RED MOUNTAIN UNDERGROUND GOLD PROJECT
VOLUME 3 | CHAPTER 15
VEGETATION AND ECOSYSTEMS EFFECTS ASSESSMENT

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15 VEGETATION AND ECOSYSTEMS EFFECTS ASSESSMENT

15.1 Introduction

The purpose of the assessment is to present the potential effects of the proposed Red Mountain Underground Gold Project (the Project) on those issues of greatest scientific, ecological, economic, social, cultural, or heritage importance (CEAA 2012; EAO 2013).

This chapter presents the assessment of potential Project effects on Vegetation and Ecosystems valued components (VCs) that were identified during early scoping phases of the Pre-Application process and in response to feedback from provincial and federal regulators, Working Group members, Aboriginal Groups, and the public. The Vegetation and Ecosystems VCs included in the assessment are:

- Ecologically Valuable Soils;
- Alpine and Parkland Ecosystems;
- Old Growth and Mature Forested Ecosystems;
- Floodplain and Wetland Ecosystems;
- British Columbia Conservation Data Centre (BC CDC) Listed Ecosystems; and
- Rare Plants, Lichens, and Associated Habitat.

The assessment is based on information provided in the Red Mountain Underground Gold Project Ecosystems, Vegetation, Terrain, and Soils Baseline Report (Volume 8, Appendix 9-A) and follows the effects assessment methodology described in Volume 3, Chapter 6 of the Application/EIS.

This chapter is linked to the potential effects of the Project on other related VCs including those identified and evaluated in the following chapters:

- Landforms and Natural Landscapes Effects Assessment (Volume 3, Chapter 9);
- Wildlife and Wildlife Habitat Effects Assessment (Volume 3, Chapter 16);
- Fish and Fish Habitat Effects Assessment (Volume 3, Chapter 18);
- Air Quality Effects Assessment (Volume 3, Chapter 7);
- Social Effects Assessment (Volume 3, Chapter 20); and
- Tsetsaut Skii km Lax Ha (TSKLH; Volume 4, Chapter 25), Métis Nation BC (MNBC; Volume 4, Chapter 26), and Nisga'a Nation (Volume 4, Chapter 27).

Vegetation and Ecosystems are an aspect of the environment that may be altered by the proposed Project, as proposed by IDM Mining Ltd. (IDM). Figure 15.1-1, Figure 15.1-2, and

Figure 15.1-3 illustrate the entire Project footprint and the established disturbance limits for the Mine Site (location of Upper and Lower Portals) and for Bromley Humps (location of Process Plant and Tailings Management Facility (TMF)).

The results of the Vegetation and Ecosystems Effects Assessment show that there will be no effects to Vegetation and Ecosystems outside of Canada.

Figure 15.1-1: Project Overview

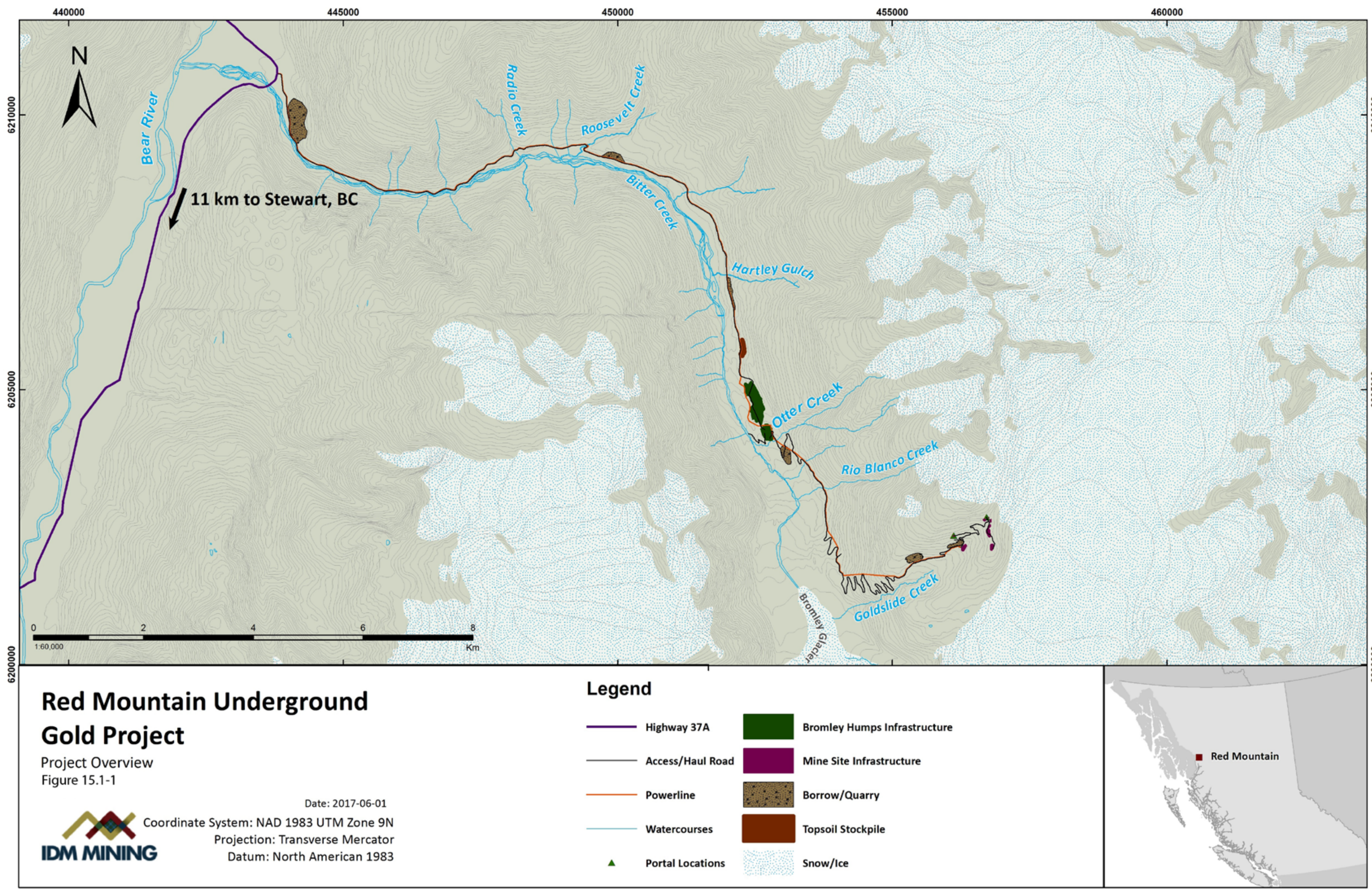


Figure 15.1-2: Project Footprint – Mine Site

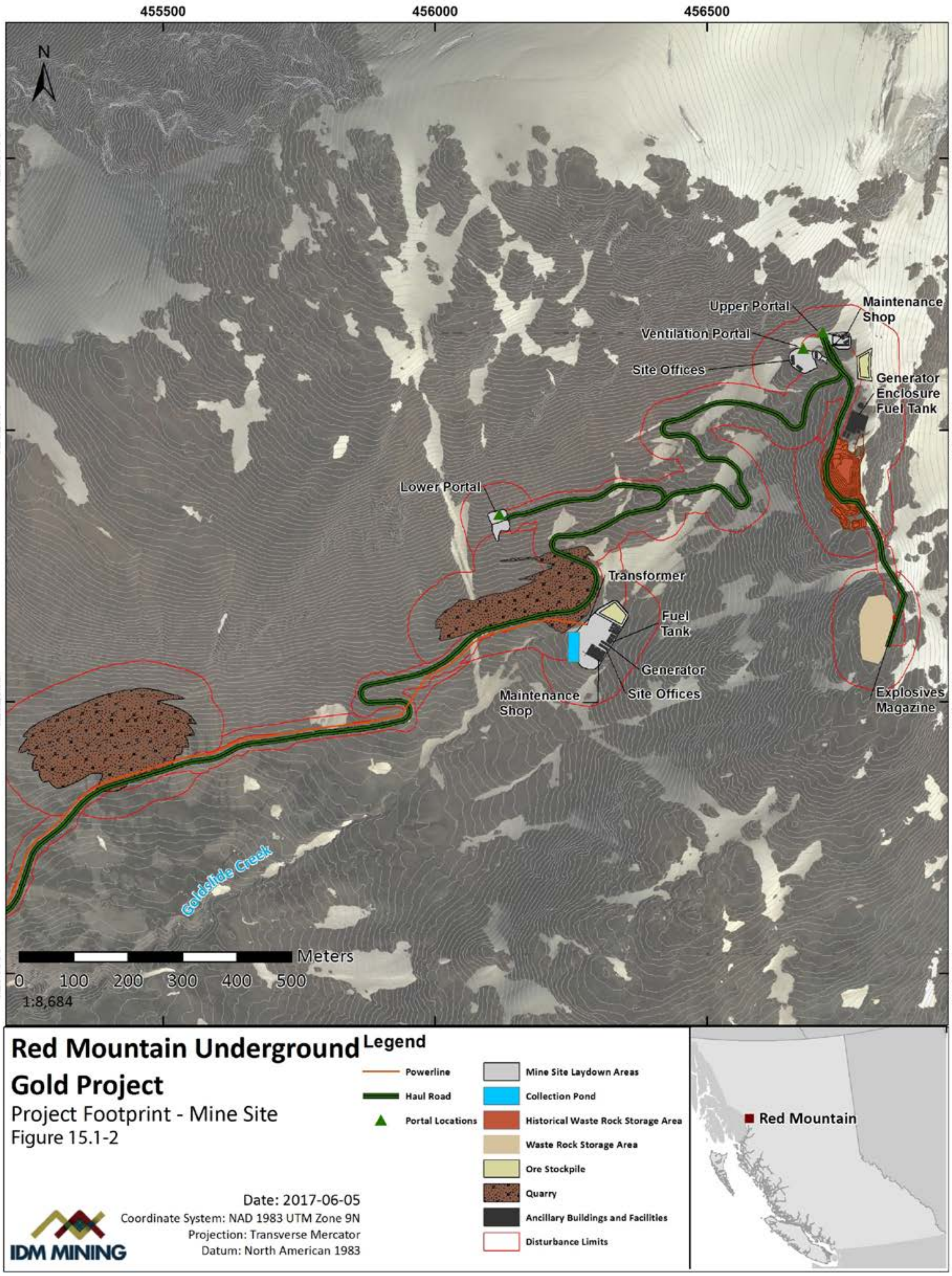
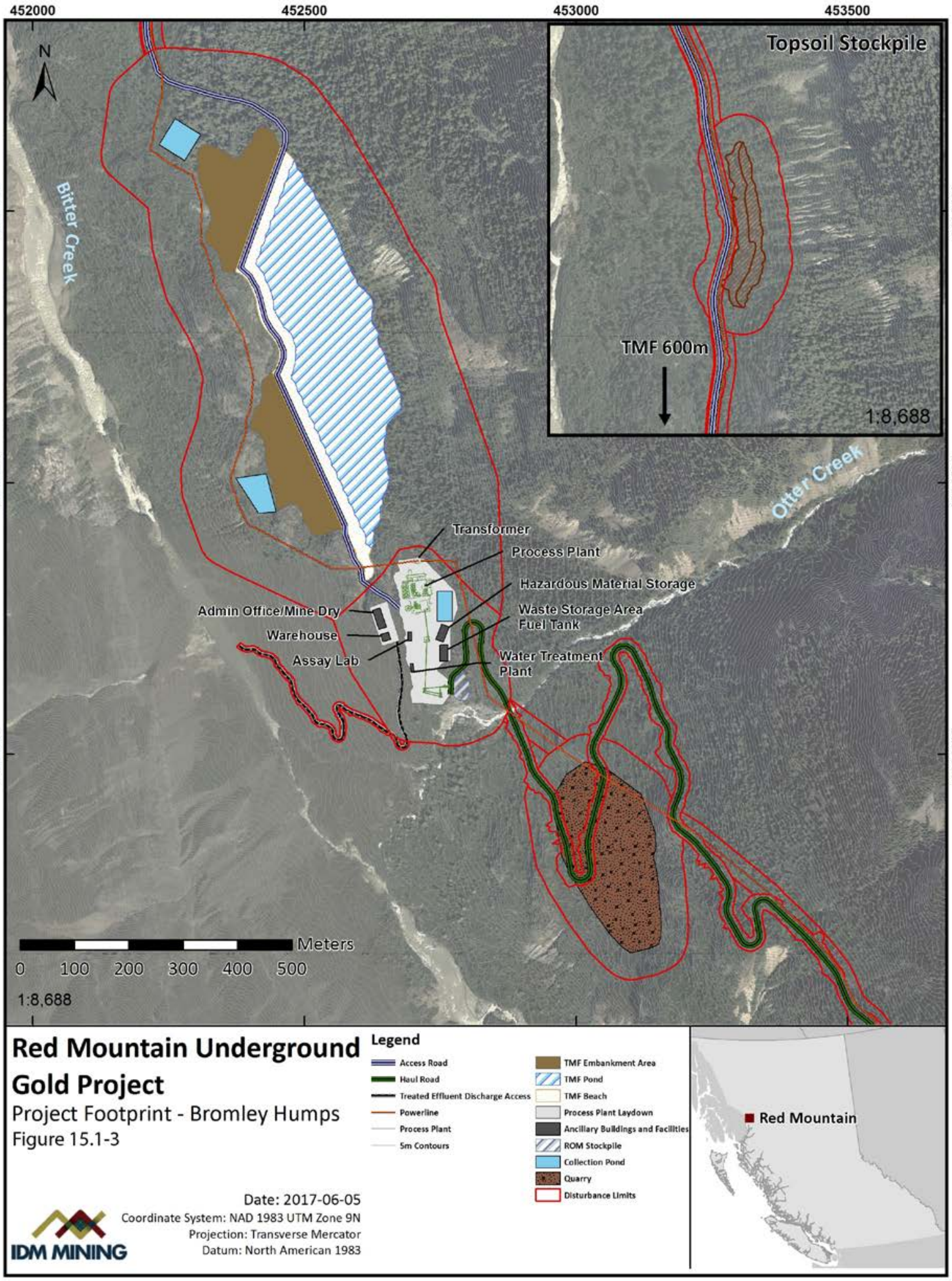


Figure 15.1-3: Project Footprint – Bromley Humps



15.2 Regulatory and Policy Setting

Under the *BC Environmental Assessment Act* (2002; BCEAA), the BC Environmental Assessment Office (EAO) issued an order under Section 11 of the BCEAA (the Section 11 Order) in February 2016. The Section 11 Order defines the process and procedure for the Project's environmental assessment (EA) under BCEAA. Under the Section 11 Order, EAO, jointly with the Agency, convened a Working Group comprised of federal, provincial, and regional regulators and government agencies whose mandates intersect with the proposed Project and its EA.

