for each of the submitted samples. Additionally, both the benzo[a]pyrene TPE and the IACR parameters were below the detection limits for each of the soil samples, demonstrating low carcinogenic risk to humans having direct contact with soil within the Soil Quality and Quantity LSA (CCME, 2010). Concentrations of PAHs detected in the soil samples analyzed during the baseline chemical surveys were found to be below the B.C. CSR standards and CCME CSQGs, with the following exceptions:

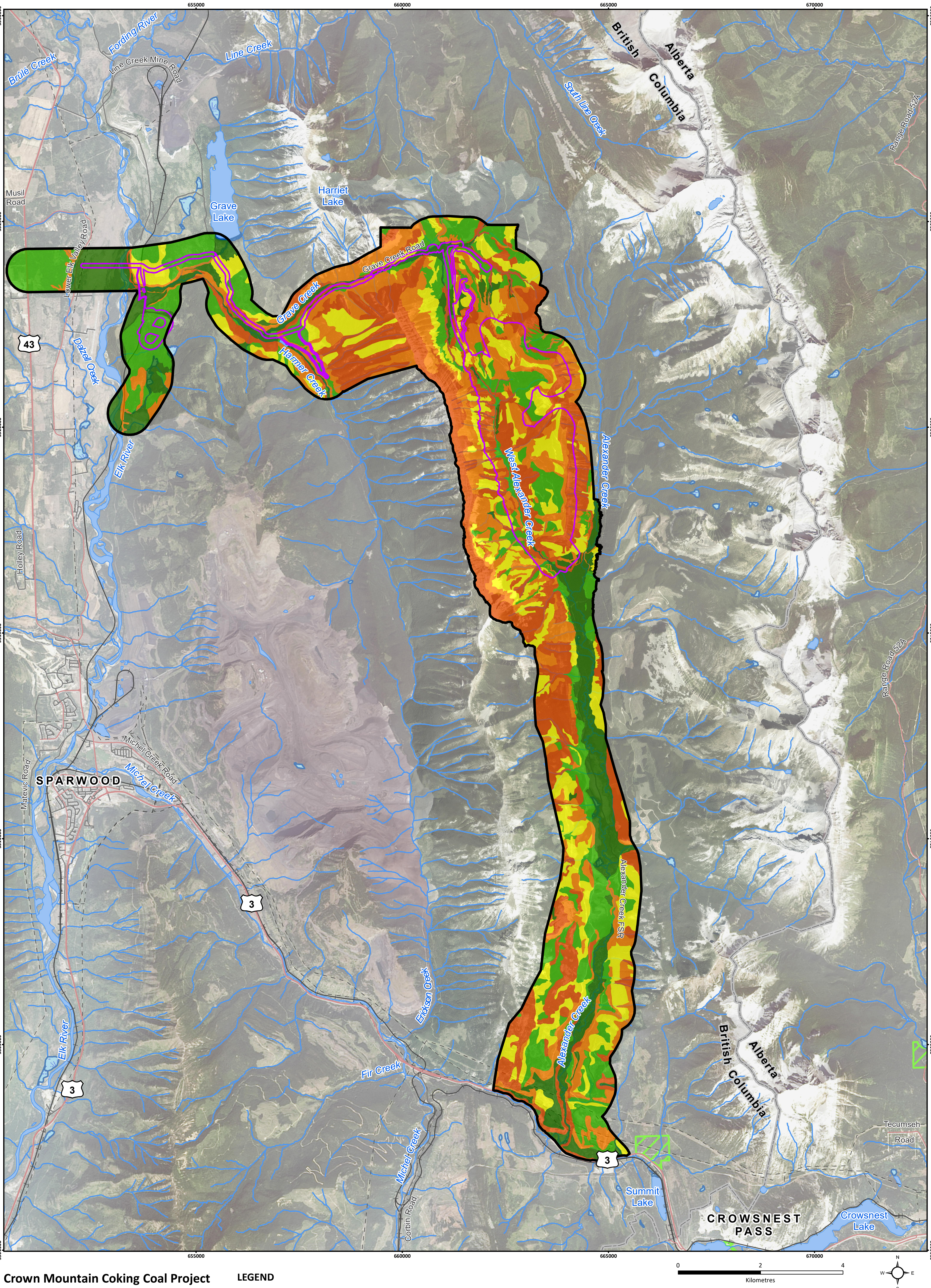
- Sample 1 VACCMEM-01, collected from near an exposed coal seam northwest of the summit of Crown Mountain, exhibited the highest concentration of phenanthrene (0.053 mg/kg), which was found to exceed the CCME CSQG for agricultural and residential /parkland of 0.046 mg/kg; however, this value represents the soil quality guideline for the protection of freshwater aquatic life, and may be applied to terrestrial soil quality where potential impacts to nearby surface water is a concern. Where there is no potential risk to freshwater, the CSQG for phenanthrene is 43.0 mg/kg.

The Baseline Soil and Vegetation Chemistry Report (KES, 2019) for the Project, including soil analytical results and laboratory certificates of analysis can be found in Appendix 8-B.

8.4.2.2.2 Terrain

Terrain Stability

Terrain stability classes indicate the likelihood of instability resulting from resource development activities that occur in the upper few metres of the land surface within in-situ surficial materials and bedrock. Terrain stability classes do not apply to future development-related deposits such as stockpiles, tailings and mine rock, or deep excavations such as open pits. As summarized in Table 8.4-9, TS Class IV and V polygons cover 47% of the Terrain LSA. Each of these polygons are located on moderately steep to steep terrain, which tends to occur on the mid and upper slopes and gullies generally around the central part of the LSA (i.e., the portion of the Terrain LSA in the Elk Valley is mostly gentle with few TS Class IV and V polygons). Figure 8.4-6 illustrate colour-themed polygons highlighting the TS Class I to V for the Terrain LSA.



Scale 1:85,000

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Figure 8.4-6
Terrain Stability Mapping

LEGEND

Terrain Stability Class (TSC)

- I
- II
- III
- IV
- V
- Terrain Local Study Area
- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
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Geohazard maps are presented in Figure 8.4-7, and include colour-themed polygons based on the presence of slow moving geohazards, rapid moving geohazards or a combination of slow and rapid geohazards. A summary of the coverage of the Terrain LSA and Project footprint for each geohazard class is provided in Table 8.4-10.

Table 8.4-9: Summary of Terrain Stability Classes across the Terrain LSA and Project Footprint

Terrain Stability Class		Terrain LSA Area (ha)	% of Terrain LSA	Project Footprint Area (ha)	% of Project Footprint
-	Negligible	4.8	0.06%	0.2	0.01%
I	Very Low	1,100.1	13.9%	68.5	5.3%
II	Low	1,655.5	21.0%	288.5	22.5%
III	Moderate	1,449.6	18.4%	236.6	18.4%
IV	High	1,592.4	20.2%	275.3	21.5%
V	Very High	2,089.9	26.5%	411.9	32.1%
	Total	7,982.3	100%	1,281.0	100%

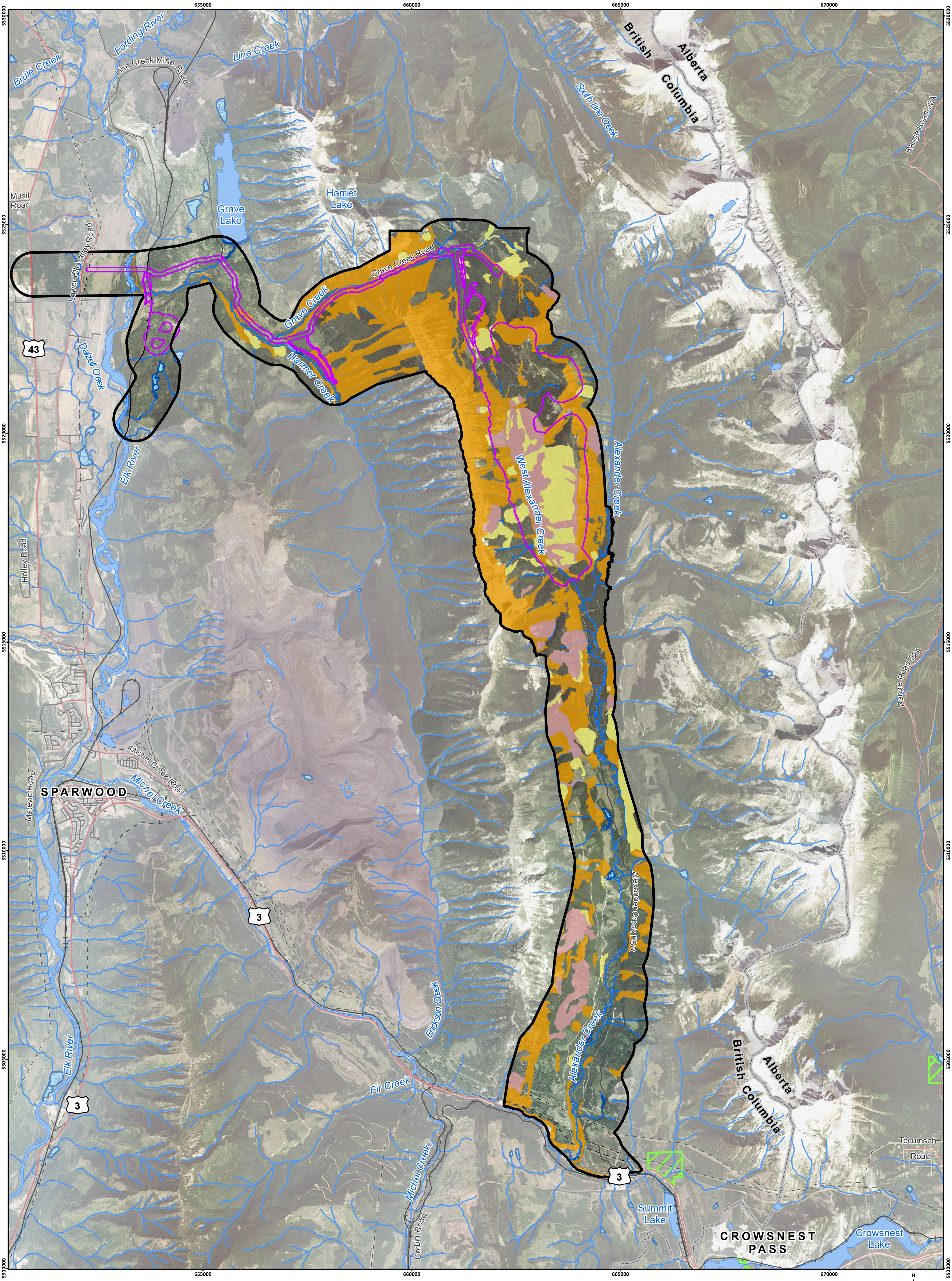
Table 8.4-10: Summary of Geohazard Classes across the Terrain LSA and Project Footprint

Geohazard Class	Terrain LSA Area (ha)	% of Terrain LSA	Project Footprint Area (ha)	% of Project Footprint
Slow Moving (Fk, Fm, Fu, Fx)	466.6	5.9%	223.2	17.4%
Rapid (Rb, Rs,R1s, Rd, Rr)	2486.1	31.5%	341.9	26.6%
Combination Slow/Rapid	478.0	6.1%	221.4	17.3%
None	4461.6	56.5%	494.5	38.5%
Total	7,982.3	100%	1,281.0	100%

Terrain type, assessed by mapping of surficial materials across the terrain LSA include till, colluvium, aeolian, fluvial, glaciolacustrine, and organic deposits, as well as weathered bedrock and anthropogenic deposits, are illustrated in Figure 8.4-8. Glaciolacustrine sediments are found throughout the Terrain LSA, and are associated with increased susceptibility to landslides and surface erosion than other materials. Glaciolacustrine sediments are prone to failure at low slope angles, long runout landslides, soil erosion, as well as shrinking and swelling, potentially leading to heave and settlement. Glaciolacustrine sediments typically consist of silt and clay. In most locations where glaciolacustrine sediments were observed in the field, the deposit consisted of clayey silt.

Within the Terrain LSA, deposits of glaciolacustrine sediments were found along the Elk River valley bottom, Grave Prairie, and the south end of Grave Lake between the elevations of about 1,200 m amsl and 1,400 m amsl. Project infrastructure in this area includes the rail spur, buildings at the north end of the rail spur, the haul road, and powerline.

A summary of the distribution of terrain types, including the percent coverage where glaciolacustrine sediments are mapped across the Terrain LSA and Project footprint, is provided in Table 8.4-11.