As per the Section 11 Order, IDM, in close collaboration with EAO, Working Group members, and NLG, issued the Application Information Requirements (AIR) for the Project in March 2017. The AIR outline the information required to be included in the Project's Application for an environmental assessment certificate. This Application/EIS has been prepared to meet the requirements of the AIR.

Under the *Canadian Environmental Assessment Act, 2012* (CEAA 2012), the Canadian Environmental Assessment Agency (the Agency) issued Guidelines for the Preparation of an Environmental Impact Statement Pursuant to CEAA 2012 (the EIS Guidelines) for the Project in January 2016. This Application/EIS has been prepared to meet the requirements of the EIS Guidelines.

The Vegetation and Ecosystems Effects Assessment follows recommended guidelines and legislated requirements pursuant to the provincial BCEAA and the federal CEAA 2012 and is consistent with the requirements of the AIR issued for the Project issued by EAO.

Vegetation and Ecosystems will be managed according to applicable legislation and regulations and coordinated with management of relevant environmental, economic, heritage, health, and/ or social features (Table 15.2-1).

Table 15.2-1: Legislation and Regulations Relevant to Vegetation and Ecosystems

Legislation	Jurisdiction	Description
BC Environmental Assessment Act (2002)	Provincial	An assessment of potential adverse environmental effects within provincial jurisdiction is required under the Reviewable Projects Regulations of the BCEAA (2002) as the Project exceeds the production capacity of 75 thousand tonnes (t) per year.
Environmental Management Act (2004)	Provincial	Prohibits the introduction of deleterious substances into the environment in any manner or quantity that may cause pollution to the environment. The Contaminated Sites Regulations (BC Reg. 131/92) included in this Act, provide quantitative standards to define site contamination and to assess reclamation success.

Legislation	Jurisdiction	Description
Forest and Range Practices Act (2002a)	Provincial	Apply constraints to when, where, and how forest clearing is undertaken (for forest and range licensees) and applies protection to old-growth forests (through establishment of old-growth management areas; OGMAs) and to riparian areas (through Division 3, Riparian Areas, of the Forest Planning and Practices Regulation).
Integrated Pest Management Act (2003)	Provincial	Regulates the use of herbicides to control weeds (invasive plants).
Invasive Plants Regulation (2004)	Provincial	Identifies species of invasive plants.
Mines Act (1996a)	Provincial	Provides broad reclamation standards within the Health, Safety, and Reclamation Code for revegetation, growth media, metal uptake, landforms, watercourses, water quality, disposal of chemicals and reagents, and monitoring and post-closure land use.
Riparian Areas Protection Act (formerly the Fish Protection Act [1997])	Provincial	Regulates provincial approvals of alterations and work in and around watercourses. Provides directives regarding the protection and enhancement of riparian areas in relation to proposed developments.
Riparian Areas Regulation	Provincial	Enacted under Section 12 of the *Fish Protection Act* in July 2004, this regulation provides directives to protect riparian areas from residential, commercial, or industrial development such that the natural features, functions, and conditions that sustain fish life processes are maintained.
Water Sustainability Act (2016)	Provincial	Governs provincial approvals associated with working in and around watercourses. Regulates changes made in and around streams and provides directives regarding the maintenance of water quality and quantity for aquatic ecosystems.
Weed Control Act (1996b)	Provincial	Imposes a duty on all land occupiers to control designated noxious plants.
Weed Control Regulation (1985)	Provincial	Defines noxious weeds.
Wildlife Act (1996c)	Provincial	Legal designation as Endangered or Threatened increases the penalties for harming a species, and enables the protection of habitat in a Critical Wildlife Management Area. Eagle, peregrine falcon, gyrfalcon, osprey, and heron nests (and the trees in which they are found) are protected year-round. Protects all active nests (i.e., nests occupied by a bird or its egg), regardless of species.
Canadian Environmental Assessment Act (2012)	Federal	An assessment of potential adverse environmental effects within federal jurisdiction is required under CEAA 2012 because the Project exceeds the minimum daily ore production threshold of 600 t/day (Section 16 of the Regulations Designating Physical Activities).

Legislation	Jurisdiction	Description
Fisheries Act (1985a) - Recent amendments to the *Fisheries Act* (2012)	Federal	Current prohibitions within the amended act focus on preventing "serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery."
Migratory Birds Convention Act (1994)	Federal	Prohibits activities that may result in the killing, capturing, injuring, taking, or destroying of migratory birds or the damaging, destroying, removing, or disturbing of nests (e.g., land clearing and vegetation management activities during the breeding bird window).
Seeds Act (1985b)	Federal	Requires that seed in Canada is free of prohibited noxious weeds and certifies standards of purity.
Species at Risk Act (2002b)	Federal	In addition to protecting listed plant species, specifies that invasive plant species that threaten rare wildlife species' habitat must be controlled.

The Project is also within the Nass Area and the Nass Wildlife Area, as set out in the Nisga'a Final Agreement (NFA). Pursuant to the NFA, Nisga'a Nation, as represented by Nisga'a Lisims Government (NLG), has Treaty rights to the management and harvesting of fish, wildlife, and migratory birds within the Nass Wildlife Area and the larger Nass Area. The Project is also within the asserted traditional territory of Tsetsaut Skii km Lax Ha (TSKLH) and is within an area where Métis Nation BC (MNBC) claims Aboriginal rights.

At a regional scale, the Nass South Sustainable Resource Management Plan (NSSRMP) is a plan to promote and encourage long-term sustainable development in the southern parts of the Nass Timber Supply Area (TSA). The NSSRMP has five primary objectives (FLNRO 2012), including to:

- Assist in reaching a broad-based forestry accommodation agreement;
- Fulfill legal obligations of the Crown;
- Promote sustainable forest management in the Nass TSA;
- Assist in streamlining subsequent consultation processes; and
- Increase certainty for long-term access and sustainable development for Gitanyow, Nisga'a Nation (as represented by NLG), and all resource sectors (e.g., forestry, fisheries, tourism, and mining).

15.3 Scope of the Assessment

The scope of the assessment provides the framework for the evaluation of potential Project effects on Vegetation and Ecosystems and includes the following steps:

- Review of the Project Overview (Volume 2, Chapter 1) relevant regulatory guidance documents, and consultation records from NLG, technical experts, and the Working Group;
- Select VCs, sub-components, and ecological indicators based on issues raised during consultation and on the Project's potential to interact with the proposed VCs;
- Conduct field studies to collect information on the type, distribution, and extent of the potential VCs;
- Define assessment boundaries for the candidate VCs;
- Identify key potential Project interactions and associated effects with Vegetation and Ecosystems VCs and identify potential pathways for interactions with other VCs;
- Determine potential mitigation, management, and follow-up measures to address potential Project effects on VCs;
- Identify and characterize residual effects that cannot be fully mitigated and/or managed and determine their significance; and
- Identify and characterize Project residual effects in combination with the residual effects of past, present, and reasonably foreseeable future projects and determine their significance.

15.3.1 Information Sources

Information used in issues scoping and VC selection processes for the Application/EIS included:

- Project field data and mapping (Ecosystems, Vegetation, Terrain, and Soils Baseline Report; Appendix 9-A);
- Recent, comparable project environmental assessments and related research conducted for comparable projects, especially in northwest BC;
- Consultation with provincial and federal regulators, Working Group members and organizations, Aboriginal Groups, local and regional stakeholders, and the public;
- Federal and provincial requirements;

- Publicly available spatial files, reports, land use plans, and background technical reports; and
- Expert knowledge and experience.

15.3.2 Input from Consultation

IDM is committed to open and honest dialogue with regulators, Aboriginal Groups, community members, stakeholders, and the public.

IDM conducted consultation with regulators and Aboriginal Groups through the Working Group co-led by EAO and the Canadian Environmental Assessment Agency (the Agency). Where more detailed and technical discussions were warranted, IDM and Working Group members, including sometimes NLG representatives, held topic-focused discussions, the results of which were brought back to EAO and the Working Group as a whole.

Further consultation with Aboriginal Groups, community members, stakeholders, and the public has been conducted as outlined by the Section 11 Order and EIS Guidelines issued for the Project. IDM incorporated the results of those consultation efforts into the assessment of potential effects of the Project on Vegetation and Ecosystems (Table 15.3-1).

More information on IDM's consultation efforts with Aboriginal Groups, community members, stakeholders, and the public can be found in Chapter 3 (Information Distribution and Consultation Overview) Part C (Aboriginal Consultation), Part D (Public Consultation), and Appendices 27-A (Aboriginal Consultation Report) and 28-A (Public Consultation Report. A record of the Working Group's comments and IDM's responses can be found in the comment-tracking table maintained by EAO.

During consultation with stakeholders, government agencies, Aboriginal Groups, and the public, a preliminary list of proposed VCs and a VC-scoping exercise was compiled to explore potential Project interactions with candidate VCs. A preliminary list of potential VCs was developed based on one or more of the following criteria:

- Issues or concerns raised during the EA Pre-Application Phase and through consultation activities;
- Input from TSKLH, MNBC, and Nisga'a Nation;
- A perceived likelihood that the VC will be affected by the Project based on scientific knowledge, past experience on other mining projects, and professional judgment regarding potential effects, thresholds, mitigation, and management measures;
- Policy guidance and/or relevance to regulatory requirements;
- Government management priorities (e.g., at-risk plants or lichens);

- Sensitivity or vulnerability to disturbance; and
- Availability of data and analytical tools to measure effects on the VC (e.g., ecosystem mapping).

All VCs identified during consultation with stakeholders, government agencies, Aboriginal Groups, and the public were included in the assessment.

Table 15.3-1: Summary of Consultation Feedback on Vegetation and Ecosystems

Topic	Feedback by*				Consultation Feedback	Response
	NLG	G	P/S	O		
Alpine and Parkland Ecosystems	X				NLG identified Alpine and Parkland Ecosystems as important for highly valued wildlife species, including mountain goats and grizzly bears.	Key potential Project effects on Alpine and Parkland Ecosystems are assessed in this Vegetation and Ecosystems Effects Assessment, Landforms and Natural Landscapes Effects Assessment (Volume 3, Chapter 9), Wildlife and Wildlife Habitat Effects Assessment (Volume 3, Chapter 16), Social Effects Assessment (Volume 3, Chapter 20), TSKLH (Volume 4, Chapter 25), MNBC (Volume 4, Chapter 26), and Nisga'a Nation (Volume 4, Chapter 27).
Wetlands		X			Environment and Climate Change Canada recommended that wetlands be separated from floodplains as a VC, suggested measurement indicators, and requested any red- or blue-listed wetland ecosystems in the area should be detailed as individual VCs (e.g. red-listed Sitka sedge-peat mosses).	The geographic areas of wetlands designated as ecologically and/or socio-economically important in the Federal Policy on Wetland Conservation will be identified.

*NLG = Nisga'a Lisims Government;

G = Government - Provincial or federal agencies;

P/S = Public/Stakeholder - Local government, interest groups, tenure and license holders, members of the public;

O = Other

15.3.3 Valued Components, Assessment Endpoints, and Measurement Indicators

Valued Components, measurement indicators, and assessment endpoints are summarized in Table 15.3-2. The rationale for their selection was informed by input from Working Group members (including NLG, stakeholders, and government regulators), review of government guidelines, consideration of other relevant projects, grey literature, published research, and professional judgment.