Crown Mountain Coking Coal Project

Figure 8.4-7
Geohazard Mapping

LEGEND

Geohazard

- Combination of Slow and Rapid Geohazards
- Rapid Geohazards (Rb, Rs, R1s, Rd, Rr)
- Slow Moving Geohazards (Fk, Fm, Fu, Fx)
- Terrain Local Study Area
- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- British Columbia/Alberta Border

0 2 4
Kilometres

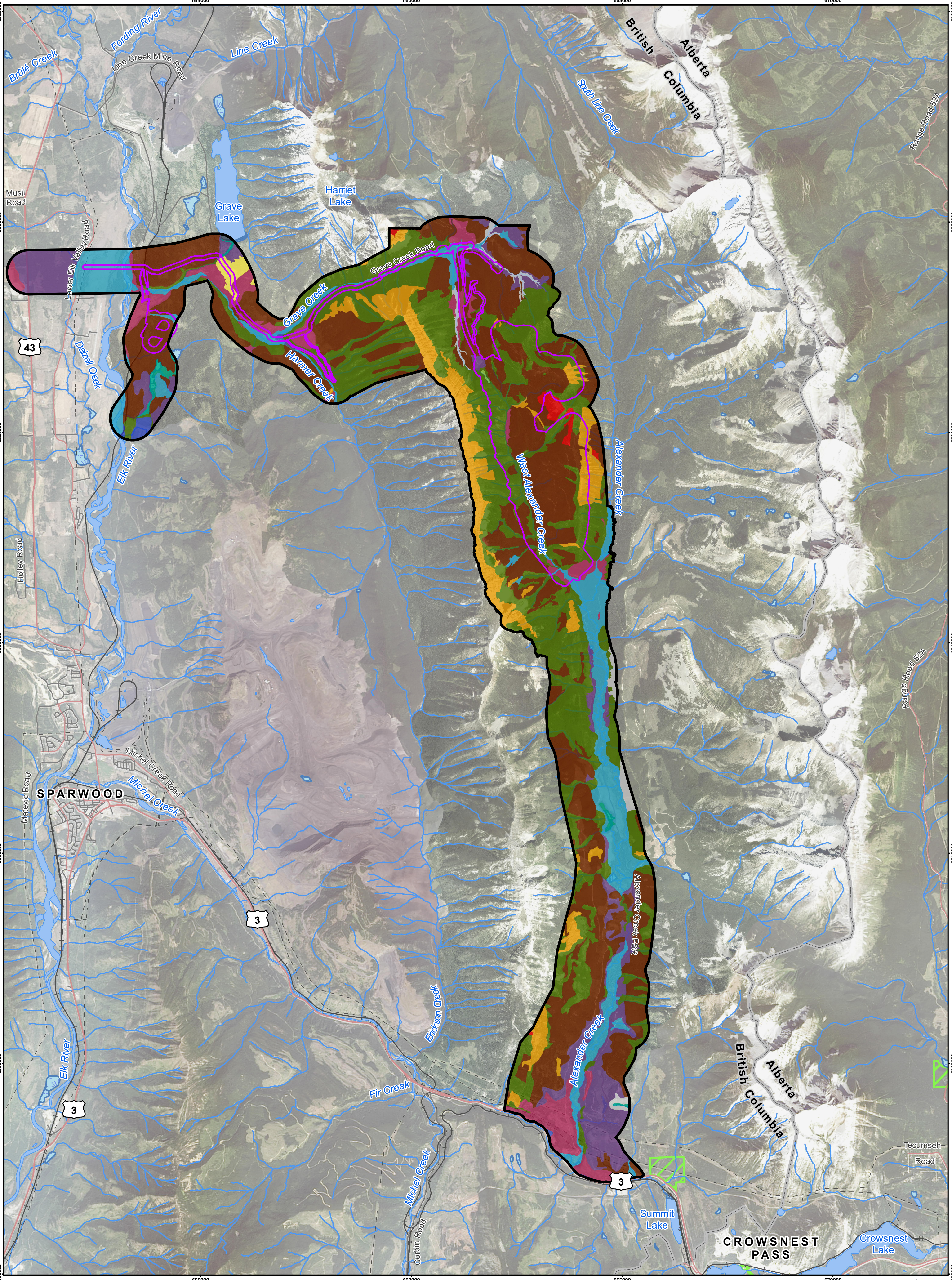
Scale 1:85,000

Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Keefer Ecological Services Ltd, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada.
Imagery Provided By Landsat 8 (Aug 2018), and GeoBC Ortho Imagery (Aug 2016).

Map Created By: RB
Map Checked By: SK
Map Coordinate System: NAD 1983 UTM Zone 11N

NWP Coal Canada Ltd

Project: 12-6231
Status: FINAL
Date: 2022-01-19



Crown Mountain Coking Coal Project

Figure 8.4-8
Terrain Type

LEGEND

Terrain Type

- A - Anthropogenic
- C - Colluvian
- D - Weathered Bedrock
- E - Eolian
- F - Fluvial
- FG - Glaciofluvial
- L - Lacustrine
- LG - Glaciolacustrine
- M - Till
- N - Non-classified (ie. Open Water)
- O - Organic
- R - Bedrock
- U - Undifferentiated
- Terrain Local Study Area
- Project Footprint
- Highway
- Arterial/Collector Road
- Local/Resource Road
- Railway
- Transmission Line
- Watercourse
- Waterbody
- Wetland
- Provincial Park/Protected Area
- British Columbia/Alberta Border

0 2 4
Kilometres
Scale 1:85,000

Map Drawing Information:
Data Provided By NWP Coal Canada Ltd, Dillon Consulting Limited, Keefer Ecological Services Ltd, Province of British Columbia GeoBC Open Data, Government of Alberta Open Data, Natural Resource Canada.
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Map Created By: RB
Map Checked By: SK
Map Coordinate System: NAD 1983 UTM Zone 11N

NWP Coal Canada Ltd

Project: 12-6231
Status: FINAL
Date: 2022-01-19

Table 8.4-11: Summary of Terrain Type across the Terrain LSA and Project Footprint

Terrain Type	Terrain LSA Area (ha)	% of Terrain LSA	Project Footprint Area (ha)	% of Project Footprint
Anthropogenic	28.2	0.4%	1.3	0.1%
Colluvium	2,415.3	30.6%	435.0	33.9%
Weathered Bedrock	43.4	0.6%	15.3	1.2%
Eolian	41.2	0.5%	9.4	0.7%
Fluvial	819.1	10.4%	46.2	3.6%
Glaciofluvial	425.8	5.4%	58.1	4.5%
Lacustrine	1.7	0.02%	1.7	0.1%
Glaciolacustrine	671.3	8.5%	14.3	1.1%
Till	2,720.8	34.5%	636.0	49.6%
Non-classified (i.e., Open Water)	4.8	0.06%	0.2	0.01%
Organic	39.0	0.45%	0.3	0.02%
Bedrock	592.5	7.5%	60.0	4.7%
Undifferentiated	89.3	1.1%	3.4	0.3%
Total	7,982.3	100%	1,281.0	100%

Karst

Karst is a distinctive topography that develops by the dissolution of carbonate bedrock (e.g., limestone, dolomite, and marble and to a lesser extent, gypsum) resulting in development of collapse and subsidence features. Common features include sinkholes, caves, disappearing streams (e.g., swallets), and springs. FLNRORD (2020) has created a Reconnaissance Karst map for the province which includes karst likelihood. Karst likelihood is the likelihood of karst-forming bedrock being present based on the proportion of soluble bedrock within the mapped polygon. Table 8.4-12 summarizes the distribution of Primary, Secondary, and Tertiary Karst likelihood within the Terrain LSA and Project footprint.

Table 8.4-12: Distribution of Karst Likelihood across the Terrain LSA and Project Footprint

Karst Likelihood Category	Definition	Terrain LSA Area (ha)	% of Terrain LSA	Project Footprint Area (ha)	% of Project Footprint
Negligible	0-5% soluble rock	857.5	10.9%	459.5	35.8%
Primary	>50% soluble rock	930.8	11.8%	8.9	0.7%
Secondary	20-49% soluble rock	1,041.6	13.2%	43.0	3.3%
Tertiary	5-19% soluble rock	3,817.2	48.4%	722.3	56.3%
	Total	6,647.0[a]	84.2%[b]	1,233.6[a]	96.2%[b]

Notes:
a - Karst mapping extent does not include entirety of Terrain LSA and Project Footprint area, respectively.
b - Percentages are based on the Terrain LSA and Project Footprint areas.

Although karst was not observed within the Terrain LSA by the terrain stability mapping, 892.9 ha (7%) of the Terrain LSA is underlain by Primary Karst likelihood, 977.7 ha (8%) by Secondary Karst likelihood, and 3,818 ha (30%) Tertiary Karst likelihood. The remainder of the area is considered to have a negligible amount of karst potential. Most of the Project infrastructure is located on areas mapped as Tertiary or unmapped. Virtually none of the Project infrastructure is located on areas mapped as Primary, and therefore karst is not considered to result in adverse effects resulting from the Project, and is not discussed further in the effects assessment.

Slope and Aspect

Slope gradients described herein are derived from LiDAR and the slope classes are based on the standard terrain classification categories (B.C. MOE, 1997), with an additional class of greater than 100% slopes. The distribution of the six slope classes is summarized in Table 8.4-13.

Table 8.4-13: Summary of Slope Classes across the Terrain LSA and Project Footprint

Slope Class	Terrain LSA Area (ha)	% of Terrain LSA	Project Footprint Area (ha)	% of Project Footprint
0-5% (plain)	600.9	7.6%	44.5	3.5
5-25% (gentle)	2,215.6	28.1%	326.9	25.5
25-50% (moderate)	2,281.0	28.9%	406.6	31.7
50-70%(moderately steep)	1,550.2	19.6%	266.6	20.8
70-100% (steep)	966.0	12.2%	204.9	16.0
>100% (very steep)	278.5	3.5%	31.5	2.5
Total	7,982.3	100%	1,233.6	100%

Slope aspects described herein are derived from LiDAR and the aspect classes are based on the four cardinal directions for slopes greater than 15%, as summarized in Table 8.4-14.

Table 8.4-14: Summary of Aspects across the Terrain LSA and Project Footprint

Aspect (degrees)	Terrain LSA Area (ha)	% of Terrain LSA	Project Footprint Area (ha)	% of Project Footprint
East: 45°-135°	2,590.9	32.8%	299.9	23.37%
North: 315°-45°	1,337.6	16.9%	161.9	12.62%
South: 135°-225°	1,610.4	20.4%	308.3	24.03%
West: 225°-315°	2,353.4	29.8%	510.9	39.82%
Total	7,982.3	100%	1,281.0	100%

Changes to slope aspect resulting from the Project are not inferred to materially adversely affect habitat function, or contribute to elevated risk of soil erosion or geohazards (i.e., landslides). Therefore, aspect is not discussed further in the effects assessment.

8.5 Project Effects Assessment

This section includes a description of the potential effects of the Project that are anticipated to occur on the soil and terrain valued components (soil quantity and quality and terrain) relative to baseline conditions and the thresholds of significance.

8.5.1 Thresholds for Determining Significance of Residual Effects

8.5.1.1 Soil Quantity and Quality

There are no specific provincial or federal regulations that set thresholds for determining the significance of effects on soil resources. In the absence of specific thresholds set by legislation, a significant adverse residual environmental effect to soil quality or soil quantity is considered to occur when soil quantity or quality are changed so that successful reclamation to self-sustaining ecosystems with an average capability comparable to that of the present baseline is prevented. This is characterized as an effect to any measurable parameter where the magnitude of the residual effect is high and the duration is long-term or permanent. For average capability to be achieved at the time of reclamation, soil quantity or quality may be higher in some areas and lower in others compared to baseline conditions; however, overall soil function in the map units will average to similar conditions and support similar ecosystems and capability.

8.5.1.2 Terrain

Key Project-related interactions with terrain were determined through a screening evaluation of proposed physical works and activities within the Terrain LSA against terrain stability mapping (BGC, 2019). A significant adverse residual effect on terrain is defined as one that results in changes to terrain that result in increased slope (in general, increase of slope of >15%) creating unstable terrain features, and increased potential for geohazards of greater frequency and magnitude.

8.5.2 Project Interactions

Project activities and components have the potential to result in adverse effects to soil quantity and quality and terrain VCs within the Soil Quality and Quantity LSA and Terrain LSA during the Construction and Pre-Production, Operations, Reclamation and Closure, and Post-Closure phases. The potential effects and pathways of interaction include the destabilization of terrain due to construction and maintenance of Project infrastructure. Project activities that are expected to interact with soil quantity and quality and terrain, with a potential for adverse effects, are presented together in an interaction matrix in Table 8.5-1. Project activities and components are assessed independently for each temporal phase to identify the potential pathways that could result in adverse effects on soil quantity and quality or terrain. Additional details relating to specific Project activities are discussed in Chapter 3.

The geotechnical designs for the major structures, mines, pit walls and mine rock storage facilities are presented in Chapter 3. These designs are based on the information presented in the 2020 Bankable Feasibility Study (Jameson Resource Limited, 2020).

8.5.3 Project Effects on Soil Quantity and Quality and Terrain

In general, the Project has the potential to adversely affect soil quantity and quality and terrain within the respective LSAs through construction and associated elevated erosion potential during soil clearing and soil salvage, dust-generating activities within the pits, processing areas, and the Mine Rock Storage Facility (MRSF), the accumulation of mine-generated dust and Metal Leaching and Acid Rock Drainage (ML/ARD). Interaction of soil with groundwater and surface water may also contribute to elevated concentrations of constituents in soil, and cause loss of soil through erosion, in the absence of mitigation measures. Potential effects on VCs are evaluated based on measurement indicators compared to significance

Table 8.5-1: Soil Quantity and Quality and Terrain VCs Interaction Matrix and Ranking

Project Phase	Project Component	Description of Activities	Soil Quantity	Soil Quality	Terrain
Construction and Pre-Production	Transportation	Highway transport trucks, light duty vehicles and crew busses will use Highway 43, Line Creek Mine Road, Valley Road, and Grave Creek Road for all phases of the Project which include transportation of personnel, materials, and consumable items	I	I	I
	Logging of Merchantable Timber	Merchantable timber will be logged from the infrastructure and pre-production development footprint	II	II	II
	Clearing and Grubbing	After the merchantable timber has been removed, the remaining vegetation will be cleared and grubbed from the infrastructure and pre-production development footprint	III	II	II
	Stockpiling Wood Waste	Wood waste will be stockpiled on site and used for reclamation as a source of coarse woody debris	I	I	I
	Quarry for Construction Materials	Excavation of road bed materials from the North Pit footprint for use on Grave Creek Road	II	II	II
	Water Management or Water Management Structures	Water management structures to support initial construction activities will be built prior to soil being salvaged from the run of mine (ROM) and plant site	II	II	II
		Interim sediment pond will be built prior to the soil removal and stockpiling from the pit access road and initial phase of the North Pit	II	II	II
		Grave Creek Reservoir will be constructed to act as a back-up source of process water	II	II	II
	Soil Salvage	Soil will be salvaged from the footprint of the infrastructure	III	II	II
	Road Upgrading and Construction	Branch C will be widened and upgraded to facilitate construction and mine traffic to plant site area	II	II	II
		Grave Creek Road will be widened to facilitate the clean coal haul	II	II	II
		A new road will be constructed off the Valley Road to access the rail loadout for construction and operation	II	II	II