Table 15.3-2: Assessment Endpoints and Measurement Indicators for Vegetation and Ecosystems Valued Components

Valued Components	Rationale for Selection	Primary Measurement Indicators	Assessment Endpoint
Ecologically Valuable Soils	Ecologically Valuable Soils are a key component of ecosystem development and function.	• Ecosystem Abundance (due to loss or alteration) • Ecosystem Distribution (loss or alteration to ecosystem distribution and connectivity) • Ecosystem Function (loss or alteration to the ecosystem's ability to provide functions such as habitat, biodiversity, nutrient cycling, and soil retention)	Maintenance of ecological conditions that support Vegetation and Ecosystems relative to current conditions.
Alpine and Parkland Ecosystems	Alpine and Parkland Ecosystems can be important to regional stakeholders for travel, recreation, and hunting areas. It provides habitat for rare plant and lichen species. This VC is also noted as an important management consideration in the Nass South Sustainable Resource Management Plan (SRMP).		
Old Growth and Mature Forested Ecosystems	Old Growth and Mature Forested Ecosystems are noted as an important management consideration in the Nass South Sustainable Resource Management Plan (SRMP).		
Floodplain and Wetland Ecosystems	Floodplain and Wetland Ecosystems are noted as an important management consideration in the NS SRMP This VC represents important habitat for highly valued wildlife species, including western screech owl, western toad, and bald eagle. It also provides structural habitat for fish and aquatic species.		
BC CDC Listed Ecosystems	BC CDC Listed Ecosystems have been identified as important due to threats to their viability. They have been noted as rare, threatened, or at-risk components of regional and/or provincial biodiversity and as an important management consideration in the NSSRMP.		
Rare Plants, Lichens, and Associated Habitat	Rare Plants, Lichens, and Associated Habitat have been identified as important due to threats to their viability and have been noted as rare, threatened, or at-risk components of regional and/or provincial biodiversity.	Loss or alteration to known occurrences of rare lichens and plants	Loss of biodiversity relative to current conditions.

The Vegetation and Ecosystems VCs are also linked to the following chapters in this Application/EIS:

- Landforms and Natural Landscapes Effects Assessment (Volume 3, Chapter 9);
- Wildlife and Wildlife Habitat Effects Assessment (Volume 3, Chapter 16);
- Fish and Fish Habitat Effects Assessment (Volume 3, Chapter 18);
- Air Quality Effects Assessment (Volume 3, Chapter 7);
- Social Effects Assessment (Volume 3, Chapter 20); and
- TSKLH (Volume 4, Chapter 25), MNBC (Volume 4, Chapter 26), and Nisg̲a'a Nation (Volume 4, Chapter 27).

15.3.4 Assessment Boundaries

Assessment boundaries define the maximum limit within which the Vegetation and Ecosystems Effects Assessment and supporting technical studies were conducted. Boundaries encompass areas and periods of time during which the Project is expected to interact with the Vegetation and Ecosystems VCs. The assessment boundaries account for constraints due to temporal, political, social, and economic circumstances and technical limitations (i.e., known limitations in predicting or measuring changes to each VC).

15.3.4.1 Spatial Boundaries

15.3.4.1.1 Regional Study Area

The regional study area (RSA) is the spatial area that encapsulates the Project and extends beyond to the height of land to include several watersheds within the region (Figure 15.3-1). The RSA boundary takes into consideration the predicted habitat of select wildlife over a season or a lifetime or both, such as grizzly bears and mountain goats. The RSA boundary provides context for the type, distribution, extent, and prevalence of ecosystems within the region. The RSA is 211,570 hectares (ha) in size.

15.3.4.1.2 Local Study Area

The local study area (LSA) was established to provide a study area boundary for assessing the effects of the Project at the local watershed level. The LSA encompasses the full extent of the Bitter Creek watershed. It extends to the height of land on all sides of Bitter Creek, including the Roosevelt Creek drainage, and a portion of Bromley Glacier to the south. The north end of the LSA includes the mouth of Bitter Creek where it passes Highway 37A and drains into Bear River, including an area of floodplain forest and Clements Lake. The LSA is 15,860 ha in size.

The LSA is the spatial area that extends to the height of land and includes the watersheds surrounding the Project (Figure 15.3-1). Watersheds represent a physical boundary within which ecological processes interact and shape the ecology of an area. For example, as water flows down from the height of land and interacts with the receiving environment, such as parent material, soil type, soil drainage, and vegetation type, the water may be absorbed into the ground, contributing to groundwater flow; pooled at the surface creating wetlands over time; or contribute to an existing stream. These interactions over time and space result in distinct assemblages of vegetation and ecosystems types. The resultant vegetation and ecosystems provide the supporting landscape for wildlife and fish habitat and provide a variety of recreational services, such as skiing and hiking within the watershed.

15.3.4.1.3 Project Footprint Study Area

The Project footprint (Figure 15.1-1) is the spatial area within which development of temporary and permanent infrastructure is expected to occur. The Project footprint is 247 ha and includes six main features: 1) the Mine Site (48 ha); 2) the Access Road (35 ha); 3) the Powerline (27 ha); 4) the Tailings Management Facility (TMF; 48 ha); 5) the Process Plant (9 ha); and 6) quarries, borrows, and stockpiles (81 ha). The Project footprint includes a 50 metre (m) disturbance buffer surrounding the proposed non-road infrastructure and a 20 m buffer on the Powerline to accommodate for potential minor siting changes prior to the final design. The Project Footprint Study Area (PFSA) includes a 150 m alteration buffer (encompassing an additional 714 ha) outside of the Project footprint to allow for the assessment of effects, including dust effects.

15.3.4.2 Temporal Boundaries

Temporal boundaries encompass the periods during which the proposed Project is expected to interact with Vegetation and Ecosystem VCs. Temporal boundaries reflect those periods during which planned Project activities are reasonably expected to potentially affect a VC and are based on the timing of the different phases of the proposed Project (Table 15.3-3).

Table 15.3-3: Temporal Boundaries for the Effects Assessment

Phase	Project Year	Length of Phase	Description of Activities
Construction	Year -1 to Year 1	18 months	Construction activities and construction of: Access Road, Haul Road, Powerline, declines, power supply to the underground, water management features, water treatment facilities, TMF, Process Plant, ancillary buildings and facilities; underground lateral development and underground dewatering; ore stockpile and ore processing start-up; and receiving environmental monitoring.
Operation	Year 1 to Year 7	6 years	Ramp up to commercial ore production and maintain a steady state of production, underground dewatering, tailings storage, water treatment, gold doré shipping, environmental monitoring, and progressive reclamation.

Phase	Project Year	Length of Phase	Description of Activities
Closure and Reclamation	Year 7 to Year 11	5 years	Underground decommissioning and flooding; decommissioning of infrastructure at portals, Process Plant, TMF, ancillary buildings and facilities; reclamation, water treatment; removal of water treatment facilities.
Post-Closure	Year 12 to Year 21	10 years	Environment monitoring.

15.3.4.3 Administrative and Technical Boundaries

The Vegetation and Ecosystems LSA is situated within the Regional District of Kitimat-Stikine and is near the District of Stewart. The RSA falls within two forest districts, within which forest resources are managed by the BC Ministry of Forests, Lands, and Natural Resource Operations (FLNRO). The Kalum Forest District to the north and the North Coast Forest District to the south. The LSA is fully within the Kalum Forest District (Figure 15.3-2).

The LSA and most northern portion of the RSA are within the NS SRMP, while the southern portion of the RSA is in the North Coast (Great Bear Rainforest) Land Resource Management Plan (LRMP) (BC Gov. 2004; BC Gov. 2008). The RSA is largely within the Nass Wildlife Area (Nisga'a Nation 2017).

The RSA contains one protected area: Bear Glacier Provincial Park. Four legal Old-Growth Management Areas (OGMAs) are located within the LSA, three of which fall within 150 m of proposed Project infrastructure; nine additional OGMAs are within the RSA. OGMAs are legally established and spatially defined areas that that forest licensees are required to maintain. They are established through landscape unit planning or operational planning to achieve biodiversity targets and retain representative old growth forests (DataBC 2017).

Figure 15.3-1: Vegetation and Ecosystems Study Areas

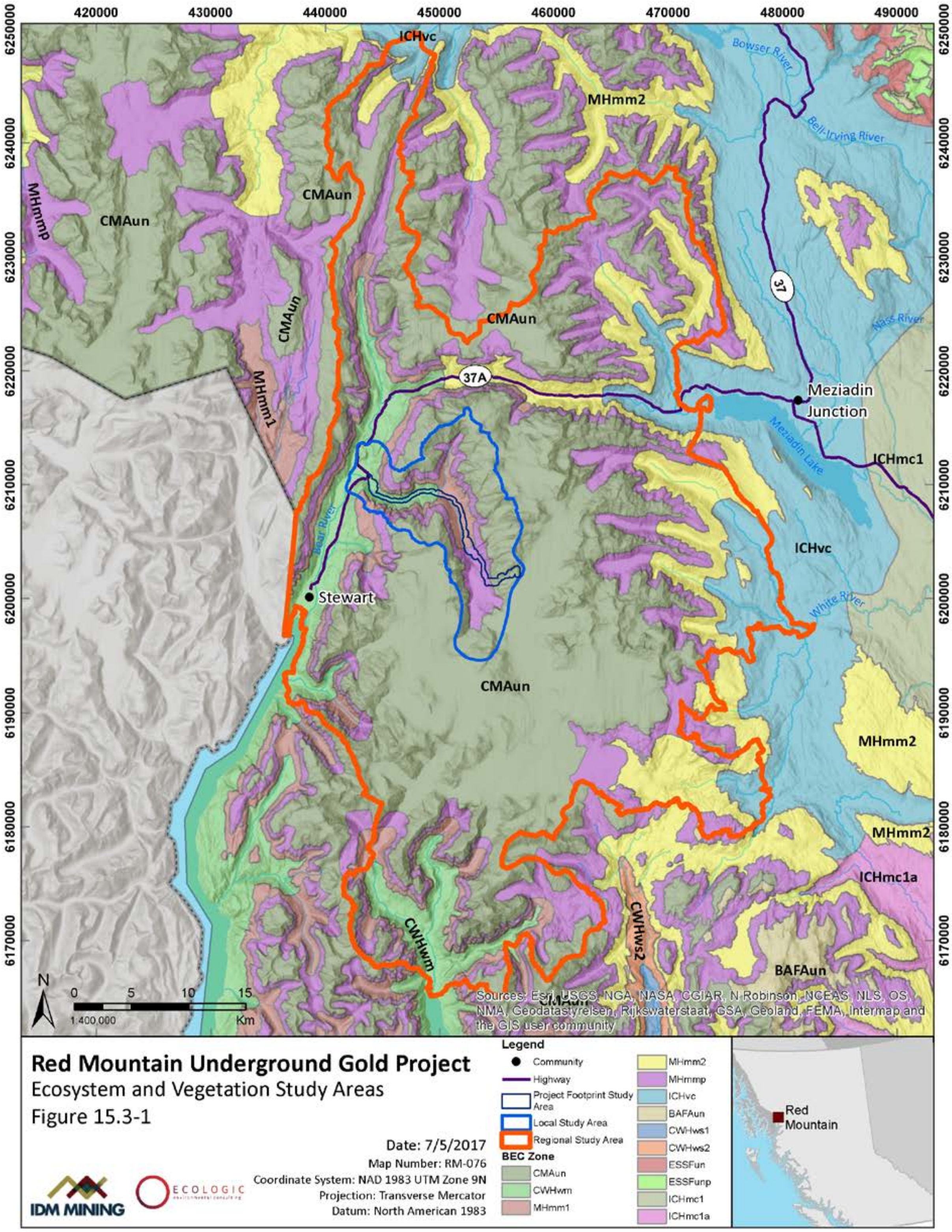
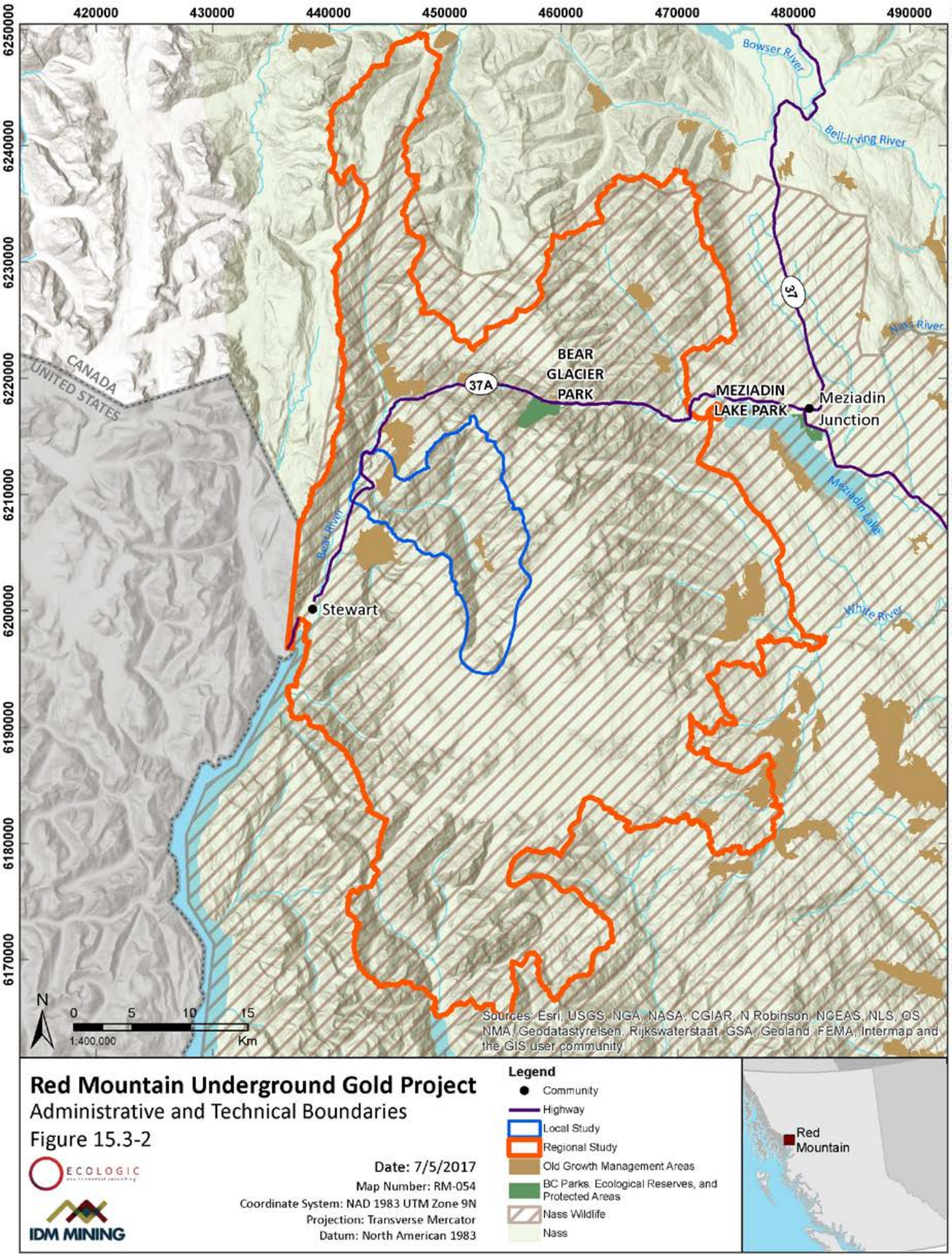


Figure 15.3-2: Administrative and Technical Boundaries



15.4 Existing Conditions

15.4.1 Overview of Existing Conditions

The Project is split between the Boundary Ranges and Nass Ranges Ecoregions (Appendix 9-A: Ecosystem Vegetation and Soils Baseline Report). Ecoregions are areas that contain major physiographic and minor macroclimatic or oceanographic variation. The 47 Ecoregions that occur in BC are further divided into 139 Ecosections based on minor physiographic, oceanic, and macroclimatic variation (Demarchi, 1996).

The Boundary Ranges Ecoregion is characterized by rugged granitic and metamorphic-based mountains that are largely ice-capped. Within the Boundary Ranges, the western half of the Project is situated within the Southern Boundary Ranges Ecosection. The Southern Boundary Ranges consists of wet, rugged mountains that contain frequent remnant icefields and glaciers. Numerous rivers dissect the mountains, including the Bear River, which drains into the Portland Canal (Pacific Ocean) at the District of Stewart. Precipitation rates from moist Pacific Ocean air are high, resulting in a landscape that is dominated by low elevation wet Coastal Western Hemlock (CWH) forests, with wet Mountain Hemlock (MH) forest on the mid- to upper-slopes, followed by a transitional MH subalpine forest above. Just east of Bear Glacier, MH forests transition into the wet, cold Interior Cedar–Hemlock (ICH) forests that dominate the lower elevations of the Meziadin Mountains Ecosection to the east. Valley bottom areas along Bear River contain extensive cottonwood floodplain forests interspersed with swamp and marsh wetlands. Alpine areas are extensive, sparsely vegetated, and contain large expanses of ice such as the Cambria Ice Field (Demarchi, 1996).

The Nass Ranges occur to the east, with roughly half of the RSA occurring in the Meziadin Mountains Ecosection, along with a small portion of the Nass Basin Ecosection to the southeast. The Nass Ranges is a transitional area from coast to interior, with western portions containing rugged, wet mountains similar to the Boundary Ranges, while eastern mountains are more subdued. The Meziadin Mountains Ecosection is comprised of rugged, granitic mountains that are located on the leeward side of the Boundary Ranges. White River and numerous small drainages flow from the LSA into Meziadin Lake and Meziadin River. The east-facing slopes of the Meziadin Mountains Ecosection contain the leeward variant of wet MH forests, with transitional MH subalpine forest above. Lower slopes and valley bottoms contain wet, cold, ICH forests. Alpine areas make up a large portion of the Meziadin Mountains Ecosection and range from large expanses of ice fields, multiple glaciers, and a variety of vegetated and sparsely vegetated areas (Demarchi 1996).

The Bitter Creek watershed is located within the Southern Boundary Ranges and contains the proposed Project components. The watershed is a largely north-south valley that drains Bromley Glacier into Bear River. Roosevelt Creek is a significant drainage occupying a hanging valley in the northeast portion of the watershed, while smaller watercourses frequently occur in deep gullies on the steep mountain slopes. The area is characterized by steep, wet slopes that contain frequent avalanche tracks. The north end of the Bitter Creek valley contains CWH forests along the lower- and mid-slopes, including large areas of mid-slope mature and old forests. The mouth of Bitter Creek, as it drains into Bear River, is characterized by flat floodplain forests and is dominated by deciduous stands adjacent to the rivers, grading into mixed forests on higher, less active floodplains. Narrow fringes of floodplain forest extend up Bitter Creek, with most of the active creek floodplain area being highly scoured rock, gravel, and occasional sparsely vegetated areas. MH forests occupy a narrow, steep band above the CWH (around 700 m in elevation) and replace the CWH at the valley bottom as elevation increases to the southeast of Roosevelt Creek. Parkland MH forests start around 900 metres above sea level (masl) in elevation and often contain old to very old forested stands before giving way to stunted Krummholz around 1,200 masl as the alpine zone begins.

As Bitter Creek climbs in elevation towards Bromley Glacier, lower slope forests begin to be replaced by early seral shrub communities where the soil development is limited and vegetation communities are in early stages of post-glaciation establishment. At the southern end of the valley the MH transitions into sparse parkland communities, with the majority of the area dominated by recently de-glaciated morainal deposits along with colluvial slopes and barren alpine communities. Alpine communities are varied in the Bitter Creek watershed, where transitional areas above the parkland forests are often diverse and contain rich herb meadow slopes, subalpine fir (*Abies lasiocarpa*) Krummholz, and expanses of alpine heath intermixed with dwarf shrub tundra-like communities. Exposed higher elevations contain extensive sparsely vegetated communities and barren rock outcrops before giving way to glaciers and icefields.

Avalanche tracks are abundant in the watershed due to steep slopes and high snowfall. Avalanche communities are typically wet, rich, and dominated by alder (*Alnus alnobetula*), with lesser components of Devil's club (*Oplopanax horridus*) and various willows (*Salix* spp.). At upper elevations the avalanche slopes contain lush herb meadows. The edge of avalanche tracks, as they pass through forested areas, often contain slide-maintained forested communities that are irregular, fragmented in extent, and contain a high percent of dead or damaged trees.

15.4.2 Past and Current Projects and Activities

The Bitter Creek watershed has a history of mines and mine explorations. Highway 37A and a BC Hydro transmission line cross the creek near the confluence with Bear River. Much of the area near Highway 37A has been, or is being, cleared or logged for various purposes. Small quarries and borrow pits associated with the highway or powerline construction occur along Highway 37A, and basic amenities have been developed for a recreation area at Clements Lake. An old, overgrown road runs parallel to much of Bitter Creek along the northern side on old floodplains and the toe of the slope. Several smaller old roads branch off up the slopes, and there are numerous old logged areas adjacent to the road. Additional roads occur around the vicinity of the old mine portal on Red Mountain.

Placer mining commenced in Bitter Creek at the base of Red Mountain at the turn of the 20th century. In 1989, gold mineralization was discovered and surface drilling was conducted from 1991 to 1994. Existing infrastructure on the Red Mountain Property includes an underground decline and drift development that was developed in 1993 and 1994 for bulk sampling the mineralized Marc zone, a 50,000 tonne (t) waste rock pile, a surface tote road network, camp buildings, helipads, numerous temporary drill pads, and used mobile equipment (JDS 2016).

15.4.3 Project-Specific Baseline Studies

15.4.3.1 Data Sources

Data sources used to inform the evaluation of Project effects on Vegetation and Ecosystems VCs include information collected through field studies and published sources, including government planning documents, technical reports, peer-reviewed research, consultation records, spatial data, guidelines and protocols, and guidebooks.

15.4.3.1.1 Field Studies

The Project-specific field studies conducted to support the Project's Application/EIS include a 2014 vegetation and ecosystems survey conducted by Triton Environmental and a vegetation, ecosystem, rare plant, and lichen survey conducted by EcoLogic Consultants Ltd. (EcoLogic) in 2016 and 2017. These baseline studies are available in Appendix 9-A (Ecosystem, Vegetation, Terrain, and Soils Baseline Report). These are also further discussed below.

15.4.3.1.2 Existing Literature

Existing literature reviewed for this Vegetation and Ecosystems Effects Assessment include:

- Nass South Sustainable Resource Management Plan (SRMP; FLNRO 2012);
- North Coast Land Resource Management Plan (LRMP);
- Nisga'a Final Agreement (Government of Canada 2012);
- Nisga'a Lisims Government website (NLG 2017);
- NatureServe Conservation Ranks (for provincially and globally rare plants and lichens);
- BC CDC, which provides information of the known occurrences of Red and Blue listed ecosystems and plants;
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC) for federally listed plants and lichens; and
- Publicly available data from other terrestrial ecosystems baseline studies conducted in the general vicinity of the Project (e.g., Brucejack Gold Mine Project, Kerr-Sulphurets-Mitchell Project, Kemess Underground Mine Project).

15.4.3.1.3 Spatial Data

Spatial data reviewed in support of this Vegetation and Ecosystems Effects Assessment include:

- Base data (e.g., hydrology, glaciers, lakes, rivers, wetlands, roads, administrative boundaries, old growth management areas, protected areas, predictive ecosystem mapping) (DataBC; Government of BC Data Distribution Service);
- Biogeoclimatic Ecosystem Classification (BEC) Zone/Subzone/Variant/Phase map (version 9, May, 2014) (DataBC; Government of BC Data Distribution Service);
- Digital Elevation Models (GeoGratis; Natural Resources Canada);
- Landsat satellite imagery (GeoGratis; Natural Resources Canada);
- Terrain Resource Information Mapping (DataBC; Government of BC Data Distribution Service); and
- Digital 2013 colour air photos that were custom flown for the Project, and black-and-white 1994 air photos that were scanned from hard copy Provincial imagery.

15.4.3.1.4 Guidelines and Protocols

The guidelines and protocols reviewed in support of this Vegetation and Ecosystems Effects Assessment include:

- Biogeoclimatic Ecosystem Classification codes and names (BECdb version 8, Feb 2012);
- Standard for Terrestrial Ecosystem Mapping in BC (1998);
- Standard for TEM Digital Data Capture in BC, Version 3.0 (2000);
- Terrain Classification System for BC, Version 2.0 (1997);
- Standards for Digital Terrain Data Capture in British Columbia, Version 1.0 (1998); and
- Standards and Guidelines to Terrain Mapping in BC (1996).

15.4.3.1.5 Guidebooks

The guidebooks reviewed in support of this Vegetation and Ecosystems Effects Assessment include:

- Biogeoclimatic Ecosystem Classification of Non-forested Ecosystems in British Columbia (MacKenzie 2012);
- Wetlands of British Columbia: a guide to identification (MacKenzie and Moran 2004);
- Field Manual for Describing Terrestrial Ecosystems; 2nd Edition (BC Min. of Forests and Range and BC Min. of Env. 2010); and
- A Field Guide to Site Identification and Interpretation for the Prince Rupert Forest Region (Banner et al. 2004).

15.4.3.2 Primary Data Collection and Analysis Methods

Terrestrial baseline studies to support the Project's Application/EIS were undertaken by EcoLogic in 2016 and 2017. The studies included terrain, ecosystem, and soils mapping at a variety of scales and extents. Field studies included ground-truthing the mapping products, rare plant and lichen surveys, invasive plant surveys, and soil sampling for metals analysis. The baseline data collection methodology is provided in the Ecosystem, Vegetation, Terrain, and Soils Baseline Report (Appendix 9-A).

The goal of these field surveys was to characterize vegetation, ecosystems, terrain, and soils that may be affected directly or indirectly by the Project at local and regional levels.

The main objectives of the terrestrial ecosystems baseline studies included:

- To map and characterize ecosystems in the RSA, the LSA, and the PFSA;
- To identify plant and lichen species present in the LSA, including invasive plant species, and those species tracked by the BC CDC, assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), protected under the *Species At Risk Act*, or otherwise considered rare or of conservation interest;
- To collect baseline metal concentration data from soil; and
- To provide sufficient information to develop the effects assessment, management and mitigation plans (see Chapter 29), and the reclamation and closure plan (Chapter 5).

Data and mapping from the terrestrial baseline studies used in this report include:

- Predictive Ecosystem Mapping (PEM) of the RSA;
- Terrain mapping of the LSA (1:20 000) and Bioterrain mapping of the PFSA (1:5 000);
- Terrestrial Ecosystem Mapping (TEM) of the LSA (1:20 000) and PFSA (1:5 000);
- TEM, PEM, soils, and terrain field surveys;
- Soil mapping of the PFSA (1:5 000);
- Rare plant and lichen field surveys of the LSA; and
- Soil samples for metals analysis.

Three levels of ecosystem mapping were completed for the Project: RSA, LSA, and PFSA. The RSA was mapped using PEM to model the general extent of ecosystem units in the regional landscape. The PEM included six BEC units, including coastal, interior, and alpine areas. Alpine (CMAun) and parkland (MHmmp) zones cover over 70% of the RSA, with the remainder including subalpine forested units (16%) and lowland interior (5%) and coastal (8%) forested units. The LSA was mapped using traditional TEM methods at a scale of 1:20,000 while the PFSA was mapped at a scale of 1:5,000. The LSA and PFSA TEM include CMAun, CWHwm, MHmm1, and MHmmp subzones.

As outlined in Chapter 6 (Effects Assessment Methodology), IDM has not conducted primary traditional use or traditional ecological knowledge (TEK) surveys in support of the Project due to the preferences of Nisga'a Nation, as represented by NLG, and EAOs and the

Agency's direction for comparatively low levels of engagement with the other Aboriginal Groups potentially affected by the Project. IDM has committed to using TEK where that information is publicly available. As no TEK relevant to this effects assessment was publicly available at the time of writing, no TEK has been incorporated.