Project Phase	Project Component	Description of Activities	Soil Quantity	Soil Quality	Terrain
	Overland Conveyor	Clearing, grubbing, and construction of overland conveyor from the plant site to Grave Creek Road	II	II	II
	Coal Handling Process Plant Construction	Excavating and pouring of foundation	II	II	II
		Transportation of materials and personnel to site	I	I	I
		Constructing of the Coal Handling Process Plant (CHPP)	II	II	II
		Commissioning of the CHPP	I	I	I
	Workshop / Mine Dry Construction	Excavating and pouring of foundations	II	II	II
		Transportation of materials to site	I	I	I
		Construction of workshop / mine dry	II	II	II
		Equipment wash bay and heavy equipment parking	II	II	II
		Administration, first aid and mine dry building	II	II	II
		Diesel tank farm	II	II	II
		Warehouse	II	II	II
		Potable water system	II	II	II
		Septic system	II	II	II
		Water supply pipelines from Grave Creek and West Alexander Creek	II	II	II
		Commissioning of the facilities	I	I	I
	Explosives Factory Construction	Construction of the explosives factory	II	II	II
	Rail Loadout Construction	Excavation and preparation of the rail bed	II	II	II
		Excavation and preparation of foundation stockpiling and coal handling systems	II	II	II
		Transportation of materials and personnel to site	I	I	I
		Construction of rail loadout	II	II	II
		Connection to the CP Fording Sub-line	I	I	I
		Commissioning of the rail loadout	I	I	I

Project Phase	Project Component	Description of Activities	Soil Quantity	Soil Quality	Terrain
	Labour	Hiring of personnel for the mine, CHPP operations administration, and coal haul	I	I	I
		Training of personnel	I	I	I
	Construction Waste Materials	Collection and transfer to a recycling facility or other approved facility	I	I	I
Operations	Explosives Factory	Ammonium nitrate / emulsion storage facilities which have the ability to load explosive agents into delivery trucks	I	II	I
		Wash facility to decontaminate the bulk explosive delivery trucks	I	II	I
		Storage of explosives (detonators and boosters)	I	II	I
	Fuel Storage	Receiving bulk fuel deliveries	I	II	I
		Onsite storage of fuel	I	II	I
		Dispensing fuel	I	II	I
		Transferring fuel to on-site delivery trucks	I	II	I
	Mine Roads Development	Building roads from material sourced onsite	II	II	II
	Mining	Progressive clearing	III	II	II
		Removal of unconsolidated material	III	II	II
		Loading, hauling and stockpiling of soil	II	II	II
		Drilling and loading of blastholes	I	I	I
		Detonating the explosives	I	II	II
		Loading, hauling and dumping of mine rock	I	III	I
		Loading, hauling and stockpiling of coal	I	III	I
	Site Water Requirements	Using contact water as the primary process make-up water from Interim Sediment Pond (Year 1 to 5)	II	II	II
		Using contact water as the primary process make-up water from the North Pit (Year 5 to 15)	II	I	II
		Backup reservoir in Grave Creek as a secondary source of process make-up water	II	II	II

Project Phase	Project Component	Description of Activities	Soil Quantity	Soil Quality	Terrain
	Coal Processing	Run of mine coal sizing	I	II	I
		Washing coal	I	II	I
		Mechanical and thermal drying of coal	I	I	I
		Coal reject disposal (part of loading, hauling and dumping of mine rock activities)	I	III	I
		Conveying clean coal	I	II	I
	Sewage Treatment	Sewage will be treated by a septic system constructed at the plant site which will support the administration, mine dry, and CHPP facilities	I	I	I
	Main Sediment Pond	Construction of Main Sediment Pond in Year 4	II	II	II
		Management of the Main Sediment Pond discharge	II	III	II
	Reclamation	Reclaiming available areas as soon as possible to achieve reclamation objectives	II	II	II
Reclamation and Closure	Dismantling Infrastructure and Buildings	Dismantling of the CHPP, maintenance facilities, administration, and other facilities	II	II	II
		Dismantling, salvaging, collecting and transferring materials to a recycling facility or other approved facility	II	II	II
	Removal of Linear Infrastructure	Removal of the powerline	II	II	II
		Removal of the natural gas line	II	II	II
	Reclamation	Reclaiming available areas as soon as possible to achieve reclamation objectives	II	II	II
	Monitoring	Reclamation monitoring	I	I	I
		Geotechnical monitoring	I	I	I
		Aquatic effects monitoring	I	I	I
	Water Management	Management of the Main Sediment Pond discharge	II	III	II
Post-Closure	Water Management	Decommissioning the Main Sediment Pond once water quality objectives have been met	II	II	II
	Road Use	Branch C Road will remain as a permanent access road for future commercial and recreational use	I	II	I
	Rail Line	The rail line will remain as a permanent feature	II	I	I

Project Phase	Project Component	Description of Activities	Soil Quantity	Soil Quality	Terrain
	Monitoring	Reclamation monitoring	I	I	I
		Geotechnical monitoring	I	I	I
		Aquatic effects monitoring	I	I	I

Notes (after EAO, 2013):
I = No or negligible effect (positive or adverse) is anticipated; not carried forward in the assessment
II = Potential adverse effects requiring additional mitigation or substantive positive effects are expected; carried forward in the assessment
III = Key interaction resulting in potential significant adverse effect or significant concern; carried forward in the assessment

thresholds. For soil quantity and quality, potential effects are assessed using measurements of thickness and distribution of soils, soil type and general properties, and concentrations of metal and non-metal constituents in soil. Measurement indicators for evaluating potential effects on terrain are assessed using terrain type, slope, and aspect.

Specifically, the Project has the potential to affect soil quantity and quality and terrain through the following Project activities:

- Clearing and grubbing during mine development during the Construction and Pre-Production and Operations phase;
- Soil salvage activities including loading, hauling, and stockpiling of soil during progressive clearing of the Project footprint;
- Generation of dust and associated ML/ARD impacting mine site drainage, attributed to loading, hauling, and dumping of mine rock, and stockpiling and dumping of coal and coal rejects; and
- Interaction of soil with mine effluent within the Interim and Main Sediment Pond during discharge through the Operations phase and decommissioning during Reclamation and Closure.

Mining and pit development activities including detonating of explosives, removal of coal and mine rock, and dumping of mine rock during Operation are anticipated to cause measurable local terrain alterations within the Project footprint; however, the effects of localized excavations, stockpiles, and limited levelling of the Project site to make way for Project-related infrastructure are anticipated to be relatively minor compared to the scale of terrain in the Rocky Mountains. As such, potential effects related to changes in terrain due to pit creation and filling by mine rock dumping are inconsequential and are not considered further.

Potential effects on terrain are considered for Project activities which remove or disturb surficial materials or otherwise have the potential to increase the frequency and magnitude of geohazards/landslides. Without mitigation, the Project has the potential to affect terrain through changes to terrain type and slope. These changes may cause instability of surficial materials during ground disturbance and construction activities, and result in increased frequency and magnitude of geohazards/landslides affecting infrastructure and personnel. The potential effects on terrain type, slope, and aspect have been considered in the context of their implications for terrain stability, given the inter-relationships between these measurement indicators.

Potential effects on soil quantity and quality and terrain as a result of the Project that are carried forward in the discussion of potential effects are identified in Table 8.5-2.

Table 8.5-2: Potential Effects on Soil Quantity and Quality and Terrain

Potential Effect	Rationale for Selection of Environmental Effect
Soil Quantity	
Loss of soil during clearing and grubbing, soil salvage, and stockpiling activities	Removal and/or relocation of soil from the Project footprint, resulting in changes to the depth and distribution of soils. Increase in potential for loss of soil through erosion and sedimentation during clearing, grubbing, and soil stockpile activities.

Potential Effect	Rationale for Selection of Environmental Effect
Loss of soil during construction of development infrastructure	Excavation and compaction during construction of development infrastructure may result in a loss of soil quantity, depth and distribution of soil. Increase in potential for loss of soil through erosion and sedimentation associated with soil disturbance stockpile activities.
Loss of soil through erosion associated with site drainage and discharge of mine site water from sedimentation ponds	Precipitation events and site drainage may result in loss of soil through erosion and sedimentation to downgradient watercourses. Discharge of mine site water at sedimentation pond discharge locations have the potential to contribute to soil loss through erosion, in the absence of mitigation measures.
Soil Quality	
Changes to soil quality associated with dust deposition during Operations	Dust generation is associated with mining operations including development of the pits through detonating explosives, loading, hauling, and dumping of mine rock and coal, processing of coal, and coal reject disposal. Dust generated through these activities has the potential to increase concentrations of metals and other contaminants in soil following deposition, potentially resulting in soil contamination.
Changes to soil quality due to interactions with ML/ARD during Operations	Drainage water in contact with development infrastructure such as pits and the Mine Rock Storage Facility (MRSF) may result in acid generation and metal leaching (i.e., sulphate, calcite, nitrate, and selenium). Seepage of drainage water to soil has the potential to increase concentrations of metals and other contaminants in soil.
Changes to soil quality due to infiltration of effluent discharge to soil from sedimentation pond discharge points during Operations, Reclamation and Closure, and Post-Closure pond decommissioning activities	Management of sedimentation ponds will include the discharge of water to West Alexander Creek once water quality objectives have been met. Potential adverse effects to soil quality are related to potential increased concentrations of metals and other contaminants associated with interactions between surface water and soil during discharge of mine effluent.
Routine use of hydrocarbon fuels on site, fuel handling, dispensing, and transferring	The storage and transport of petroleum hydrocarbon products (e.g., gasoline, diesel, lubricants, hydraulic fluids, and solvents), as well as fueling and maintenance of machinery, heavy equipment, and vehicles, have the potential to affect soil quality in the local vicinity of those activities.
Terrain	
Changes to terrain type, slope, and aspect through each Project phase	Logging, clearing, grubbing, soil salvage and stockpiling, and construction of development infrastructure require soil disturbance, and are likely to result in changes to terrain type throughout the Project footprint. Slope hydrology and the distribution of existing slope classes and erosion potential may be affected, which may affect terrain stability, causing interactions with other intermediate VCs for the Project, including soil quality and quantity, and surface water quality. Receptor VCs which may be affected include landscapes and ecosystems, fish and fish habitat, and wildlife. Areas where slope has increased as a result

Potential Effect	Rationale for Selection of Environmental Effect
	of the Project have the potential to affect terrain stability (discussed below). Minor changes to the distribution of existing aspect classes as a result of the Project are not anticipated to adversely affect terrain stability. The potential effects of changes to terrain type, slope, and aspect have been considered in the context of their implications for terrain stability, given the inter-relationships between these measurement indicators as described below.
Changes to terrain stability resulting in increased frequency and intensity of geohazards (i.e., rapid and slow mass movement/landslides) through each Project phase	Changes to terrain type and areas of increased slope from the Project may affect terrain stability, as a result of activities that destabilize surficial materials on slopes.

In addition to the above, soil quantity, soil quality and terrain have important linkages to a number of receptor VCs, including various wildlife such as mountain goat, bighorn sheep, grizzly bear, and American badger (Chapter 15); vegetation (Chapter 14); fish and fish habitat (Chapter 12); and terrestrial ecosystems (Chapter 13). These effects are discussed in their respective chapters as well as in the human and ecological health assessment (Chapter 22) and are therefore not repeated here.

8.5.3.1 Discussion of Potential Effects

The potential effects identified in Table 8.5-2 are discussed in the context of each Project phase (Construction and Pre-production, Operations, Reclamation and Closure, and Post-Closure) in the following subsections. Note that this assessment focuses only on planned activities within the designed scope of the Project related to soil quality, soil quantity, and terrain. Potential effects related to unplanned events such as slope failures, snow avalanches and earthquakes are discussed in Chapter 20, and accidents and malfunctions are presented in Chapter 21.

The following Construction and Pre-Production phase activities will have minimal or no interaction with soil, transportation of personnel and construction materials, stockpiling of wood waste, commissioning of facilities, hiring and training of personnel and administration, and collection and transfer of construction waste materials to disposal facilities.

During the Operations phase, no interaction is expected from any drying of coal or sewage treatment. Monitoring activities associated with the Reclamation and Closure and Post-Closure phases are not expected to result in substantial interactions with soil. Each of the Project activities ranked as Level I in Table 8.5-1 are not expected to result in significant adverse effects and have not been considered further in this effects assessment.

8.5.3.1.1 Construction and Pre-Production

During Construction and Pre-Production, construction of new access roads and site infrastructure will require quarrying and excavation of construction materials. Overburden stripping, soil salvaging and stockpiling, quarrying of rock, and dust generation are expected to result in increased sediment load, if not mitigated. These process may cause soil contamination through deposition of dust and transportation/relocation of soil. Soil loss may occur through erosion by wind or water and may result in the loss of soil materials throughout the Project footprint and affect the success of reclamation activities. Relocation and stockpiling of soil may result in a loss of soil productivity through admixing, and may cause changes in ecosystem composition and abundance. Admixing occurs when less or non-productive soil horizons are mixed with the more productive surficial topsoil, resulting in reduced overall soil quality. Such changes have the potential to interact with other VCs for the Project, including landscapes and ecosystems, surface water quality, fish and fish habitat, and wildlife. Soil will be salvaged and stockpiled following best management practices (BMPs) and protected against erosion through the implementation of erosion and sediment control measures.

Changes to soil depth and distribution (soil quantity) are anticipated in the Construction and Pre-Production phase through the upgrading and use of existing roads within the Project footprint (e.g., Valley Road, Grave Creek Road, Branch C), logging and grubbing, quarrying of road materials, the construction of water management structures, soil salvage, and the construction of the rail loadout. Construction activities may result in a loss or change in the depth and distribution of soil during construction of development infrastructure through excavation and compaction. In addition, soil disturbance can increase terrain instability, which can lead to loss of surface soils by rapid and slow mass movement.

There is an increase in the potential for loss of soil through erosion and sedimentation associated with any activity that will cause soil disturbance and relocation. Logging, clearing, and grubbing of the land will affect soil local soil quantity through physical removal of soil, and losses through erosion and sedimentation during clearing of the Project footprint. In the absence of vegetative cover, surficial soils that remain will be more susceptible to soil erosion and sedimentation by wind or storm water runoff to watercourses.

The Project footprint encounters every soil erosion potential (SEP) class mapped in the Soil Quality and Quantity LSA, as discussed in Section 8.4.2.2.1. The classes apply to in situ surficial materials that have been exposed due to vegetation removal and ground disturbance. The classes do not apply to future development-related deposits such as quarries, stockpiles, and mine rock. Ground disturbance and vegetation removal, especially on polygons rated SEP class high (H) and very high (VH) have a high to very high likelihood of erosion during and following construction. SEP class VH slopes typically consist of glaciolacustrine sediments and steep slopes covered by glacial sediments that are gullied. SEP class H polygons include steep slopes of glacial sediments. Fortunately, approximately 74% of the soils in the Project footprint have low to moderate soil erosion potential (Table 8.4-5), thereby minimizing the potential for soil erosion to occur as a result of Project development. Where surficial materials will be excavated so that remaining surfaces will consist of bedrock and anthropogenic materials, the SEP ratings will no longer be applicable.