15.4.3.2.1 Predictive Ecosystem Mapping

PEM was created using the most recent version of the LandMapR methodology, originally created by Bob McMillan (LandMapper Environmental Solutions Inc. 2003), and with revisions by John Simms (independent consultant).

Nutrient and moisture modelling were performed using a combination of 'R' and Python scripts. The modelling was completed using 30 m resolution federal Digital Elevation Models (DEM) processed using LandMapR scripts using standard variables and a 10 m cell size. Both models used several SAGA and LandMapR layers; the soil moisture regime model also included the fuzzy classification layers generated by LandMapR.

Image classification was completed using Landsat 8 satellite imagery. The imagery has a spatial resolution of 30 m x 30 m and an acquisition date of August 12, 2013. Training areas were provided as polygons with varying areas. To simplify the training process, randomly distributed points were generated for each training polygon and assigned the habitat class for that polygon. The final model was then used to predict the habitat classes across the entire study area covered by bands 1 to 7.

All modelling data were converted to polygons using the raster to shapefile tool in ArcGIS, version 10.3.1. The resultant polygon layer was then clipped to the most recent provincial Biogeoclimatic Ecosystem Classification (BEC) mapping layer to separate the data into discrete files for each BEC subzone/variant/phase. The raw data was used to predict ecosystem types for each polygon. Ecosystem predictions were then made for each polygon using a legend derived from provincial guidebooks, as listed in Section 15.4.3.1.5. One or more map codes were entered for each polygon after all the expected ecosystem types were modelled using the expected SMR and SNR range from the guidebooks along with professional opinion and field data regarding how the image classification related to ecosystem types. The final map was then assigned assumed structural stage attributes to facilitate the end use wildlife habitat suitability mapping. Structural stages were assigned based on the descriptions provided in the *Field Manual for Describing Terrestrial Ecosystems; 2^nd^ Edition* (BC MOF 2010) and range from a single structural stage to an expected range of structural stages.

Adrian de Groot (Drosera Ecological Consulting) reviewed the modelling results and provided extensive feedback that was incorporated into the final product. Spatial and attribute quality assurance and quality control were completed by an EcoLogic geomatics specialist.

There are several known limitations of the PEM:

- 30 m resolution of the DEM and Landsat used for initial modelling was larger than desired. This resulted in a final cell size that was coarse and likely generalized some features.

- SMR and SNR modelling results were biased towards mesic and medium conditions resulting in a higher percentage of mesic/medium ecosystem types and likely under-representing the wet dry ecosystems.

- Limited number of training sites. Additional training sites, especially given the large number of final ecosystem types, would be expected to increase the overall accuracy of the PEM.

- Difficulty in differentiating between some ecosystem types (e.g., certain floodplain ecosystems, avalanche slopes from edaphic shrub communities, certain wetland classes, with the exception of bogs, and rock outcrops from some cliffs) resulted in the generalization of some ecosystem units.

- A small percentage of the initial modelling resulted in null data. These areas were combined into a no-data layer, merged with the final PEM, and classified as NoData.

- Numerous small and scattered polygons with random ecosystem classifications are present throughout the PEM. While the overall and larger polygons (or accumulations of like polygons) are reasonably accurate, the small, scattered polygons generally have poor accuracy. These errors are directly related to the limitations (quality) of the DEM used for the project and are consistent with other PEM projects reviewed in preparation for this Project.

15.4.3.2.2 Terrain and Terrestrial Ecosystem Mapping

The terrain, bioterrain, and TEM was conducted using digital, colour, aerial photographs that were custom flown for the Project in 2013 and black-and-white aerial photos from 1994 that were scanned from hard copy imagery. The 2013 imagery covers the proposed Project footprint and a sizeable adjacent area. The 1994 imagery covers the majority of the LSA; however, there are three portions of the LSA that fall outside of the imagery coverage and as a result were not mapped due to poor image quality. The unmapped area is far removed from predominately high elevation bedrock and glaciers and far removed from Project infrastructure.

Mapping was completed in stereo using various versions of ArcMap 10 and PurVIEW. Vertical control for PurVIEW included the use of provincial TRIM 20-metre contour elevation data. Mapping products completed for the Project include the following:

- 1:20,000 terrain mapping completed in 2016 by SNC Lavalin;

- 1:5,000 bioterrain mapping completed in 2016 by Polar Geoscience and expanded in 2017 by Dave Yole Consulting;

- 1:5,000 soil mapping in 2017 by David Yole;

- Preliminary 1:20,000 TEM completed in 2016 by Triton Environmental Consultants;

- Revised 1:20,000 TEM completed in 2017 by EcoLogic Consultants; and

- 1:5,000 TEM completed in 2017 by EcoLogic Consultants.

Quality assurance and quality control was carried out throughout each phase of the assessment. Initial polygon delineation for TEM mapping was checked for slivers and other errors by senior GIS staff. Once polygons were attributed, image interpretation and data entry were assessed by a senior ecologist. Data cards were assessed for entry and interpretive errors.

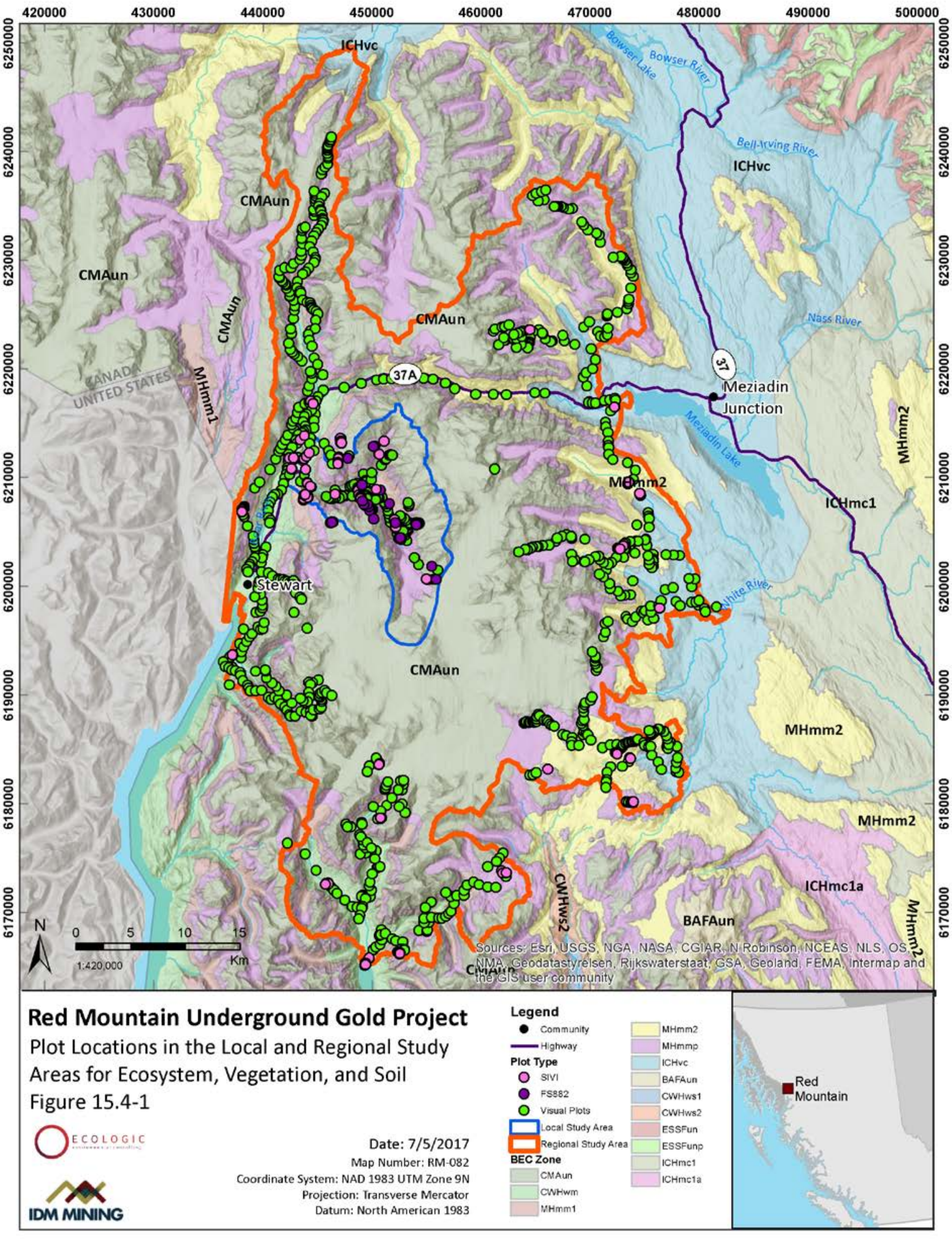
The preliminary 1:20,000 mapping was reviewed by senior ecologists and terrain specialists for both ecosystem classification and for completeness of mapped attributes. The revised 1:20,000 TEM was reviewed primarily for mapped attributes. The 1:5,000 TEM was reviewed using a random polygon selection process and revised as necessary.

15.4.3.2.3 TEM, PEM, Soil and Terrain Field Surveys

Field surveys were conducted by four qualified professionals (ecologists, a soil scientist and a botanist) and two Nisg̲a'a assistants from July 4 to 11th, 2016**.** Surveys to confirm preliminary TEM, PEM, and terrain mapping included the completion of 21 detailed ecosystem (FS882) plots, 23 site visit (SIVI) plots, and 30 visual inspections (Figure 15.4-1). At a minimum, the field data included the ecosystem classification, terrain classification, and vegetation structural stage attributes. In addition, 146 SIVI plots and over 500 visual observations (mainly from a helicopter) were made throughout the RSA. These observations were completed to support the PEM modelling and ranged from descriptions of leading vegetation and structural stage, slope and terrain comments, and identification of obvious ecosystem classification.

The Survey Intensity Level (SIL) for both the PFSA and the LSA is 3. SIL 3 generally supports mapping in the 1:10,000 range. SIL 3 is considered an appropriate survey level to evaluate potential effects of the Project at the landscape level. This information and intensity level is used to inform the evaluation of effects of the Project on the environment and is used to guide overall Project planning, management, and mitigation.

Figure 15.4-1: Plot Locations in the LSA and RSA for Ecosystems, Vegetation, and Soil



15.4.3.2.4 Soil Mapping

Soil inspections (including profile descriptions) were carried out following the guidelines established in the *Field Manual for Describing Terrestrial Ecosystems* (BC Ministry of Environment Lands and Parks and BC Ministry of Forests Research Branch 1998). Soils classification, to the order level, is inferred primarily from soil morphologic observation interpretations with very limited lab data. Soil orders and horizon characterization follow the Canadian System of Soil Classification (Soil Classification Working Group 1998). Twenty-one sites had ground inspections, which facilitated lab analysis for basic soil fertility, total carbon (C), pH, available cations, percent base saturation, available metals in saturated paste extract, particle size analysis, and $CaCO_3$ equivalent.

Soil inspection information is used to assist in determining general soil map units (SMU), the basic units of the soil map. Soil mapping is largely an interpretive exercise based upon field data, terrain attributes, PurVIEW 3D imagery, local climate, and experience with similar and nearby soils and mapping. It is completed primarily to identify sensitive soil areas and to support soil salvage and reclamation planning.

The goal of soil sample inspections in representative soil polygons of the PFSA is to achieve a sense of reliability in the soils map produced and the individual soil map types.

15.4.3.2.5 Rare Plant and Lichen Surveys

Rare plant and lichen surveys were conducted to identify those species that are Red- or Blue-listed by the BC CDC, have a conservation-priority S-ranking (subnational conservation ranking) according to NatureServe, have protection under the *Species at Risk Act* (SARA 2002), or are ranked as threatened or endangered by COSEWIC. In addition to these target rare species, additional research was conducted to identify species previously unreported for the province and possibly of conservation concern. Based on the list of potential rare species, areas of greater likelihood for finding rare species (e.g., cliffs, rock outcrops, alpine scree slopes, and wetlands) were selected for the rare plant surveys.

Rare plant and lichen surveys were timed to optimize plant identification (e.g., during flowering and/or fruiting) and occurred during the summer of 2016 (July 4 to 8 and August 8 to 11). Survey efforts focused on sites where proposed Project components overlapped with potential rare plant habitat within the LSA.

All surveys were conducted by Curtis Björk, a qualified botanist with extensive experience in the region. Surveys were conducted using a controlled intuitive wander method, where the surveyor focuses on habitats and landscape features that yield the highest numbers of species and that have the greatest likelihood of containing rare species (US Department of the Interior 2009).

A full floristic survey was conducted for each site concurrent with the rare plant and lichen surveys. These inventories further support rare plant and lichen data by provided better understanding of their habitats and plant associations.

15.4.3.2.6 Soil Samples for Metal Analysis

Soil samples were collected at 21 locations within the LSA to establish current metal concentrations. Approximately one litre of soil was collected at each site. Samples were kept cool and sent to Caro Labs as soon as practical for subsequent drying, sieving, and subsampling prior to lab work by standard BC methodology for soil analysis. Generally, the 0 to 15 cm surface layer of mineral soil was sampled from each site for particle size, soil fertility, and metal determination.

The metals analyses determine current metal levels in the area of proposed infrastructure as well as control sites outside of the expected zone of influence of Project environmental effects (i.e., the LSA). This data comprises the basis to evaluate changes in metal levels due to the Project. Results from the metals analysis may be used for human health assessments and/or future monitoring programs. All analyses were carried out by Caro Labs in Richmond, BC.