Soils will be salvaged from the logged, cleared, and grubbed areas of the Project footprint where it is operationally feasible and safe (i.e., sufficient depth and suitable terrain). It was estimated by Stantec, using data from KES (2017), that roughly 50% of the excavated topsoil will be suitable for reclamation, which is relatively consistent with the fact that approximately 39% of the Project footprint has good to fair soil salvage potential (Table 8.4-6). Seasonality is key to successful soil salvage both in terms of safety and productivity. Whenever possible, soils should be salvaged in relatively dry conditions to minimize the risk of compaction upon placement, but not so dry that losses are incurred through dust migration. Soil compaction is the loss of pore space through compression, which leads to reduced soil fertility and ecological function. Heavy machinery and construction of development infrastructure are the primary causes of soil compaction. Compaction can lead to soil loss through increased erosion since it reduces the porosity and water storage capacity of soil, leading to increased runoff.

Construction and Pre-Production activities require the majority of soil disturbance activities (i.e., logging, clearing, and grubbing) that will alter terrain type. The Project footprint intersects every type of terrain (i.e., surficial material), including bedrock, mapped in the Soil Quality and Quantity LSA. In many cases, the terrain types are a metre or two thick overlying bedrock; in some cases, the terrain types are several metres thick; and, in a few locations, there are two surficial materials layered on top of each other. Depending on the type of infrastructure constructed or operational activities occurring, the depth of excavation into the overburden required will vary for each feature or polygon it intersects.

The Project footprint intersects every terrain stability (TS) class mapped in the Terrain LSA. Terrain stability classes indicate the likelihood of instability resulting from resource development activities that occur in the upper few metres of the land surface within in situ surficial materials and bedrock. Terrain stability classes do not apply to future development-related deposits such as quarries, stockpiles, mine rock, or deep excavations such as open pits. Ground disturbance and vegetation removal, especially in polygons rated TS Class IV and V, have a moderate to high likelihood of landslide initiation following construction. Such surface features associated with the Project that intersect these polygons include access roads, transmission lines, pits, MRSFs, conveyors, ditches, soil stockpile areas, Main Sediment Pond, contingency areas, plant site, dam, and the spillway (Figure 8.2-2).

Ground disturbance and vegetation removal, especially on polygons rated TS Class IV and V, have a moderate to high likelihood of landslide initiation following construction. Project infrastructure that intersect with TS Class IV and V include the Project access road, transmission line, pits, MRSF, conveyor, soil stockpile area, contingency area, dam, plant site, spillway, water management structures, The Interim Sediment Pond, and the water supply pipeline. The construction of the Interim Sediment Pond in polygons of TS class IV and V is a key interaction of this phase. The Interim Sediment Pond is entirely overlapping with terrain features that are prone to instability. Construction and Pre-Production activities in these areas will require mitigation and a geohazard risk assessment.

8.5.3.1.2 Operations

Dust generating activities associated with pit development by detonation of explosives, loading, hauling, and dumping (including mine rock, coal, and coal rejects), coal washing and processing, and stockpiling have the potential to increase concentrations of metals and other contaminants in soil through fugitive dust deposition. This may result in an increase in concentrations of metal and non-metal constituents in soil and result in measureable alteration of soil quality, expressed as a change in metal availability, pH, ions, porosity, and $CaCO_3$. Typically, soil alteration resulting in a reduction in soil function occur as a result of erosion, compaction, acidification, and contamination through contact with seepage water, spills, and dust effects.

Soil acidification and eutrophication of soils can occur through rainfall or as dry deposition of airborne compounds (nitrogen oxides and sulphur dioxide) associated with heavy equipment exhaust. Depending on the natural soil buffering capacity, these effects can lower soil pH levels and alter ecosystem function through changes to metal availability and biochemistry.

Adverse effects on soil quality may be caused through infiltration of impacted mine site drainage water. Drainage water in contact with development infrastructure such as pits and the MRSF may result in acid generation and metal leaching (i.e., sulphate, calcite, nitrate, and selenium), resulting in an increase in the concentrations of metal and non-metal constituents. Seepage of drainage water to soil has the potential to increase concentrations of these constituents in soil, if not effectively managed. Similarly, mine site water contained within sedimentation ponds has the potential to impact local soil quality at the point to discharge water to West Alexander Creek. Through bioaccumulation, such changes have the potential to interact with other VCs for the Project, including vegetation and wildlife. Surface and ground water quality as well as metal uptake monitoring will continue through all Project phases and will be critical in the evaluation of changes in metal and non-metal concentrations in soil.

Progressive reclamation will begin during the Operation phase, where reclamation activities will initiate in available areas as soon as possible to achieve reclamation objective when stable landforms are created; some opportunities exist in Years 6, 8, 10, 11, and 15 of the Operations phase. It is estimated by Year 10 that about 76 ha will have been reclaimed. All other reclamation activities will occur in Year 15 and later (closure). As with any activity that requires the disturbance and relocation of soil, loss of soil through excavation and erosion is possible. Management plans and BMPs for the reduction of erosion and sedimentation will be implemented throughout the duration of the reclamation of the site.

Changes to soil depth and distribution are anticipated during the Operations phase through the loading, hauling, and stockpiling of soil, the construction of the Main Sediment Pond and the management of discharge, and progressive reclamation activities. These effects are anticipated to occur through excavation (i.e., physical removal/relocation of soil), compaction, and erosion. Of these effects, most can be mitigated through the implementation of soil salvage, BMPs, and management plans. A discussion of additional mitigation measures, such as the design of the Main Sediment Pond and mine site drainage, are discussed in the management plans presented in Chapter 33.

Changes to terrain stability are anticipated in the Operations phase through the building, use, and maintenance of roads, the removal of unconsolidated material, and the construction of the Main Sediment Pond. These effects are of particular importance in TS classes IV and V, which are prone to instability. The Main Sediment Pond overlaps with terrain features that are prone to instability. A landslide or slump (mass movement) into the sediment pond could result in a breach of the dam; however, this type of event is discussed in Chapter 21 and is not discussed further herein. It is also possible that soil stockpiling activities scheduled for this phase may interact with terrain stability if stockpile locations are in TS class IV or V polygons. Operations activities in these area will require mitigation and a geohazard risk assessment.

8.5.3.1.3 Reclamation and Closure

As discussed previously, reclamation activities are anticipated to require soil placement, soil disturbance, and revegetation of portions of the site, which may result in loss of soil quantity through erosion, compaction, and relocation. The complete area to be reclaimed totals about 788 ha. Changes to terrain stability are anticipated in the Reclamation and Closure phase through the decommissioning of linear features such as the transmission line and natural gas pipeline. These effects are of particular importance in TS classes IV and V, which are prone to instability. Reclamation and Closure activities in these areas will require mitigation.

Soil quality may also be affected during reclamation activities and soil replacement throughout the Project footprint. Potential adverse effects may be caused depending on method of replacement and potential for establishment of invasive species. These effects can be mitigated through the implementation of BMPs and environmental management plans (refer to Chapter 33).

Sedimentation pond effluent has the potential to impact local soil quality at the point to discharge water to West Alexander Creek. In addition, high velocity or volume flows may result in downstream erosion and have the potential to adversely affect soil quantity. Effluent discharge will be managed through the Reclamation and Closure phase in accordance with management plans and BMPs to confirm that water quality objectives have been met prior to discharge, and reduce the potential for adverse effects on soil quality and quantity.

Changes to TS and increased geohazard risk are anticipated through the decommissioning of linear features such as the transmission line and natural gas pipeline. These effects are of particular importance in areas rated as TS class IV and V, which are prone to instability. Reclamation and Closure activities in these areas will require mitigation and a geohazard risk assessment.

8.5.3.1.4 Post-Closure

Changes to soil depth and distribution (soil quantity) are anticipated in the Post-Closure phase through the decommissioning of the Main Sediment Pond (changes to native soil depth and distribution) and the continued use of Branch C as a permanent access road (e.g., erosion). These potential effects will require mitigation in this phase.

Changes to terrain stability are anticipated in the Post-Closure phase through the existence of Branch C as a permanent access road. As such, natural drainage patterns and drainage structures must be monitored for their long-term impact on terrain stability, particularly in TS class IV and V polygons. Post-Closure activities in these areas will require mitigation.

Decommissioning of the Main Sediment Pond and final release of effluent to West Alexander Creek will occur once water quality objectives have been met. Potential effects include local impacts to soil quality at the point to discharge water to West Alexander Creek, and soil loss through erosion by high velocity or volume flows. Pond decommissioning and final reclamation efforts will be conducted in accordance with management plans and BMPs to minimize adverse effects on soil quantity and quality, and meet the reclamation objectives and target post mine ecosystems at closure of the site.

Changes to TS are anticipated following mine closure through the existence of Branch C as a permanent access road. Natural drainage patterns and drainage structures must be monitored for their long-term impact on terrain stability, particularly those located within TS class IV and V rated areas.

Changes to the distribution (area measured in hectares) of slope and aspect classes are anticipated as a result of the Project. Comparatively, between the baseline landscape and the predicted post-mine landscape (including post-closure/reclamation), slopes in the Terrain LSA which are affected by the Project are generally less steep in the post-mine environment. As a result of the Project, changes in the distribution of aspects will result in a slight increase in north and west aspects. This change in aspect is not anticipated to materially affect soil quality, quantity, or terrain, and therefore is not discussed further.

Since changes to terrain type and slope have the potential to destabilize surficial material on slopes, the effects assessment considers these in the context of their potential effects on terrain stability, going forward, in order to avoid duplication.

8.5.3.1.5 Transboundary Effects

The Project is located approximately 5 km west from the Alberta border and 85 km north from the Montana border in the United States. As discussed in Chapter 1, Section 1.3.3, the nearest federal lands to the proposed Project are the ?aq'am First Nation Bummer's Flat 1 Reserve (approximately 69 km southwest), Stoney Nakoda Edan Valley 216 Reserve (approximately 70 km northeast), Tobacco Plains 2 (approximately 80 south), Piikani Nation Peigan Timber Limit 147B (approximately 52 km east in Alberta), and Parcels 73 and 82 of the Dominion Coal Blocks (approximately 20 and 40 km southwest, respectively). Federal land is not required to facilitate the Project and the Project does not overlap with any federal land.

Due to their distance from the Project and associated Project activities and components, potential effects on soil quantity and quality and terrain arising from the Project are not expected to occur in either the bordering province of Alberta, the bordering State of Montana, or on federal lands. As such, transboundary effects on soil and terrain arising from the Project are not expected to occur in either province or state or on federal lands.

8.5.3.2 Mitigation Measures

The mitigation measures proposed for soil quantity and quality and terrain are based on available best management practices, provincial and federal guidance documents, mitigation measures conducted and accepted for similar projects, and professional judgment. The identification and selection of technically and economically feasible mitigation measures followed the mitigation hierarchy approach outlined by the provincial Environmental Mitigation Policy and related Environmental Mitigation Procedures (Ministry of Environment, 2014). For the purposes of this assessment, mitigation measures are defined to include Project design features, procedures, or practices that will reduce or eliminate Project-related changes to soil quality and quantity and terrain and related effects to receptor VCs. Where mitigation measures are considered to be highly effective, potential Project effects to soil quantity and quality and terrain are not identified as residual effects.

8.5.3.2.1 Mitigation Measures for Changes to Soil Quantity

The following subsections describe mitigation strategies for the following potential Project effects on soil quantity from:

- Loss of soil during clearing and grubbing, and soil salvage activities through the Construction and Pre-Production phase;
- Loss of soil during construction of development infrastructure within the Project footprint through the Construction and Pre-Production phase; and
- Loss of soil through erosion associated with site drainage and discharge of mine site water from sedimentation ponds during Operations, Reclamation and Closure, and Post-Closure.

Soils within the mine footprint will be salvaged where it is operationally feasible and safe (i.e., sufficient depth and suitable slope and terrain). Seasonality is key to successful soil salvage both in terms of safety and productivity. Whenever possible, soils will be salvaged in relatively dry conditions to minimize the risk of compaction upon placement, but not so dry that losses are incurred through dust migration. Prior to soil salvage activities, there will be a resource identification process that uses the existing soil mapping, supplemented with field surveys, when and where needed. Soils will be stripped with a combination of excavators and dozers, and windrowed to facilitate loading and hauling.

It is critical to salvage the productive upper soil separately from the underlying parent material. From soil sampling at the Project footprint, developed (and hence more productive) soil is found to a depth of about 60 cm. Parent materials are found below this depth. The upper approximately 60 cm of soil should be stripped and stored separately from the underlying salvaged soil. The parent soil material (>60 cm depth) should be stripped either to bedrock or where unconsolidated rock becomes dominant over < 2 mm particle size soil (coarse fragment content exceeds 50%). Soil salvage will be practiced everywhere where soil is disturbed, including areas outside of the main mine area, such as footings for conveyor and powerline towers, and the road leading to and clearing for the explosives storage facility. Salvaged soil in these smaller disturbances will be stored locally for replacement at closure.

Biomass salvage will occur concurrently with soil salvage activities during logging, clearing, and grubbing activities during Construction and Pre-Production. Merchantable timber will be removed by conventional logging, (or push-over harvest, to facilitate removal of root systems prior to soil salvage), under the Cutting Permit for the Project. If merchantable timber is conventionally harvested, then root systems will be extracted mechanically prior to soil salvage. All non-merchantable tree harvest will be accomplished by push felling. This will allow for more efficient and thorough soil salvage. Various treatments incorporating woody debris into the soil salvage through breaking up the wood or chipping to allow for efficient handling by equipment will be evaluated for implementation during the Project.