The interpretation of baseline data included comparing analytical results to the industrial guidelines provided for 19 metals by the Canadian Council of Ministers of the Environment (CCME 2007). Additional parameters, including pH, carbon, texture, $CaCO_3$ equivalence, and cation exchange capacity were analyzed to provide information on potentially significant characteristics relative to reclamation suitability and soil management.

15.4.4 Baseline Characterization

15.4.4.1 Ecologically Valuable Soils

Ecologically Valuable Soils are those that have some characteristics that allow them to support ecological development. In mountainous environments, processes occur that allow for the deposition of materials that are often mapped as soils but are not capable of supplying soil functions. These areas would include low bench floodplains dominated by coble and boulder sized materials, alpine fellfields, and bedrock outcrops.

Table 15.4-1 shows a rating of ecological value for each SMU (Appendix 9-A). Ecologically Valuable Soils maps are presented in Figure 15.4-2. Based upon characteristics, including texture, coarse fragment contact, soil depth for rooting and drainage, organic matter content, soil chemistry data, and clay content, SMUs were assigned a rating of high, medium, low, and none.

Potential Project effects were identified and evaluated in relation to the SMUs. The ratings are relative, meaning that the high-rated soils are the most valuable soils within the PFSA and are not necessarily the most valuable soils within a larger context, such as the RSA.

Details regarding SMU classification, soil chemistry and terrain characteristics are presented in Appendix 9-A.

Table 15.4-1: Summary of Soil Map Units Mapped in the PFSA

Soil Mapping Unit	Project Footprint Study Area		Soil Mapping Unit Name	Ecologically Valuable Soils Rating	Soil Mapping Unit Description
	Area (ha)	Proportion (%)			
1a	85.3	8.9	Mesic Site, Average Mid-Slope Soils	Moderate	• Well- to rapidly drained, coarse-textured deep soils often of sandy, silty (dominantly loamy sand), and gravelly texture and derived from glacial till and colluvium materials. • Commonly found on mesic or average sites with average- to below-average nutrients and fresh or moist soil moisture. • Typically occur on mainly glacial till blankets (>1 m depth) with slope gradients ranging from gentle to steep (e.g., 15-50% slope gradient) and occur in all slope positions. • Coarse fragment content ranges from 20-50%. Typical soil classification (CSSC 1998) for this type includes O.HFP, EL.DYB, O.DYB, and O.EB.
1b	24.3	2.5	Mid-Lower Slope positions	Moderate	• Soil textures range from loamy (L-SL) - SiL tills on 5-40% slope gradient. • Soils of this type mainly on lower-toe slope position, and as such, have slightly higher organic matter content (i.e., are medium-brown in colour). Ah horizons <0-5 cm in depth and can include somewhat richer intermixed soil materials owing to slope movement. Soils are moist but not saturated for long duration, thus gleying and intense mottling are uncommon. Typical soil classification is variable for this SMU include O.HFP, O.DYB, GL.DYB, O.EB, and GL.EB
1c	11.1	1.2	Fine Silt Loam Veneer at Surface of Till	Moderate	• Mesic, well drained Podzols and Brunisols with a veneer of silt loam at surface of glacial till. • Surface mineral material prone to surface water erosion. • Difficult to discern from imagery and needs on-site ground assessment. Slightly more productive forests. More common gullying evident.

Soil Mapping Unit	Project Footprint Study Area		Soil Mapping Unit Name	Ecologically Valuable Soils Rating	Soil Mapping Unit Description
	Area (ha)	Proportion (%)			
4	33.4	3.5	Fine-Textured Soils	Moderate	• Finer mineral textures and often overlying compact clay-enriched in mineral soils (e.g., SiCL, L, CL) occur in conjunction with gentle sloping glacial till or lacustrine-type environments forming in lower/toe to undulating slope positions. • Weak mottling and subsurface compacted soil layers (weak compacted clay pans) are common. • Soil gullying and failures are relatively common, particularly on slope gradients from 40 to ≥70+%. Soils can include "Solifluction" (-S) process in deeper deposits in colder alpine or subalpine environments. • Common soil subgroups include O.EB, O.DYB, O.MB, BR.GL (weak), GLBR.GL, and GLD.GL. Soils are generally >1 m in depth. • These soil types are potentially valuable soil materials for construction of containment facilities or settling ponds.
4a	44.0	4.6	Fine Texture Soils, Evidence of Erosion or Movement	High	• Moist, fine-textured glacial till (Mb) and glaciolacustrine materials (LG) (often L to SiCL texture). • Moderately well to imperfectly drained soil materials with common seepage but no prominent mottling. • Commonly occur on lower- to toe-slope positions and often near the vicinity (i.e., side slopes) of creek draws. • Soil subgroups include GL.MB, O.MB, and O.SB. Variable coarse fragment content. Potentially unstable soil materials, as evidenced by tree buttressing or surface tension fractures, and requiring careful management during construction phases. • Very good soil types to salvage for construction or reclamation activities requiring finer soil textures and moisture retention, but caution required owing to high compaction potential, especially during wet periods.

Soil Mapping Unit	Project Footprint Study Area		Soil Mapping Unit Name	Ecologically Valuable Soils Rating	Soil Mapping Unit Description
	Area (ha)	Proportion (%)			
4b	13.0	1.4	Dark, Finer Texture Soils	High	• Generally, includes dark colours, till, colluvium, or glaciolacustrine soils that look "rich" in nutrients often containing silt loam textures in the upper 30 cm. • Occurs most often on moist to wet seepage sites in lower/toe to near-level slope positions. Also found alongside creek draws or beside avalanche tracks. • Rooting depth is often >60 cm, most often contain organic-enriched brown to black surface horizons (Ah and Bm horizons) of SiL to SiCL texture, and are often underlain by coarser sandy gravelly till or colluvium surficial materials. • Soil drainage ranges from well- to imperfectly-drained and with common seepage. • Common in the vicinity of unstable "moving" soil material, as evidenced by butressed trees and soil pedoturbation (i.e., mixed up soil layers). • Soil subgroups include O.MB and GL.EB (with darker brown colours).
5	25.5	2.7	Glaciofluvial sands and gravel-gentle to level	Moderate	• Occurs on flat- to gently undulating Glaciofluvial sand and gravel terraces. • Relatively loose soils with high coarse fragment content, commonly >50% clast volume; shallow main rooting zone, often <25 cm from surface. • Main soil types include bright coloured Humo-Ferric Podzols and Dystric Brunisols (O.HFP, E.DYB, and O.DYB). • Can be moisture- and nutrient-deficient for part of the growing season.
5a	29.5	3.1	Glaciofluvial-Steep	Poor	• Glaciofluvial materials on steeper 30 to 60% slope gradients. • May include hummocky eskers type terrain with well to rapid drainage and sandy/gravely soils. • Depth soil usually 30 to 60 cm. • Soils often have nutrient poor conditions and are prone to brief periods of summer drought, especially in warm aspects. • Rapid debris failures (dry ravelling) common down to a creek feature. • Main soil types include bright coloured Podzols and Brunisols (O.HFP, E.DYB, and O.DYB).

Soil Mapping Unit	Project Footprint Study Area		Soil Mapping Unit Name	Ecologically Valuable Soils Rating	Soil Mapping Unit Description
	Area (ha)	Proportion (%)			
6	122.5	12.8	Shallow Soils	Poor	• Shallow soil deposits of colluvium, saprolite (rotten rock), or morainal veneers over bedrock. • Often high coarse fragment content (>50%). • May be derived from decaying bedrock or failures or thin glacier deposits over bedrock outcrops and common on steep slopes (often >50-75% slope gradient). • Very common to upper and crest slope positions and moisture shedding. Soil types include acidic Podzols and Brunisols. • Main soil types include O.HFP, E.DYB, O.R, and Non-Soil (NS). Lithic and Shallow Soil Phase common in forested and alpine areas where bedrock is <50 cm.
6a	12.0	1.3	Rubbly Talus	Poor	• Rubbly/bouldery talus materials, often with >65 to 90% coarse fragment volume derived from varied local bedrock types. • Slope gradient 50-100%. • Soil types commonly include O.R, O.DYB, and O.MB. Mostly <30-75 cm to bedrock contact.
6b	73.2	7.6	Loose Moderately Deep Colluvium	Moderate	• Moderately deep colluvium (>45 to 60% gradient), relatively deep (zsCwks) and loose soils with angular coarse fragments. • Surficial material depth to bedrock often 50-100 cm. • Main soil types include O.HFP, EL. DYB, and O.DYB. • Often submesic moisture and nutrient regime (i.e., slightly drier and poorer). Common evidence of soil movement.
6c	81.0	8.4	Colluvium in Lower/Toe Slope Positions	Poor	• Shallow colluvial toe and lower slope position, soils moist to wet for majority of growing season. • Common presence of soil mottles suggesting very brief periods of soil saturation. • Soils often dark colours at surface and commonly have seepage but generally soils are well-aerated conditions. Soil types commonly include GL.MB, GL.EB, and O.EB and often <50 cm to bedrock.

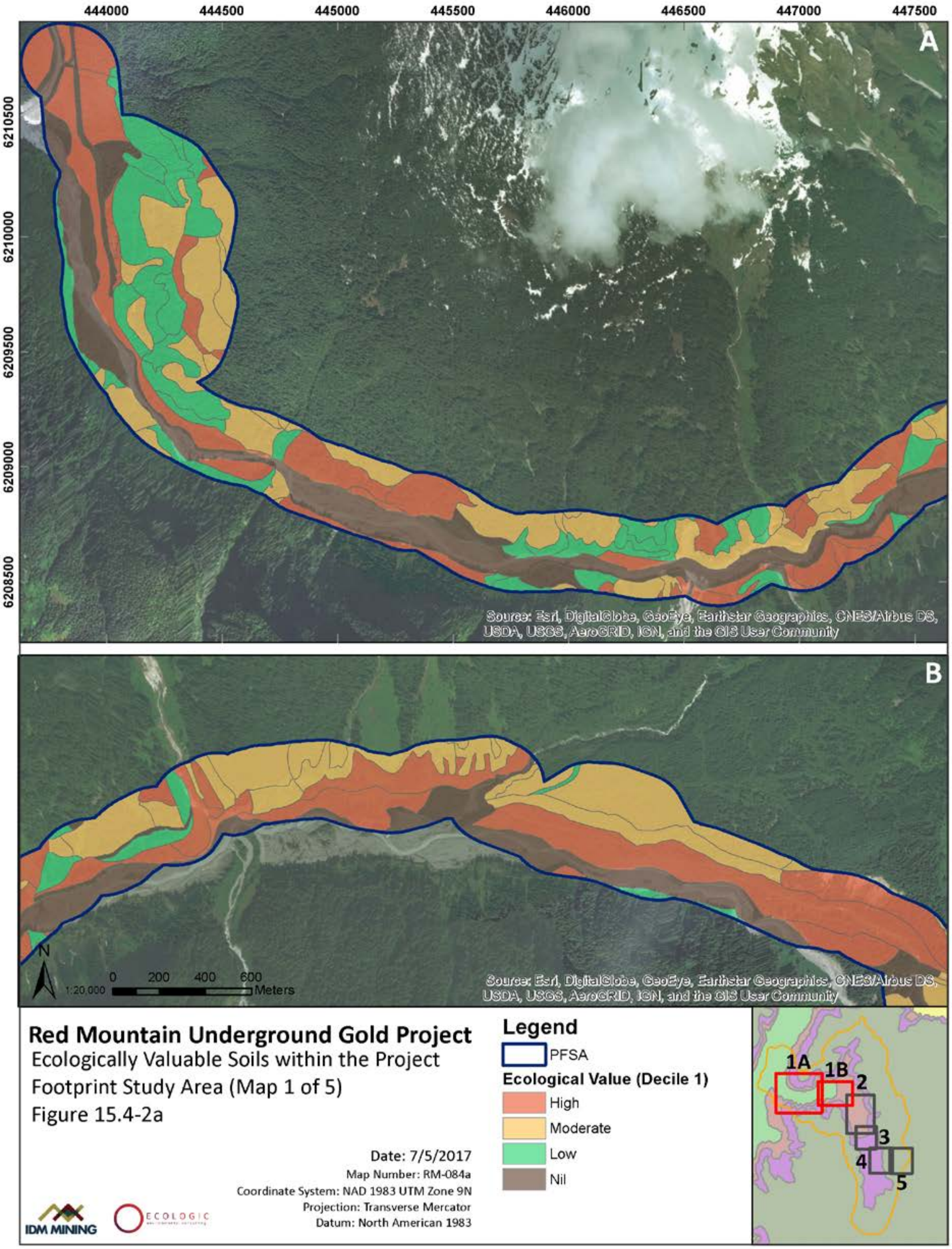
Soil Mapping Unit	Project Footprint Study Area		Soil Mapping Unit Name	Ecologically Valuable Soils Rating	Soil Mapping Unit Description
	Area (ha)	Proportion (%)			
6d	60.1	6.3	Active and Older Snow Avalanche Scars	High	• Active snow avalanche terrain and older unstable terrain subject to previous disturbance. • Areas subject to failures, flash channel/draw flooding, gullying, and continuous seepage. • Areas at toe of slope subject to wind-shear, blow-down events, and pedoturbation. • Common soil types include GL.MB, GL.EB, O.RG, O.HG.
7a	20.8	2.2	Alpine Soils	High	• Alpine/subalpine moist meadows and brown to black soils common. • Mostly till (Mv/R) and saprolite veneers (Dv/R) over rock with seepage common in receiving positions or in close proximity to springs. • Soils classification includes O.HFP, O.EB, O.DYB, O.MB, and O.SB (Lithic Phases common).
7b	4.6	0.5	Wetlands (Fens, Swamps, Marshes)	High	• Shrubby fens swamp or marshes in alpine/ subalpine and forested areas. • This SMU is uncommon and limited in extent, usually <0.5 ha. • Generally, these soil materials form as thin veneers (<1 m) of organic material (Ov), mostly derived from saturated conditions and sedge vegetation in depression slope positions. • Spring flooding common. • Soils often less than 30 cm depth to bedrock or compact till/lacustrine. Soils typically include TE.M and TE.FI. • Water table and seepage is usually <25 cm from the surface.
7c	0.2	0.0	Carex-Dominated Wetlands and Organic Soils	High	• Sedge-dominated wetlands in depression or toe slope position in subalpine, alpine and forested locations. These sites and soils are very rare and limited in extent. • Soil types expected include moderately decomposed Mesisols (T.M and TY.M). • Water table and seepage is usually <10 cm from the surface.