During the Operations phase, salvaged soil storage will occur temporarily in designated areas not being actively mined. Soil stockpiles will be constructed in lifts (layers) with a maximum of 3:1 (33%) slopes to a maximum height of 15 m for stability and to reduce the potential for slumping or failure. The stockpile surfaces will be loosely constructed to produce surface roughness, protectively matted when required, and revegetated to limit erosion from wind, snow melt, and precipitation. Revegetation will also enhance soil organic matter accumulation over time. Revegetation will be done using species that do not have persistently viable seed, so that seed does not germinate after salvaged soil has been placed for ultimate revegetation. Stockpiles will be revegetated in the spring or fall, as soon as possible following their establishment to achieve a stable vegetation cover in a timely manner. Natural revegetation is anticipated to supplement the initial revegetation measures. Further best management practices at the toe of the stockpiles (e.g., silt fencing, bale barriers) will be implemented to limit the loss of fines by erosion. Perimeter ditching will also be constructed around the stockpiles to capture erosion and direct runoff around the stockpiles from uphill sources. Stockpiles will be monitored such that eroded areas can be addressed as soon as practical; the stockpiles will also be monitored for vegetation establishment, control of invasive species, and sediment release.

Upon establishment of stable post-mining landforms, the created landforms will be covered with salvaged soil. On gently sloping (<25% slope) terrain, subsoil (parent material) will be laid down first and then a capping of upper soil horizons will be applied to a total depth of about 30 cm. On more steeply sloping terrain (>25% slope), upper and subsurface soils will be mixed before placing on the mine rock landform, again to a depth of approximately 30 cm. Dark-colored salvaged soil material will not be placed on warm-aspect, sloping ground to avoid creating temperature stress. Surfaces to be covered with salvaged soil will be roughened so that microtopography (approximately 50 to 100 cm relief) is produced across all sites. As well, these surfaced will be loosened by ripping if they are compact and may provide a barrier to root or water infiltration. Salvaged soil will be laid down in such a manner that soil compaction does not occur.

In general, mitigation measures to address soil loss through erosion and sedimentation during storm events and by mine site drainage and wind effects will be established through an Erosion and Sediment Control Plan (ESCP) for the site (Chapter 33, Section 33.4.1.4). The Erosion and Sediment Control Plan provides a range of environmental protection measures that will be implemented to avoid or reduce the potential for the occurrence of erosion or a sediment release on the Project, and to appropriately respond to and mitigate erosion or a sediment release should they occur during any phase of the Project.

An overview of the mitigation strategy for the preservation of soil quantity for the Project is as follows:

- Avoid
  - Prevention is the preferred manner of addressing erosion or a sediment release throughout all phases of the Project. Implementation of the following measures detailed in Table 8.5-3 will contribute to the effective prevention of erosion or sediment releases.
- Minimize
  - Where prevention of soil loss is not feasible, mitigation measures to minimize soil loss through erosion and sedimentation will be implemented throughout all phases of the Project. Implementation of the following measures detailed in Table 8.5-4 will contribute to the effective mitigation of erosion or sediment releases.

Table 8.5-3: Erosion and Sediment Control Prevention/Avoidance Measures

Controls	Purpose	Control Prevention
Construction Scheduling	Develop erosion and sediment controls prior to construction and assess and anticipate the needs for additional controls	• Schedule construction activities to limit durations of exposed soils, as exposed soils are susceptible to both water and wind erosion • Consider the time of year when developing construction schedule so as to avoid particularly wet and or windy seasons when erosion potential is higher
Construction Design	Minimize infrastructure footprints to reduce need for disturbed area and sediment controls	Consider reducing building size in erosion-prone areas to reduce risk of erosion of de-stabilized and/or exposed soils
Construction Phasing	Allows for a phased approach to revegetation of exposed soils, resulting in a reduction in the length of time soils are subject to water and wind erosion	Consider phasing construction to allow for phased revegetation and stabilization of exposed soils.
Designated Vehicle Travel Areas	Vehicle and heavy machinery travel will be restricted to designated road surfaces	Areas at elevated risk of soil compaction and the resulting soil loss will be avoided by vehicles and heavy equipment under the ESCP.

Table 8.5-4: Erosion and Sediment Minimization Measures

Controls	Purpose	Control Prevention
Benching	Reduces slope lengths, which reduces water erosion through slowing water velocity, allowing for the settling of sediment	Implement benching techniques to reduce slope length, when possible
Ditching	Assists in moving surface water away from the construction site to designated locations to reduce water erosion and sedimentation	The development of ditches should occur along roads and the perimeter of the work site
Check Dams	Reduces the velocity of water to allow for temporary retention of water that allows sediment to settle out of the flow	Check dams should be installed in locations with limited drainage areas to reduce water velocity
Retention and Settling Ponds	Allow for the collection of water, slowing the flow of water, and allowing for sediment to settle out prior to spilling over the edge to enter the natural environment	• Retention or settling ponds should be established at the base of steep slopes that have high potential for water erosion and sedimentation • Several retention or settling ponds may be required in a series to be effective • Additional treatment prior to discharge may be needed • Numbers and sizes of retention or settling ponds will be dependent on flow rate and volume of water and sediment
Re-contouring and Surface Features	Reduces the amount of sheet and rill erosion by surface water runoff and reduces surface water flow velocity to allow for sediment to settle	• Re-contour when possible by reducing the length of the slope and decreasing the angle of the slope • Maintain slope gradients and exposed slopes to prevent accelerated erosion of soils and surficial materials • Establish undulation or troughs parallel to the slope
Stabilized Construction Exits	Limit the spread of sediment off-site via vehicle traffic	Stabilize site access and exit points and temporary roads using common stabilizers such as gravel or wood chips
Mulching, Hydromulching, and Hydroseeding	Protects soil surface from erosion, and if seed is included, aids in enhanced germination and revegetation to exposed soils	• Apply mulch through hydromulching and/or hydroseeding in areas with high potential for erosion • Stabilize exposed slopes by hydroseeding or seeding as soon as possible to avoid erosion and sedimentation • Prior to hydroseeding or seeding, track walking slopes should be

Controls	Purpose	Control Prevention
		completed in order to slow water runoff and reduce erosion and sedimentation
Revegetation	Stabilize exposed soils to reduce wind and water erosion	• Establish permanent vegetation or temporary seeding in areas of exposed soils as soon as possible • Consider using fast growing vegetative species to provide faster stabilization and erosion control • Vegetative species will be selected based on slope, aspect, growth medium, and stabilization goals, using non-invasive, native seed mix
Erosion Blankets	Stabilizes slopes and exposed soils to reduce erosion	Consider the use of erosion blankets on steep slopes with exposed soils.
Silt Fencing	Protects downslope areas by preventing further movement of sediment being transported by water	• Consider using silt fencing to reduce soil erosion on gentle slopes • If sediment has the potential to enter a waterbody, silt fencing should be properly installed along the base of the cut or fill
Straw Bales and Waddles	Protects downslope areas by slowing the velocity of water and collecting sediment	• Consider using straw bales on gentle slopes to slow the velocity of water and collect sediment • Straw waddles can be used on exposed slopes to slow water erosion and sedimentation • Confirm bales or waddles have been approved and are weed free
Sheeting	A temporary erosion control method used for emergency situations and intended to be replaced by a more permanent application in the near future	• Consider the use of sheeting using impermeable polyethylene sheets, in areas with exposed soils that require immediate, temporary and short-time erosion prevention • Regular maintenance of Polyethylene sheets will be required as they are susceptible to tears and movement by wind or heavy precipitation events
Dust Control	Soil erosion can occur by wind, through the transportation of fine-textured materials from exposed soils including roads and soil stockpiles. The fine-textured particles have the potential to be deposited in waterbodies.	During windy seasons, consider applying dust control methods such as calcium chloride or water to reduce wind erosion

Controls	Purpose	Control Prevention
Rock, Riprap, or other Materials	Reduces exposed soil surfaces that have the potential to enter waterbodies	Use rock, riprap, or other materials on exposed soil surfaces the bank of waterbodies to reduce erosion and sedimentation

While prevention is the preferred manner to manage erosion and sediment transfer, a response and countermeasures plan is required in the event of an erosion or sediment release occurrence during any phase of the Project. A key to effective response is the timely implementation of controls and mitigation measures by following clearly established procedures. Details of the notification process and response actions are provided in the ESCP, Chapter 33, Section 33.4.1.4.

Restore on Site

Progressive reclamation objectives toward the restoration of the site and post-mine environment targets have the goal of creating a diverse post-mine landscape, which recreate biodiversity features and habitat linkages through the reclamation of post-mine landforms. The post-mine environment was stratified through elevation, aspect, slope, and expected moisture. It is assumed that through reclamation, all areas will receive salvaged soil to a minimum depth of 30 cm and woody debris and will be revegetated. During slope recontouring and soil replacement, there will be emphasis placed on the creation of both micro- and meso-topography that will help facilitate diverse ecosystems. Examples, such as rough and loose surface preparation (including the incorporation of woody debris), provide an effective way to control erosion and create conditions that promote revegetation and a diversity of habitats, thereby improving the ecological resilience of a site. The objective will be to replace soils within the Project footprint so that self-sustaining ecosystem function is restored, and soil quality and soil quantity are unchanged in their average capability compared to present baseline condition. In the event that insufficient volume of soil is available from soil salvage stockpiles to meet the reclamation objectives, imported soil will meet the soil quality objectives for the site based on land use and ecological function.

A monitoring program is a key component of the Erosion and Sediment Control Plan, as it will be used to evaluate the effectiveness of preventative erosion and sediment control strategies throughout all phases of the Project. The monitoring program will be implemented and managed by the NWP Environmental Manager; however, a range of Project personnel will be trained to participate in the program.

Under the Erosion and Sediment Control Plan, the NWP Environmental Manager (or a responsible designated alternate) will be responsible for the reporting requirements relevant to erosion and sediment control throughout all phases of the Project including Reclamation and Closure and Post-Closure. This reporting will be conducted in accordance with the requirements and conditions of all permits, approvals, and authorizations obtained for the Project with relevance to erosion and sediment control, including annual permit and license reporting, corporate reporting, and potential additional reporting requirements based on the occurrence of erosion and sediment release events. Reporting will include the notification of appropriate government agencies, stakeholders, landowners, and nearby communities, as required.

8.5.3.2.2 Mitigation Measures for Changes to Soil Quality

This subsection describes mitigation strategies for the following potential Project effects on soil quality.

To address potential changes to the physical properties of soil (i.e., soil quality) through the soil salvage, soil will be cleared and stockpiled following BMPs. In order to reduce soil degradation and changes to ecosystem function, small diameter salvaged biomass will be incorporated into salvaged soil prior to its placement, with larger amounts being incorporated into the organic-matter-poor subsoil and locations where plants tolerant of higher C/N ratios (e.g., black huckleberry) are to be established. Larger diameter coarse woody debris (CWD) will be placed on the ground surface in locations where it will function as erosion control, to provide favourable microsites for establishment of vegetation, and provide wildlife habitat. Greater amounts of CWD will be placed in ecosystems with greater productivity, with ecosystems that are graminoid dominated seeing little or no CWD being placed. Coarse woody debris will also be placed within waterbodies (pit lakes, sediment pond) to create habitat diversity.

There are extensive areas of coal-derived soils that may be salvaged at the upper elevations of Crown Mountain. The moisture holding capacity of the coal-derived subsoils are relatively poor. There is potential to mix the coal-derived subsoils with till parent material to increase the moisture holding capacity of the coal-derived soil while adding a humic acid source to the till. An additional benefit of mixing the coal-derived subsoil with till parent material is that the resultant soil material will be a lighter color than the coal-derived soil. On warm aspect slopes, soil temperatures can become limiting to plant growth on coal-derived soil (J. Przeczek, pers. comm. May 3, 2021). Testing the effect of this soil mixing on reclaimed vegetation productivity is suggested as a component of the Restoration Research Program as noted in the Ecological Restoration Plan (Chapter 33, Section 33.4.1.3).

As part of the mine closure phase, buildings and machinery, the transmission line, conveyor, storage tanks and other infrastructure (including scrap metal) will be dismantled, demolished, or disposed of appropriately. Concrete foundations will be broken up or buried under a suitable depth of cover (soil resources permitting) prior to revegetation. Roads and shop/laydown areas will be ripped by dozers to remove compaction and recontoured prior to soil replacement to effectively manage runoff. Soil replacement (to an average depth of 30 cm) will occur prior to revegetation in these areas. Areas of soil disturbance, within the powerline and conveyor corridors, will be reclaimed; otherwise vegetated areas will be left to continue their successional trajectory unless treatment of invasive plants is required.

In general, mitigation measures to the potential for increased contaminant loads in soil are addressed through the implementation of the Air Quality and Greenhouse Gas Management Plan (Chapter 33, Sections 33.4.1.1), the Site Water Management Plan (Chapter 33, 33.4.1.8), and the Soil Management Plan (Chapter 33, Section 33.4.1.9).

The primary measure to mitigate changes to soil quality from dust deposition is to reduce the potential for dust to settle within the Project footprint and to a lesser degree, within the surrounding areas. In addition, reducing soil contact with mine site drainage through storm water control and diversion ditches will reduce contaminant loadings in soil. Specific mitigation measures, as organized by mitigation hierarchy level, include:

- Avoid
    - Earth moving activities throughout the life of mine will be scheduled to limit the durations of exposed soils and to avoid dust-generating activities during windy periods, where practicable;
    - Dust generation from mining activities and equipment will be contained through the application of standard emission control measures (e.g., fabric covers for the coal stockpiles

and conveyers, a dust canopy for the run of mine [ROM] dump hopper) to intercept dust before it reaches the receiving environment;
  - Regular inspections will be conducted to verify air quality and dust control measures are effective and functioning properly, which will allow for timely maintenance and adjustments as required; and
  - Avoid soil contact with seepage water and storm runoff through drainage features such as drainage/diversion ditches and sedimentation ponds.
- Minimize
  - The layout of the site has been designed to minimize travel distances between operations (e.g., between the pits and the Coal Handling Process Plant) in order to reduce vehicle travel distances and speeds that would result in additional generation of dust emissions;
  - Enforcement of low speed limits for vehicular traffic throughout the site;
  - Unpaved roads will be regularly maintained and kept in good repair, including regular compaction and use of coarse aggregate with low silt content, where practicable;
  - Establish and follow site Soil Management Plan;
  - Soil stockpiles will placed at appropriate locations, and soil stored and shaped in ways to provide slope stability and reduce moisture content loss, including establishment of vegetation to reduce exposure to wind and water erosion; and
  - Water or dust suppression methods will be used from May to November to mitigate dust generation in areas including unpaved roads, work areas, and storage piles. Water for dust suppression will be withdrawn from the Interim Sediment Pond and Grave Creek Reservoir for the first five years of Operations, and then supplemented from the North Pit sumps for the remainder of the mine life.
- Restore On-Site
  - Progressive reclamation and re-vegetation will occur throughout the mine life to minimize wind erosion potential and reduce the Project footprint, minimizing the potential for dust deposition to nearby watercourses.