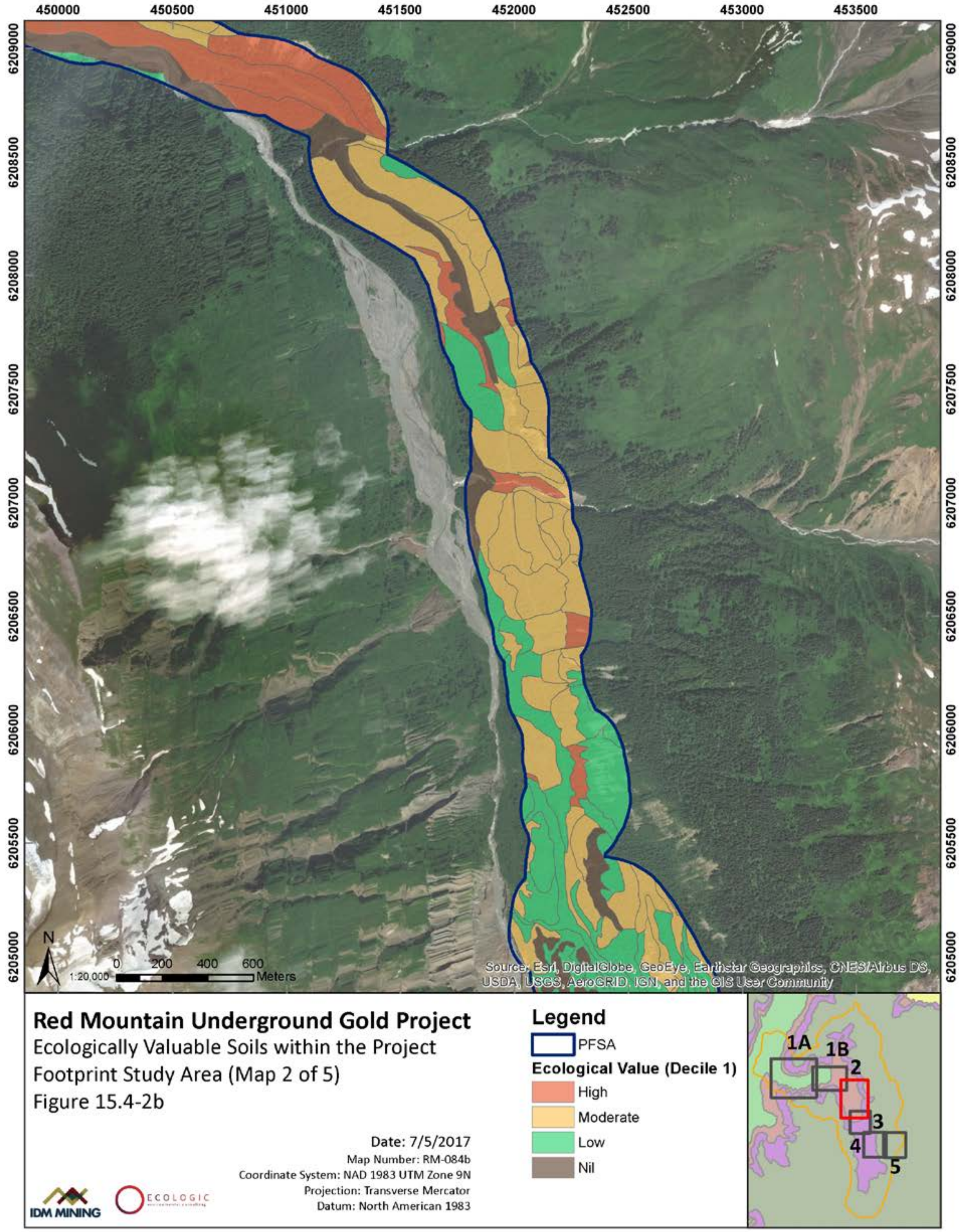
Soil Mapping Unit	Project Footprint Study Area		Soil Mapping Unit Name	Ecologically Valuable Soils Rating	Soil Mapping Unit Description
	Area (ha)	Proportion (%)			
7d	77.4	8.1	Alpine Tundra, Shallow Soils	Moderate	• Alpine/subalpine drier exposed alpine tundra with heathers, sparse grasses lichens; shallow to broken rock or saprolite. • Most commonly brown Brunisolic soils with some minor Ah horizons (3-10 cm depth). • Deeper Ah horizons can occur on long open slopes >30-45% gradient common where “flowing lobes of soils” or “Solifluction” geomorphic process occurs in frozen/thaw environments on moderate to strong slopes (i.e., near to glacier interface). • Texture of mineral material often gravelly, fine, sandy loam. Relatively rare or unique soil type in vicinity of the PFSA.
8	7.4	0.8	River, Fluvial Soils	None	• Soils forming in moist to wet creek draws and channels and subject to annual or semi-annual flooding. • These are newly deposited surficial materials often with minimal soil development (Regosols) and are laid down in highly erosive environments often with a finer sand or silt capping over coarser gravelly, cobbly materials. • Creek channels usually <10 m width occur in steep mountainous areas.
8a	71.6	7.4	High Bench Fluvial	High	• Inactive and older mid- to high-bench fluvial terraces. • Relatively older fluvial terraces, often well drained. • Not necessarily rich, but can be rich. • Soil types include O.EB, O.MB, GL.R, and O.R (in very coarse dry sands). • Can be very sensitive soils/sites to compaction and water erosion depending on soil texture.
8b	71.2	7.4	Active Fluvial	None	• Active fluvial deposits and floodplains. • Annual flooding is common (e.g., Bitter Creek) and includes some low-bench fluvial and active river deposits with prolonged periods of water inundation. • Subsurface seepage is usually present (depth of 20 to 50 cm) for most of year and at the surface in early spring freshet. • Most of these soils have high erosion potential, especially where fine sand and silt layers exist at the surface. • Common soil types O.R, GL.R, CU.R, and GLCU.R.

Soil Mapping Unit	Project Footprint Study Area		Soil Mapping Unit Name	Ecologically Valuable Soils Rating	Soil Mapping Unit Description
	Area (ha)	Proportion (%)			
8c	9.9	1.0	Fluvial Fans	None	• Fluvial fans forming on and gentle slopes (5 to 30%) and often richer than average and potentially subject annual fluvial sediment input, erosion, and gullying. • Subsurface seepage common and rich vegetation includes alder and ferns. • Common soil types include O.EB and GL.MB. Often high coarse fragment content >50%.
A	21.1	2.2	Low Bench Active Fluvial	High	• Active fluvial deposits and floodplains. • Annual flooding common (e.g., Bitter Creek) and includes some low bench fluvial and active river deposits with prolonged periods of water inundation. • Subsurface seepage usually 20-50 cm most of year and at the surface in early spring freshet. • Most of these soils have high erosion potential, especially where fine sand and silt layers exist at the surface. • Common soil types O.R, GL.R, CU.R, and GLCU.R
RO	42.4	4.4	Bedrock-dominated materials	None	• Bedrock outcrops, very common in upper slope positions and high elevation areas. • Can include very thin saprolite or till veneers of <10 cm mineral soil to rock. • Soil types include Non-Soil and RO.
I	16.9	1.8	Ice-dominated Materials	None	• Ice materials at or near the glacier ice. • Snow often persists late in the growing season in depression slope positions or areas of cold air drainage. • Frozen soils and soil-forming processes can exist under or near the ice margins and undergo cryoturbation soil-forming processes, such as solifluction.
Total	**960.3**	**100.0**			

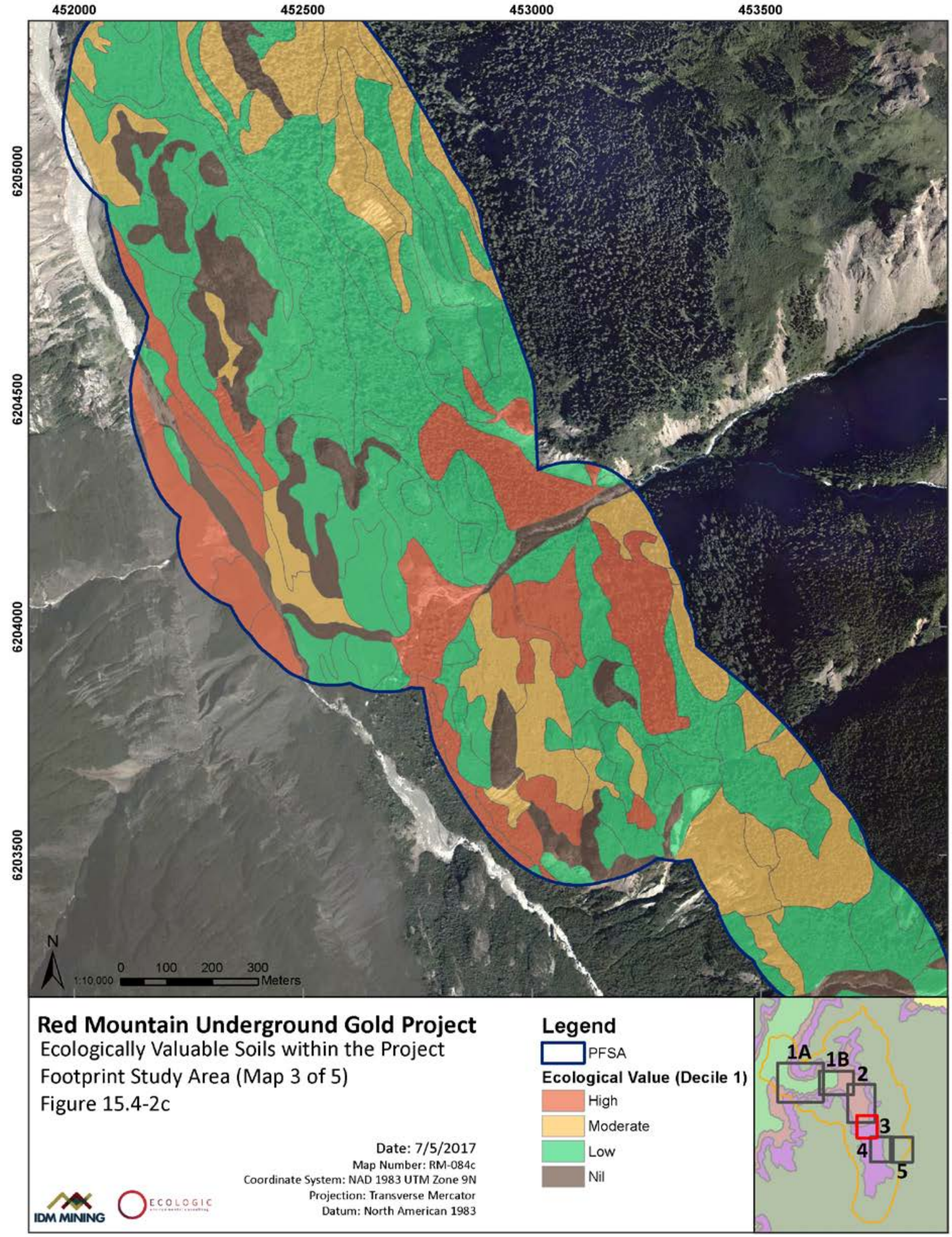
Note:
Values may not sum to total shown because of rounding.