A full list of mitigation measures for dust emissions is provided in Chapter 6. Residual effects from dust deposition are not predicted on surface water quality through the implementation of the Air Quality and Greenhouse Gas Management Plan (Chapter 33, Section 33.4.1.1) and dustfall monitoring and adaptive management will be used to validate the efficiency of the proposed mitigation measures.

Potential adverse effects to soil through interaction with seepage water and metal leaching are addressed through a layered mine rock design, as an in situ mitigation strategy for selenium leaching. Based on scientific studies and wider knowledge of the geochemistry of Elk Valley coal mines, it is evident that ARD is typically of low concern; however, these studies have all identified metal leaching, specifically relating to the release of selenium, of principal concern. The approach to mine rock management for the Project is based on a layering of coal rejects and mine rock within the MRSF. The aim of the layered design is to mitigate against the oxidation of pyrite to prevent the release of selenium and nitrate in the long term. Excess neutralizing potential will also lead to attenuation of elements such as cadmium, zinc, and copper by reaction with iron oxides under basic weathering conditions.

The MRSF and pits are the primary sources of ML/ARD impacted seepage water on site. Interaction of soil with seepage water from these sources has the potential to adversely affect local soil quality. Adverse effects will be minimized through the implementation of the Site Water Management Plan (Chapter 33, Section 33.4.1.8) and the Soil Management Plan (Chapter 33, Section 33.4.1.9).

At reclamation, the MRSFs will receive roughly 30 cm of salvaged soil to facilitate revegetation of productive and diverse (in relation to previously reclaimed mines) plant communities. The sloping portions of the rock storage terraces will have CWD placed after salvaged soil is laid down to mitigate potential erosion and provide protected microsites for vegetation establishment.

The primary measure to mitigate potential effects to soil quality from metal and non-metal constituents contained in mine seepage will be to direct storm and contact water to the Interim and Main Sediment Ponds for settling to remove suspended solids and allow the testing of water to verify that water quality objectives are met prior to discharge into West Alexander Creek, as detailed in the SWMP. Infiltration/seepage from ponds into the ground has the potential to adversely affect soil quality; however, effects are expected to be effectively mitigated using impermeable liners to prevent losses. BMPs for pond management include requirements which must be met prior to discharge.

The sediment ponds are sized according to B.C. Ministry of Environment Technical Guidance 7 Environmental Management Act requirements (B.C. MOE, 2015), to settle particles having a diameter of 5 to 10 microns or greater during conveyance of runoff resulting from the 10-year, 24-hour storm event. They also include riprap spillway structures and containment berms to contain and convey the 200-year, 24-hour storm and maintain adequate freeboard. Avoidance measures include the diversion of clean, non-contact water away from the sediment ponds and other Project infrastructure, where possible, to reduce the burden on the sediment ponds. Restorative measures include progressive reclamation and revegetation throughout mine life to reduce the Project footprint, minimizing the potential for surface runoff from mine disturbed areas. The Main Sediment Pond will be decommissioned Post-Closure once effluent quality objectives have been met.

During reclamation, the water management structures, including the sedimentation pond and collection ditches, will remain in place until the reclamation earthwork activities have been completed; these include re-sloping dump faces and re-establishing vegetation to prevent surface erosion across the site. Once the reclamation activities have been completed, the collection ditches will be recontoured to match the adjacent landform and capped with topsoil to meet the closure water management plan requirements. The two ponds in East Pit will be re-graded in a manner that allows for them to be converted to shallow water wetlands that are geotechnically stable for the long-term and not classified as water retaining structures. This will allow surface waters to flow along the new drainage features. Depending on potential selenium management requirements into the Post-Closure phase, portions of the existing water management system can (may) be left in place for an extended period for continued mitigation of downstream effects on the receiving environment.

Dust control measures will be detailed in the site-wide Air Quality and Greenhouse Gas Management Plan, which will be further developed through the permitting process. In general, avoidance measures will be implemented to reduce dust generation from the Project activities, to meet air quality objectives and to reduce potential effects to reasonable levels. Dust levels and associated metal loadings that are in compliance with ambient air quality standards for dust are not anticipated to materially affect soil quality composition over the lifetime of the mine, compared to baseline levels. Minimization strategies and control measures to reduce dust generation will be implemented, and include avoiding windy periods, containment and interception, and regular inspections include mine site layout design to minimize travel distances and dust generation, low vehicle speed limits, maintenance of the site to reduce dust, and dust suppression from May to November as required. Coal processing, including hauling, run of mine sizing, stockpiling, and loading are conducted in designated areas on controlled surfaces or indoors to prevent coal dust deposition and infiltration of water to subsurface (i.e., soil). Dustfall monitoring and adaptive management will be used to validate the efficiency of the proposed mitigation measures.

Fuelling activities and bulk fuel storage activities are not anticipated to result in soil contamination, given the following mitigation measures. Fuel-related activities will occur in designated areas only. Fuel storage and fuelling stations will be located on the southern edge of the main shop pad area, and service fluid tanks will be located adjacent to the maintenance shop on a bermed secondary containment pad. Vehicle washing and routine maintenance activities will also occur in a lined facility or equivalent. Mitigation measures to minimize hydrocarbon releases to surface water are described in the Spill Prevention, Control, and Countermeasures Plan (Chapter 33, Section 33.4.1.10) and include, as organized by mitigation hierarchy level:

- Avoid
  - Designation of appropriate locations where mobile equipment will be refueled, lubricated, and serviced with appropriate containment measures; and
  - All fuels will be delivered to site by a licensed contractor.
- Minimize
  - Implementing procedures for handling and storing fueling and fuel transfer;
  - Developing, implementing, and documenting regularly scheduled site inspections, which include fueling locations and shops;
  - Inspecting vehicles and equipment regularly for leaks and document their condition;
  - Developing, implementing, and documenting a preventative maintenance program for all vehicles and equipment on site; and
  - Placement of spill kits at high risk locations (i.e., in areas with the highest risk activities).

Residual effects from hydrocarbons are not predicted on soil quality through the implementation of the Spill Prevention, Control, and Countermeasures Plan, and monitoring and adaptive management will be used to validate the efficiency of the proposed mitigation measures.

Additional mitigation measures to minimize potential effects on soil quality include the following:

- Coal processing activities including washing and run of mine sizing will be conducted within designated areas on controlled surfaces or indoors;
- Coal stockpiling and processing is contained within a building with concrete floor and containment, where process water enters via an interior sump and is recycled within the plant. Wash water is recirculated and reused throughout the process, which is a closed circuit with the exception of dryer by-products, clean coal product, and plant rejects; interaction of wash water and soil is not anticipated with these mitigations in place;
- Implement protection measures against contamination (Spill Prevention, Control, and Countermeasures Plan);
- Implement invasive plant control as per the Vegetation and Ecosystems Management and Monitoring Plan (Chapter 33, Section 33.4.1.11); and
- Continue metal uptake monitoring program

8.5.3.2.3 Mitigation Measures for Changes to Terrain

The Terrain LSA is located in steep mountainous terrain and landslides are often frequent processes on rugged ground. In general, potential Project-related changes to terrain will be reduced through design mitigation, regulatory requirements, BMPs, including management plans, monitoring, and adaptive management. Beyond those mitigation measures previously discussed for changes to soil quantity, the following mitigation measures will be implemented for effects on terrain and geohazards:

- Avoid
  - Identify and assess TS class IV and V and SEP class H and VH terrain that is located within or upslope of Project infrastructure;
  - Conduct terrain stability field assessments on areas classified as TS IV and V;
  - Detailed geotechnical plans required to avoid adverse effects;
  - Follow-up monitoring to determine effectiveness of mitigation;
  - Design adaptation to address stability issues; and
  - Designation of appropriate locations where mobile equipment will be refueled, lubricated, and serviced with appropriate containment measures.
- Minimize
  - Reduce spatial probability of impact (likelihood that the landslide will reach or impact the element at risk);
  - Reduce the temporal probability of impact (likelihood of workers being present in the zone subject to the hazard); and
  - Reduce the vulnerability (the degree of loss to a given element at risk within the area affected by the landslide hazard).
- Restore On-Site
  - Maintain mine slope and ramp stability (refer to Chapter 3).

Management plans and BMPs for the control of erosion and sedimentation will be implemented throughout the duration of the reclamation of the site into Post-Closure. The post-mine environment will receive salvaged soil to a minimum depth of 30 cm and woody debris and will be revegetated. In the event that insufficient volume of soil is available from soil salvage stockpiles to meet the reclamation objectives, imported soil will meet the soil quality objectives for the site based on land use and ecological function. During slope recontouring and soil replacement, there will be emphasis placed on the creation of both micro and meso-topography that will help facilitate diverse ecosystems. Examples, such as rough and loose surface preparation (including the incorporation of woody debris), provide an effective way to control erosion and create conditions that promote revegetation and a diversity of habitats, thereby improving the ecological resilience of an area. The re-contouring of the post-mine TEM ecological treatment will be designed to effectively improve terrain within the Project footprint to further prevent geohazards within the Project footprint. No soil disturbance will occur outside of the Project footprint; however, Project activities may result in minor instability in upgradient. This is not anticipated to result in widespread changes to terrain stability in the Terrain LSA as a result of the Project.

8.5.3.2.4 Summary of Mitigation Measures for Soil Quantity and Quality and Terrain

The key mitigation measures proposed to mitigate potential effects on soil quantity and quality and terrain are summarized in Table 8.5-5. This table also identifies the anticipated residual effects that will be carried forward in the characterization of residual effects, significance, and likelihood and confidence.

These proposed mitigation measures are generally accepted, understood, and proven to effectively reduce environmental effects related to soil and terrain. If monitoring indicates that the effectiveness of mitigation measures is lower than predicted, further mitigation may be required as per adaptive management strategies. Given that the effects on soil quantity and quality cannot be completely avoided,

the overall effectiveness of the proposed mitigation to address potential soil loss during clearing, grubbing, and soil salvage activities, and alteration of soil quality due to interactions with seepage and ML/ARD are rated as moderate. Where mitigation measures do not or may not mitigate all effects or if there is a low level of confidence in their effectiveness, the effect was carried forward for further analysis of residual effects. Mitigation measures that are expected to completely mitigate potential effects with a high level of confidence based on their proven effectiveness elsewhere were classified as having no expected residual effects.

Additional information regarding mitigation measures, BMPs and their effectiveness are addressed through various site-specific management and monitoring plans (Chapter 33). If monitoring indicates that the effectiveness of mitigation measures is lower than predicted, further mitigation, monitoring and/or adaptive management strategies will be implemented.

With the implementation of proposed mitigation measures, the following potential Project effects on soil quantity, soil quality, and terrain are not carried forward as residual effects because they are anticipated to be completely mitigated by the proposed measures for the Project:

- Loss of soil during construction of development infrastructure within the Project footprint;
- Loss of soil through erosion associated with site drainage and discharge of mine site water from sedimentation ponds;
- Changes to soil quality associated with fugitive dust deposition;
- Changes to soil quality due to infiltration of effluent discharge to soil from sedimentation pond discharge points and during pond decommissioning;
- Routine use of hydrocarbon fuels on site, fuel handling, dispensing and transferring; and
- Changes to terrain type, slope, and aspect, in the context of their potential effects on terrain stability, which have the potential to result in increased frequency and intensity of geohazards/landslides.

8.5.3.3 Characterization of Residual Effects, Significance, Likelihood, and Confidence

Based on the evaluation of potential Project effects on soil quantity, soil quality, and terrain, potential residual effects that may remain after implementation of proposed mitigation measures include:

- Loss of soil quantity during clearing and grubbing, and soil salvage activities; and
- Changes to soil quality due to interactions with seepage and ML/ARD.

Table 8.5-5: Proposed Mitigation Measures for Soil Quantity, Soil Quality, and Terrain

Potential Effect	Mitigation Measure	Rationale	Applicable Project Phase(s)	Effectiveness	Residual Effect
Soil Quantity					
Loss of soil during clearing and grubbing, and soil salvage activities	• Biomass salvage, soil salvage. • Implementation of the ESCP through avoidance and minimization controls • Implementation of a response plan in the event of a sediment release • Progressive reclamation and soil replacement and revegetation • Erosion control measures such as rough and loose surface preparation and incorporation of woody debris provide an effective way to control erosion	• Implementation of controls through the ESCP are effective in minimizing soil loss by erosion and sedimentation during clearing and grubbing. Responding to and reporting any sediment release events will minimize the long term effects • Soil replacement and mitigation of erosion effects promote revegetation and a diversity of habitats. This contributes to a more ecologically resilient post-mine landscape, which recreate biodiversity features and habitat linkages through the reclamation of post-mine landforms	• Construction and Pre-Production • Operations • Reclamation and Closure • Post-Closure	Moderate	Yes
Loss of soil during construction of development infrastructure within the Project footprint	• Engineered controls such as benching, ditching, damming, retention and settling ponds, revegetation and recontouring, slope stabilization, mulching, silt-fencing, designated vehicular and heavy equipment travel areas, and placement of other erosion control features during development of the site, in accordance with the ESCP • Implementation of a response plan in the event of a sediment release	• Erosion and sediment control measures (e.g., silt fencing) are standard industry practices and proven to be effective against soil loss through erosion and compaction. Regular inspection of erosion and sediment control measures allow for timely repairs and adjustments as required. Minimizing the Project footprint minimizes potential erosion and sedimentation effects to surface water	• Construction and Pre-Production • Operations • Reclamation and Closure • Post-Closure	High	No

Potential Effect	Mitigation Measure	Rationale	Applicable Project Phase(s)	Effectiveness	Residual Effect
	• Conduct regular inspections to confirm control measures are effective and functioning properly • Limit the mine disturbance footprint through Project design and progressive reclamation and revegetation as available	• Responding to and reporting any sediment release events will minimize the long term effects • Soil replacement and mitigation of erosion effects promote revegetation and a diversity of habitats			
Loss of soil through erosion associated with site drainage and discharge of mine site water from sedimentation ponds	Engineered site drainage directing storm and contact water flow to sediment ponds. Discharge of water from designated discharge points to West Alexander Creek, including implementation of erosion control measures in accordance with the ESCP	Implementation of ESCP measures at discharge points and throughout the site to minimize the erosion potential of discharge events from the sediment ponds.	• Operations • Reclamation and Closure • Post-Closure	High	No
Soil Quality					
Changes to soil quality associated with fugitive dust deposition	• Efforts to reduce dust generation such as avoiding windy periods, containment and interception, and regular inspections • Minimization strategies include mine site layout design to minimize travel distances and dust generation, low vehicle speed limits, maintenance of the site to reduce dust, and dust suppression from May to November • Generally, processing and handling of coal product is on controlled surfaces or indoors	• Residual effects from dust deposition are not predicted on soil quality through the implementation of the Air Quality and Greenhouse Gas Management Plan, and dustfall monitoring and adaptive management will be used to validate the efficiency of the proposed mitigation measures • Coal processing, including hauling, run of mine sizing, stockpiling, and loading are conducted in designated areas on controlled surfaces or indoors to prevent infiltration of water to subsurface (i.e., soil)	Operations	High	No

Potential Effect	Mitigation Measure	Rationale	Applicable Project Phase(s)	Effectiveness	Residual Effect
Changes to soil quality due to interactions with seepage and ML/ARD	• Engineered layering of coal rejects and mine rock at the MRSF, engineered site drainage, and progressive reclamation by re-vegetation and re-sloping • Implementation of a ML/ARD plan for the site, including diversion of storm runoff around mine disturbed areas, where practical • Conduct regular inspections to confirm control measures are effective and functioning properly	• Routing of potentially ML/ARD-affected water around the MRSF and from pits to sedimentation ponds will reduce the potential for infiltration of water to soil, thereby reducing the potential impacts of metal and non-metal contaminants in water on soil quality • The proposed layered MRSF design will be evaluated during the first few years of Operations to determine if successful by monitoring for evidence of decreasing oxygen levels and water chemistry indicators of nitrate and selenium removal such as stable isotopes • Progressive reclamation will limit exposure time of the MRSF	• Operations • Reclamation and Closure • Post-Closure	Moderate	Yes
Changes to soil quality due to infiltration of effluent discharge to soil from sedimentation pond discharge points and during pond decommissioning	• Engineered site drainage directing storm and contact water flow to sediment ponds • Discharge of water from designated discharge points to West Alexander Creek once water quality objectives have been met • Installation of impermeable liners in the Interim and Main Sediment Ponds and appropriate sizing of sediment ponds to minimize seepage losses and convey runoff during storm events	• Implementation of ESCP measures at discharge points and throughout the site to minimize the potential interaction of mine site water with soil, thereby reducing the potential impacts of metal and non-metal contaminants in water on soil quality • Impermeable geomembrane liners are proven to be effective in preventing seepage of pond water to the subsurface (including soil) • Appropriately sized sediment ponds are proven to be effective to settle particles	• Operations • Reclamation and Closure • Post-Closure	High	No

Potential Effect	Mitigation Measure	Rationale	Applicable Project Phase(s)	Effectiveness	Residual Effect
Routine use of hydrocarbon fuels on site, fuel handling, dispensing and transferring	• The storage and transfer of fuel will be restricted to designated areas • Implementing procedures for handling and storing fueling and fuel transfer such as appropriate secondary containment infrastructure and training of staff • Conducting regular site and vehicle inspections • Preventative maintenance for all vehicles and equipment on site	• Standard industry practices for handling, storing, and transferring fuel are proven to be effective at reducing the release of hydrocarbons to the receiving environment • Regular inspections of the site, vehicles, and equipment allow for timely repairs and adjustments as required	• Construction and Pre-Production • Operations • Reclamation and Closure • Post-Closure	High	No
Terrain					
Changes to terrain type, slope, and aspect	• Biomass and soil salvage will be conducted within the Project footprint disturbance areas according to BMPs, including segregation of the upper productive soil unit from lower soils • Progressive reclamation including recontouring towards stable post-mine landforms using salvaged soil and biomass, with an emphasis on the creation of both micro- and meso-topography to facilitate diverse ecosystems	• Soil salvage stockpiles will be managed according to BMPs including erosion control and revegetation measures and enhance soil organic matter accumulation over time • Progressive reclamation with the objective of meeting post-mine site restoration and environmental targets. The goal is to create a diverse post-mine landscape, which recreates biodiversity features and habitat linkages through the reclamation of post-mine landforms	• Construction and Pre-Production • Operations • Reclamation and Closure • Post-Closure	High	No
Changes to terrain stability resulting in increased frequency and intensity of geohazards (i.e., rapid and slow mass	• Implementation of the ESCP through avoidance, minimization controls, and on-site restoration • Detailed geotechnical plans required to avoid adverse effects,	• Implementation of controls through the ESCP are effective in minimize soil loss by erosion and sedimentation, thereby decreasing the risk of soil destabilization.	• Construction and Pre-Production • Operations • Reclamation and Closure	High	No

Potential Effect	Mitigation Measure	Rationale	Applicable Project Phase(s)	Effectiveness	Residual Effect
movement/landslides) through each Project phase	and design adaptation to address stability issues • Implementation of a response plan in the event of a sediment release • Identification of high risk areas for terrain stability and geohazards, and avoidance of soil disturbance within and downslope • The post-mine TEM ecological treatment has been designed to improve terrain within the Project footprint by reshaping during Reclamation to further prevent geohazards over the long term	Responding to and reporting any sediment release events will minimize the long term effects • Avoidance of high risk areas will minimize the spatial probability, temporal probability, and vulnerability (i.e., degree of loss) of impacts resulting from geohazards and reduced terrain stability • The final resloping of the Project footprint during Reclamation and Closure will have a stabilizing effect on terrain, and is not anticipated to result in a widespread reduction in slope stability	• Post-Closure		

Potential loss of soil resulting from construction of development infrastructure and discharge of mine effluent from sedimentation ponds are expected to be effectively managed through avoidance and minimization measures, and implementation of the ESCP and BMPs. Adverse effects on soil quality at pond discharge points will be mitigated through the construction design of the ponds, including impermeable liners. Pond discharge effluent will meet water quality targets prior to discharge to West Alexander Creek. Avoidance measures will be implemented to reduce dust generation and deposition to meet air quality objectives and to reduce potential for soil contamination due to fugitive dust to reasonable levels. Fuelling activities will be restricted to designated areas with spill and release controls in place, as well as implementation of safe refuelling procedures. Measures including reduction of admixing, incorporation of woody material, soil stockpiling and biomass salvage, and progressive reclamation and revegetation are expected to effectively mitigate adverse effects on soil quality associated with clearing, grubbing, and salvage activities. Post-mine ecological treatment and resloping during Reclamation and Closure have been designed to improve stability within the Project footprint, and are not anticipated to result in widespread increases in the frequency and intensity of geohazards/landslides. Accordingly, these potential adverse effects to soil quantity and soil quality due the Project have not been identified as residual effects and are not carried forward.

8.5.3.3.1 Loss of Soil Quantity during Clearing and Grubbing, and Soil Salvage Activities

Removal and/or relocation of soil from the Project footprint will alter the thickness and distribution of soils. Soil clearing, grubbing, salvage, and stockpiling activities increase the potential for loss of soil through erosion and sedimentation. Implementation of the ESCP through avoidance and minimization controls provide the key mitigation measures to reduce the potential loss of soil quantity resulting from these activities during the Construction and Pre-Production and Operations phases. Progressive reclamation, soil replacement and revegetation and a diversity of habitats during reclamation, and responding to and reporting any sediment release events, will minimize any long term effects. These measures will contribute to an ecologically resilient post-mine landscape, which recreates biodiversity features and habitat linkages through the reclamation of post-mine landforms. The residual effect that will remain to soil quantity associated with soil clearing and salvage activities is characterized as follows:

- Duration: Permanent, in some portions of the Project footprint, soil loss due to erosion during clearing and grubbing will be permanent; however, the majority of areas will receive salvaged soil during progressive reclamation and be revegetated at Reclamation and Closure.
- Magnitude: Low, the post-mine environment will receive salvaged soil to a minimum depth of 30 cm and woody debris and will be revegetated in the majority of areas.
- Geographic Extent: Discrete, clearing, grubbing, and soil salvage activities are confined to the specific areas to be physically disturbed within the Project footprint. Mitigation measures will be implemented to avoid soil loss beyond the Project footprint.
- Frequency: Continuous, the potential for soil loss is anticipated to be at a maximum during the Construction and Pre-Production phase, during which the majority of clearing and soil disturbance activities will occur, and to a lesser extent during the Operations phase with the progressive development of the pits and MRSF.
- Reversibility: Reversible long-term, changes in soil quantity resulting from the Project are anticipated to be potentially reversible, following replacement of salvaged soil and revegetation during progressive reclamation and Post-Closure.

- Context: Neutral, soil quantity is anticipated to have neutral sensitivity and resilience to disruption and is anticipated to have neutral context relating to other ecological and social VCs following reclamation.

Determination of Significance

A significant effect is considered to soil quantity when it is changed so that successful reclamation to self-sustaining ecosystems with an average capability comparable to that of the present baseline is prevented. Given that the majority of the post-mine environment will be reclaimed to facilitate overall soil health and ecosystem function, and will be revegetated to prevent future erosion, successful reclamation is anticipated to occur. As such, the residual effect on soil quantity during clearing, grubbing, and soil salvage activities during the Project is considered not significant. Receptor VCs that are related to soil quantity include wildlife such as American badger; Chapter 15), and each of the landscapes and ecosystems receptor VCs (Chapter 13). Potential effects of the Project on these receptor VCs were found to be not significant, and by extension, the corresponding residual effects on soil quantity are therefore not significant.

Likelihood and Confidence

Effects that are determined to be not significant do not require a characterization of likelihood.

Confidence considers the reliability of data and analytical methods used in the assessment of effects. The confidence in the characterization of the residual effect to soil quantity associated with clearing, grubbing, and soil salvage activities is considered moderate, since there are gaps in data related to the final distribution of soils throughout the post-mine reclaimed environment.

8.5.3.3.2 Changes to Soil Quality due to Interactions with Seepage and ML/ARD

Mine site drainage water in contact with development infrastructure such as pits and the MRSF may result in acid generation and metal leaching (i.e., sulphate, calcite, nitrate, and selenium). Without mitigation, generation of ML/ARD associated with active mine site operations has the potential to affect soil quality through interactions with impacted mine site drainage and seepage water by increasing concentrations of metals and other contaminants in soil. Key mitigations measures for the reduction of ML/ARD include implementation of a ML/ARD plan for the site, including diversion of storm runoff around mine disturbed areas, where practicable. MSRF engineered design incorporates layering of coal rejects and mine rock to reduce oxygen ingress and generation of ML/ARD. Where practicable, mine site drainage will be routed around the MRSFs and from pits to sedimentation ponds and will reduce the potential for infiltration of potentially ML/ARD-impacted water to soil, thereby reducing the potential impacts of metal and non-metal contaminants in water on soil quality. Progressive reclamation by re-vegetation and re-sloping will limit exposure time of the mine rock, and further reduce ML/ARD potential over the long term. The residual effect that will remain to soil quality associated with interactions with mine site drainage/seepage and ML/ARD is characterized as follows:

- Duration: Permanent, soil contact with seepage associated with ML/ARD has the potential to occur through each Project phase. Effects on soil quality are anticipated to persist beyond 34 years within the Project footprint.
- Magnitude: Moderate, contaminant loadings in soil are anticipated to be measurable compared to baseline conditions; however, given the generally low ML/ARD potential in the Soil Quality and Quantity LSA, are not anticipated to exceed standards/guidelines. Should exceedances occur, they

would be expected to occur only for parameters that are already elevated in the area due to geology or other factors, and would likely be approximately equal to or only marginally above standards/guidelines.

- Geographic Extent: Discrete, soil impacts associated with mine site drainage/seepage that could adversely affect soil quality would be expected to be confined to within the limits of the Project footprint. BMPs and mitigation measures such as layered mine rock design and water management/sedimentation ponds will be implemented to reduce ML and contaminant loadings in mine effluent and seepage. BMPs, the ESCP, and avoidance measures will be implemented to reduce the contact of soil with mine contact water and storm drainage.
- Frequency: Continuous, the potential for soil contact with ML/ARD is anticipated to be at a maximum during the active mining Operations phase; however, will occur to a lesser degree during each Project phase.
- Reversibility: Irreversible, contaminant loadings in surficial soil resulting from ML/ARD within the limits of the Project footprint are anticipated to be permanent.
- Context: Neutral, soil quality is anticipated to have neutral sensitivity and resilience to disruption and is anticipated to have neutral context relating to other ecological and social VCs following reclamation.

Determination of Significance

A significant effect is considered to soil quality when it is changed so that successful reclamation to self-sustaining ecosystems with an average capability comparable to that of the present baseline is prevented. ML/ARD potential for the Project is generally low, based on the ML/ARD characterization of the coal and mine waste, and implementation of ML/ARD management strategies are effective mitigation measures for the protection of soil quality. Given that the majority of the post-mine environment will be reclaimed to facilitate overall soil health and ecosystem function, and will be revegetated, successful reclamation is anticipated to occur. As such, the residual effect on soil quality resulting from impacts associated with ML/ARD generation during the Project is considered not significant. Further, receptor VCs that are related to soil quality are linked to potential contaminant uptake by landscapes and ecosystems (Chapter 13), vegetation (Chapter 14), and wildlife (Chapter 15). Exposure pathways and potential effects are addressed in the human and ecological health assessment (Chapter 22) and are therefore not repeated here. Potential effects of the Project on these receptor VCs were found to be not significant, and by extension, the corresponding residual effects on soil quality are therefore not significant.

Likelihood and Confidence

Effects that are determined to be not significant do not require a characterization of likelihood.

Confidence considers the reliability of data and analytical methods used in the assessment of effects. The confidence in the characterization of the residual effect to soil quality associated with seepage and ML/ARD is considered moderate, since there are gaps in data related to the final distribution of soils throughout the post-mine reclaimed environment.

8.5.3.3.3 Summary of Residual Effects Assessment

Residual effects and the selected mitigation measures, characterization criteria, likelihood, significance determination, and confidence are summarized in Table 8.5-6. No significant residual effects to soil quantity, soil quality, and terrain are anticipated as a result of the Project.

Table 8.5-6: Summary of Residual Effects on Soil Quantity and Soil Quality

Residual Effect	Project Phase(s)	Mitigation Measures	Summary of Residual Effects Characterization	Significance (Significant, Not Significant)	Confidence (High, Moderate, Low)
Soil Quantity					
Loss of soil quantity during clearing and grubbing, and soil salvage activities	• Construction and Pre-Production • Operations • Reclamation and Closure • Post-Closure	• Biomass salvage, soil salvage. • Implementation of the ESCP through avoidance and minimization controls • Implementation of a response plan in the event of a sediment release • Progressive reclamation and soil replacement and revegetation • Erosion control measures such as rough and loose surface preparation and incorporation of woody debris	Duration: Permanent Magnitude: Low Geographic Extent: Discrete Frequency: Continuous Reversibility: Reversible long-term Context: Neutral	Not Significant	Moderate
Soil Quality					
Changes to soil quality due to interactions with seepage and ML/ARD	• Operations • Reclamation and Closure • Post-Closure	• Engineered layering of coal rejects and mine rock at the MRSF, engineered site drainage, and progressive reclamation by re-vegetation and re-sloping • Implementation of a ML/ARD plan for the site, including diversion of storm runoff around mine disturbed areas, where practicable • Conduct regular inspections to confirm control measures are effective and functioning properly	Duration: Permanent Magnitude: Moderate Geographic Extent: Discrete Frequency: Continuous Reversibility: Irreversible Context: Neutral	Not Significant	Moderate

8.6 Cumulative Effects Assessment

8.6.1 Overview of Residual Effects

Based on the characterization of residual effects on soil quantity and soil quality, those Project effects that may remain after implementation of proposed mitigation measures were characterized as not significant. These potential residual not significant effects include:

- Loss of soil quantity during clearing and grubbing, and soil salvage activities; and
- Changes to soil quality due to interactions with seepage and ML/ARD.

Residual effects on terrain were not identified during the Project effects assessment.

8.6.2 Assessment Boundaries

The spatial boundary of the cumulative effects assessment is the Soil Quality and Quantity RSA, which is spatially equivalent to the Soil Quantity and Quality LSA (Figure 8.2-1). Since potential effects on soil quantity and quality are directly associated with areas of soil disturbance within the Project footprint only, the Soil Quality and Quantity RSA provides a conservative boundary to constrain the areas where soil may be affected by Project activities.

Temporal, administrative, and technical boundaries for the cumulative effects assessment are equivalent to those used in the characterization of residual Project Effects (refer to Section 8.2.3).

The effects of past and present projects and activities in the Soil Quality and Quantity RSA are generally represented by Existing Conditions as documented in Section 8.4.

8.6.3 Identifying Past, Present, and Reasonably Foreseeable Projects and/or Activities

The Project is nearby to other metallurgical coal mines in the Elk Valley and Crowsnest coal fields, including Teck's Elkview Operations (8 km southwest) and Line Creek Operations (12 km north); however, these are both located outside of the Soil Quality and Quantity RSA for the Project. No past, present, or reasonably foreseeable future projects or activities that may have an adverse effect on soil quantity or soil quality are expected to spatially overlap with each other within the Soil Quality and Quantity RSA, since effects on soil quality or soil quantity are generally limited to within the footprint of the specific project in question.

8.6.4 Potential Cumulative Effects

8.6.4.1 Soil Quantity

Potential loss of soil quantity during clearing and grubbing, and soil salvage activities for the Project is predicted to occur in the form of excavation, erosion, and compaction during the removal and/or relocation of soil from the Project footprint. Similar activities would be expected to occur for other reasonably foreseeable future projects or activities. These changes to the depth and distribution of soils within disturbed areas are expected to occur only within the respective footprints of the Project and those of other reasonably foreseeable future projects or activities, none of which overlap each other spatially within the Soil Quality and Quantity RSA. As such, changes to soil quantity confined to the limits of the Project footprint and the respective footprints of other reasonably foreseeable future projects or activities, are not considered significant at the scale of the Soil Quality and Quantity RSA. Since potential changes in soil quantity beyond the Project footprint are not significant, and because there are no overlapping effects of other past, present, or reasonably foreseeable future projects or activities within the Soil Quality and Quantity RSA itself, there are no cumulative effects on soil quantity resulting from clearing and grubbing, and soil salvage activities as a result of the Project in combination with other past, present, or reasonably foreseeable future projects or activities. Therefore, further cumulative effects assessment for soil quantity is not required.

8.6.4.1.1 Determination of Significance of Residual Cumulative Effects

A significant residual cumulative effect is considered to soil quantity when it is changed so that successful reclamation to self-sustaining ecosystems with an average capability comparable to that of the present baseline is prevented. Given that the majority of the post-mine environment will be reclaimed to facilitate overall soil health and ecosystem function, and will be revegetated to prevent future erosion, successful reclamation within the areas of soil disturbance (i.e., Project footprint) is anticipated to occur. Given that there is no anticipated spatial and temporal overlap between any potential effects on soil quantity and those of other past, present, and reasonably foreseeable future projects or activities, the residual cumulative effect on soil quantity during clearing, grubbing, and soil salvage activities is considered not significant.

8.6.4.1.2 Likelihood and Confidence

Effects that are determined to be not significant do not require a characterization of likelihood. Since the effects on soil quantity are directly linked to changes in the footprints of the Project and those of other past, present, and reasonably foreseeable future projects are activities, none of which overlap spatially with each other, there is a high level of confidence in the significance prediction for cumulative effects on soil quantity.

8.6.4.2 Soil Quality

A summary of the baseline soil quality for the Project is provided in Section 8.4.2.2.1. Based on statistical analysis, elevated concentrations of some metals in soil, namely selenium and barium, are likely attributable to naturally elevated baseline conditions associated with the local geology, rather than adjacent land use (e.g., other mining operations within the Elk Valley). The not-significant residual effect identified for adverse effects on soil quality is due to interactions with mine site water (i.e., seepage) and ML/ARD.

Since any residual effects on soil quality due to the Project are limited to the extent of the Soil Quality and Quantity RSA, no spatial or temporal overlap of the Project effects on soil quality with those of past, present, and other reasonably foreseeable future projects or activities is anticipated. Given that there is no anticipated spatial and temporal overlap between any potential effects on soil quality associated with the Project and those of other past, present, and reasonably foreseeable future projects or activities, it follows that cumulative effects are not likely to occur, and a cumulative effects assessment for soil quality is not warranted.

8.6.4.2.1 Determination of Significance of Residual Cumulative Effects

A significant residual cumulative effect is considered to occur when it is changed so that successful reclamation to self-sustaining ecosystems with an average capability comparable to that of the present baseline is prevented. ML/ARD potential for the Project is generally low, based on the ML/ARD characterization of the coal and mine waste, and implementation of ML/ARD management strategies are effective mitigation measures for the protection of soil quality. Given that successful reclamation with the goal of facilitating overall soil health and ecosystem function is anticipated to occur, and given that there is no anticipated spatial and temporal overlap between any potential effects on soil quantity and those of other past, present, and reasonably foreseeable future projects or activities, the residual cumulative effect on soil quality resulting from impacts associated with ML/ARD generation is considered not significant.

8.6.4.2.2 Likelihood and Confidence

Effects that are determined to be not significant do not require a characterization of likelihood. Since the effects on soil quality are directly linked to changes in the footprints of the Project and those of other past, present, and reasonably foreseeable future projects are activities, none of which overlap spatially with each other, there is a high level of confidence in the significance prediction for cumulative effects on soil quality.

8.6.5 Summary of Cumulative Effects Assessment

In consideration of the above, there are no residual cumulative effects of the Project in combination with those of other past, present, and reasonably foreseeable future projects or activities on soil quantity and soil quality during all phases of the Project; they are, by default, rated not significant, with a high level of confidence.

8.7 Follow-up Strategy

For any residual effects due to the Project assessed, in consideration of applied mitigation measures and best practices to avoid, minimize, or reduce environmental effects, the residual environmental effects of activities associated with the Project, during each of the Project phases, on soil quantity and soil quality were rated not significant, with a moderate level of confidence. As described previously in Section 8.6, further cumulative effects assessment for soil quantity and soil quality is not warranted; however, the Canadian Environmental Assessment Act, 2012 requires that a follow-up program be conducted when the level of confidence in the Project effects assessment is less than high, either to verify the effects predictions or to verify the effectiveness of mitigation measures.

Effective design and construction, mitigation, adaptive measures, and good housekeeping and management practices, as well as additional geohazard risk assessments will be required during all phases of the Project. The implementation of these site-specific mitigation and/or adaptation measures, including appropriate design, monitoring, maintenance of facilities, and response to incidents, can significantly reduce the potential for adverse effects on soil quantity, soil quality, and terrain.

Additional follow-up measures include a monitoring program for soil quantity and quality, as outlined in the Soil Management Plan (Chapter 33, Section 33.4.1.9). The monitoring program will be used to evaluate the effectiveness of preventative erosion and sediment control strategies throughout all phases of the Project, and may include the following components:

- A schedule for routine inspections of the Project footprint, including inspection of developed areas to identify unstable or potentially unstable terrain, early signs of erosion, and evidence of sediment transportation;
- Guidelines outlining when work would be temporarily stopped, based on risk to nearby watercourses and/or wetlands resulting from precipitation and/or snow-melt events;
- Installation and inspection of erosion and sediment control measures and implementation of best management practices;
- Establish monitoring stations at watercourses and/or wetlands adjacent to the Project footprint and along access roads;
- Development of a communications plan for the reporting on the effectiveness of mitigation measures, and notification procedures in the event of erosion or sediment control failure, incidents, and/or potential geohazards; and
- A reporting plan, in which the documented monitoring results and observations are submitted to senior management and applicable regulatory agencies, as required.

The monitoring program will be refined and supplemented with additional site-specific details prior to commencement of the Construction and Pre-Production phase, as the permitting process progresses. Throughout each Project phase, monitoring results will be compared to baseline data to assess the effectiveness of mitigation measures to support the evaluation and improvement of soil management and erosion control practices, and inform the development of adaptive management measures, should they be required.

8.8 Summary and Conclusions

The Crown Mountain Coking Coal Project (the Project) is predicted to result in a not significant residual effect on soil quantity in the form of loss of soil quantity during clearing and grubbing, and soil salvage activities within disturbed areas of the Project footprint. In addition, a not significant residual effect is predicted to occur to soil quality due to interactions with seepage and ML/ARD associated with mine site drainage infrastructure. Based on the characterization of residual effects on soil quantity and soil quality, potential local effects are associated with disturbance areas and engineered mine site drainage infrastructure (i.e., drainage ditches and sedimentation ponds) within the Project footprint.

The maximum loss of soil quantity is predicted to occur during clearing and grubbing, and soil salvage activities for the Project resulting from excavation, erosion, and compaction during the removal and/or relocation of soil from the Project footprint. Changes to soil quantity are confined to the limits of the Project footprint and the respective footprints of other reasonably foreseeable future projects or activities, are considered not significant at the scale of the RSA, given the implementation of erosion control and other mitigation measures. Since potential changes to soil quantity beyond the Project footprint are not significant, and because there are no overlapping effects of other past, present, or reasonably foreseeable future projects or activities within the RSA itself, no cumulative effects on soil quantity resulting from the Project have been identified and further cumulative effects assessment for soil quantity is not warranted. The residual cumulative effects of the Project in combination with those of other past, present, and reasonably foreseeable future projects or activities on soil quantity during all phases of the Project are rated not significant, with a high level of confidence.

The Project is predicted to result in a not significant residual effect to soil quality marked by increased concentrations of some constituents in soil (primarily metals) within the Project footprint. The adverse effects on soil quality are predicted to result from interactions with mine site water (i.e., seepage) and ML/ARD within the context of engineered mine drainage infrastructure. Given that ML/ARD potential for the Project is generally low, based on the ML/ARD characterization of the coal and mine rock, and implementation of ML/ARD management and other mitigation measures considered effective for the protection of soil quality, successful reclamation is anticipated to be feasible, and is anticipated to result in no cumulative effect on soil quality. The residual effects on soil quality due to the Project are rated not significant, with a high level of confidence, and are limited to the extent of the RSA with no spatial or temporal overlap with those of past, present, and other reasonably foreseeable future projects or activities; no cumulative effects are deemed likely to occur. As such, a cumulative effects assessment for soil quality is not warranted.

Potential residual effects on terrain resulting from the Project were not identified during the effects assessment.

The implementation of a Project-specific follow-up program to verify the effects predictions and the effectiveness of mitigation measures will improve the high level of confidence assigned to the prediction of residual effects on soil quantity and quality. Effective design and construction, mitigation, adaptive measures, and good housekeeping and management practices, as well as additional geohazard risk assessments, will be required during all phases of the Project. The implementation of these site-specific mitigation and/or adaptation measures, including appropriate design, monitoring, maintenance of facilities, and response to incidents, can significantly reduce the potential for adverse effects on soil quantity, soil quality, and terrain.

The follow-up program includes a monitoring program for soil quantity and quality, which will be used to evaluate the effectiveness of preventative erosion and sediment control strategies throughout all phases of the Project. The follow-up program will include scheduled inspections, implementation of plans and guidelines, installation and inspection of erosion control measures, monitoring stations at watercourses, communication and reporting plans, as well as reports documenting the findings of the monitoring program for submission to senior management and the applicable regulatory agencies, as required.

The monitoring program will be refined and supplemented with additional site-specific details prior to commencement of the Project and throughout each Project phase. Monitoring results will be compared to baseline data to assess the effectiveness of mitigation measures to support the evaluation and improvement of soil management and erosion control practices, and inform the development of adaptive management measures, should they be required.

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