Figure 15.4-2: Ecologically Valuable Soils within the PFSA





Red Mountain Underground Gold Project
Ecologically Valuable Soils within the Project Footprint Study Area (Map 2 of 5)
Figure 15.4-2b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Meters
Red Mountain Underground Gold Project
Ecologically Valuable Soils within the Project Footprint Study Area (Map 3 of 5)
Figure 15.4-2c
Legend
PFSA
Ecological Value (Decile 1)
High
Moderate
Low
Nil
Date: 7/5/2017
Map Number: RM-084c
Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
IDM MINING
ECOLOGIC
1A
1B
2
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4
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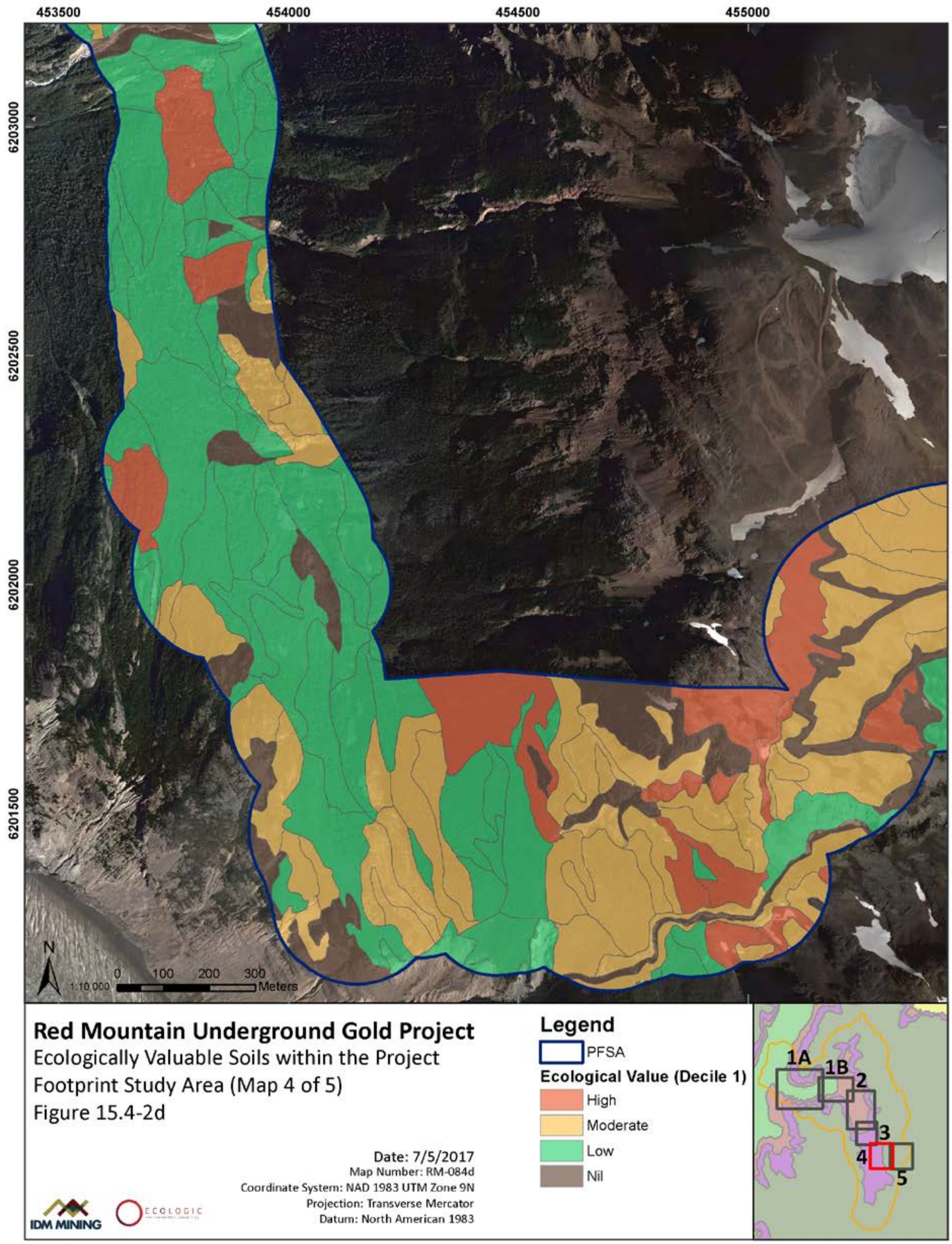
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Red Mountain Underground Gold Project
Ecologically Valuable Soils within the Project Footprint Study Area (Map 4 of 5)
Figure 15.4-2d
Date: 7/5/2017
Map Number: RM-084d
Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
IDM MINING
ECOLOGIC
Legend
PFSA
Ecological Value (Decile 1)
High
Moderate
Low
Nil
1A
1B
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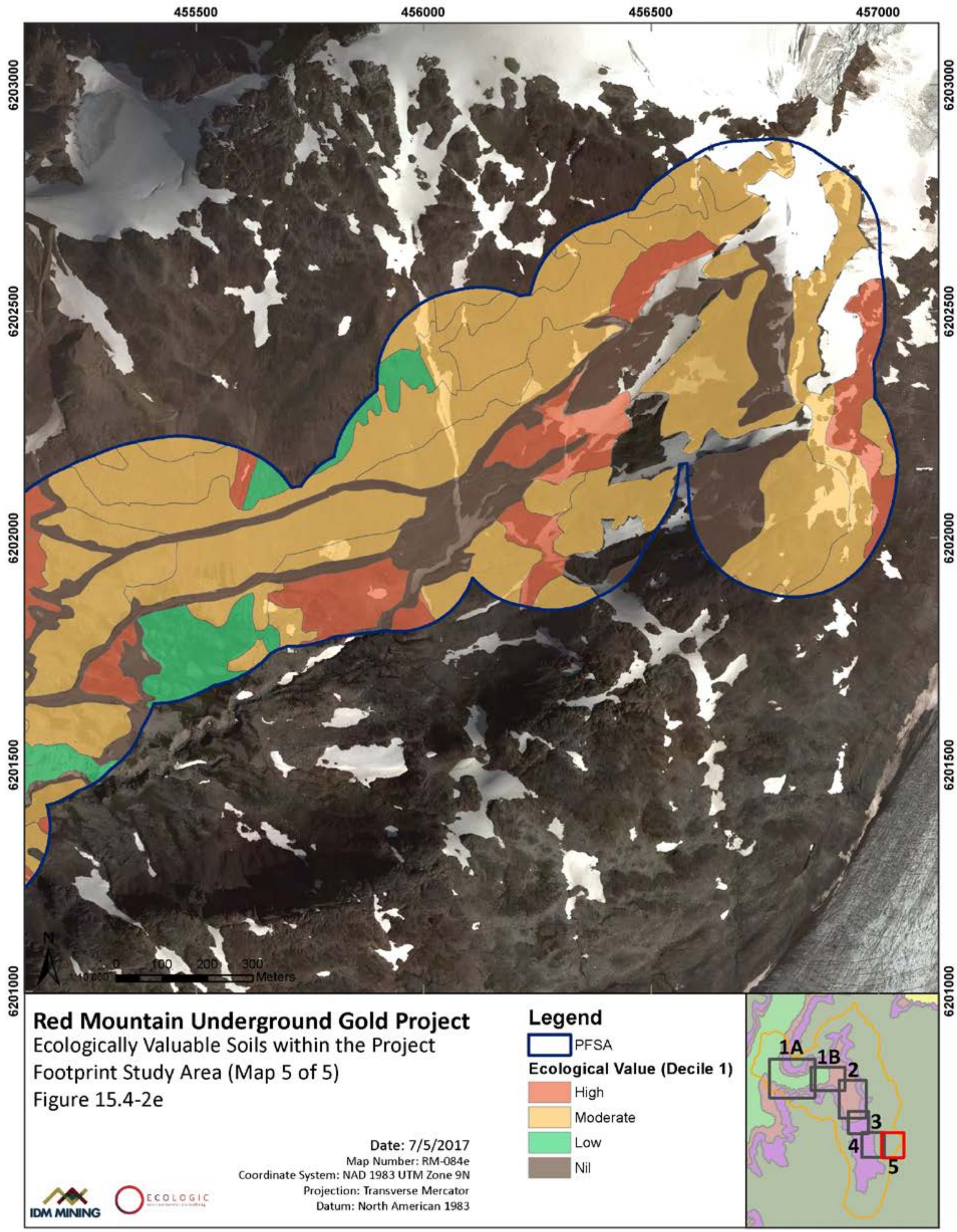


Red Mountain Underground Gold Project
Ecologically Valuable Soils within the Project Footprint Study Area (Map 5 of 5)
Figure 15.4-2e

Date: 7/5/2017
Map Number: RM-084e
Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983

15.4.4.2 Local and Regional Ecosystems

Three levels of ecosystem mapping were completed for the Project: RSA, LSA, and PFSA (Table 15.4-2). The RSA was mapped using PEM to model the general extent of ecosystem units in the regional landscape (Figure 15.4-3). Predictive Ecosystem Mapping (PEM) was completed for the 211,570 hectare RSA. The PEM included six BEC units, including coastal, interior and alpine areas. Alpine (CMAun) and parkland (MHmmp) zones cover over 70% of the RSA, with the remainder including subalpine forested units (16%) and lowland interior (5%) and coastal (8%) forested units. The LSA was mapped using traditional TEM methods at a scale of 1:20 000 (Figure 15.4-4), while the PFSA was mapped at a scale of 1:5 000 (Figure 15.4-5). The LSA and PFSA TEM include CMAun, CWHwm, MHmm1 and MHmmp subzones.

Table 15.4-2: BEC Units in the RSA, LSA, and PFSA

BEC Unit Name	BEC Unit Label	RSA Extent (ha)	RSA Extent (%)	LSA Extent (ha)	LSA Extent (%)	PFSA Extent (ha)	PFSA Extent (%)
Coastal Mountain-heather Alpine - Undifferentiated Subzone	CMAun	106,165.7	50.2	8,222.9	51.8	165.7	17.2
Coastal Western Hemlock - Wet Maritime Subzone	CWHwm	17,695.6	8.4	1968.9	12.4	352.2	36.7
Interior Cedar Hemlock - Very Wet Cold Subzone	ICHvc	11,199.9	5.3	-	-	-	-
Mountain Hemlock - Moist Maritime Subzone - Windward Variant	MHmm1	10,849.2	5.1	2,264.5	14.3	240.0	25.0
Mountain Hemlock - Moist Maritime Subzone - Leeward Variant	MHmm2	23,317.0	11.0	-	-	-	-
Mountain Hemlock - Moist Maritime Parkland	MHmmp	42,342.0	20.0	3,403.6	21.5	202.9	21.1
Total		211,569.6	100.0	15,859.9	100.0	960.7	100.0

Figure 15.4-3: Predictive Ecosystem Mapping within the RSA

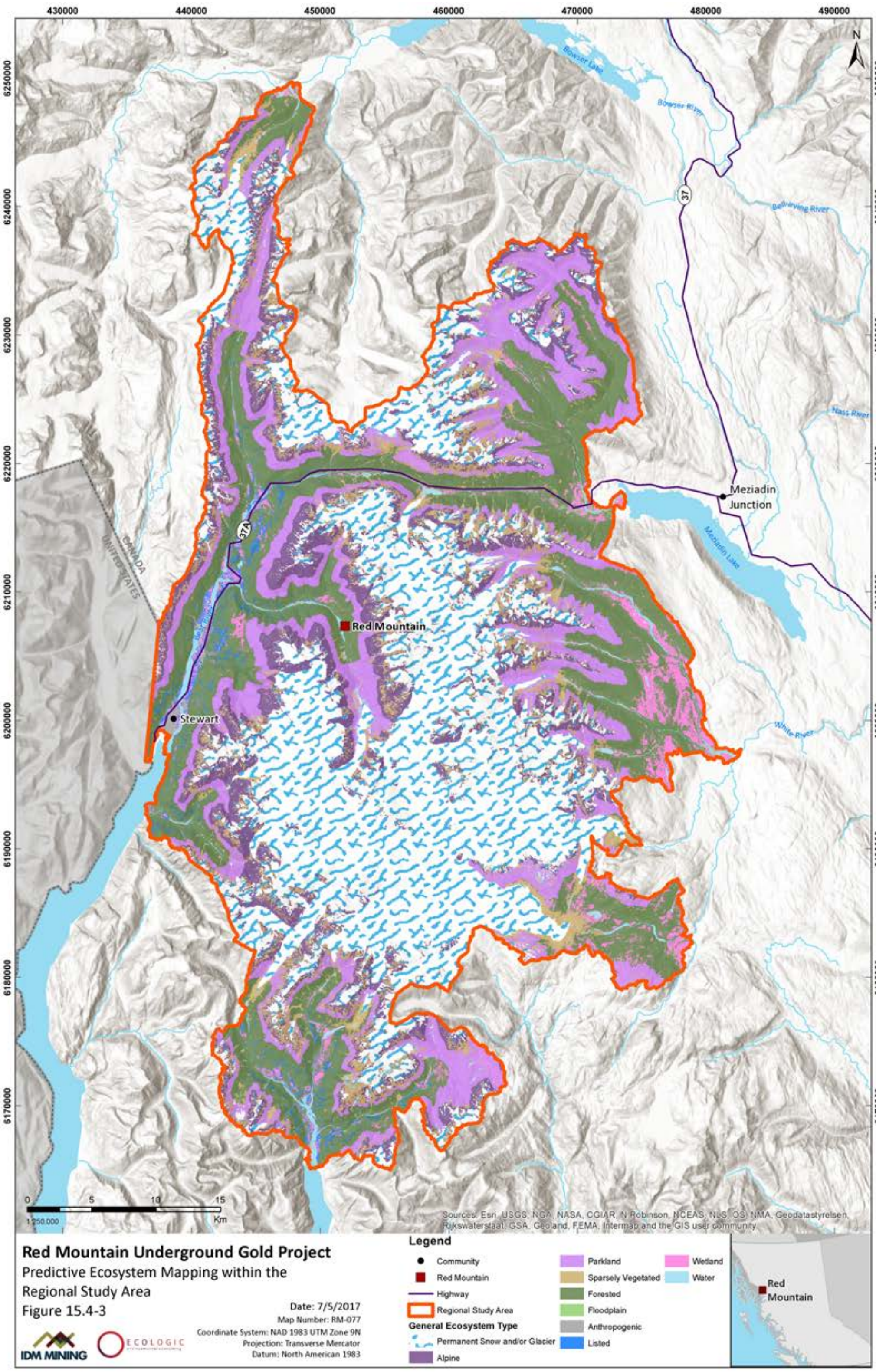


Figure 15.4-4: Terrestrial Ecosystem Mapping within the LSA

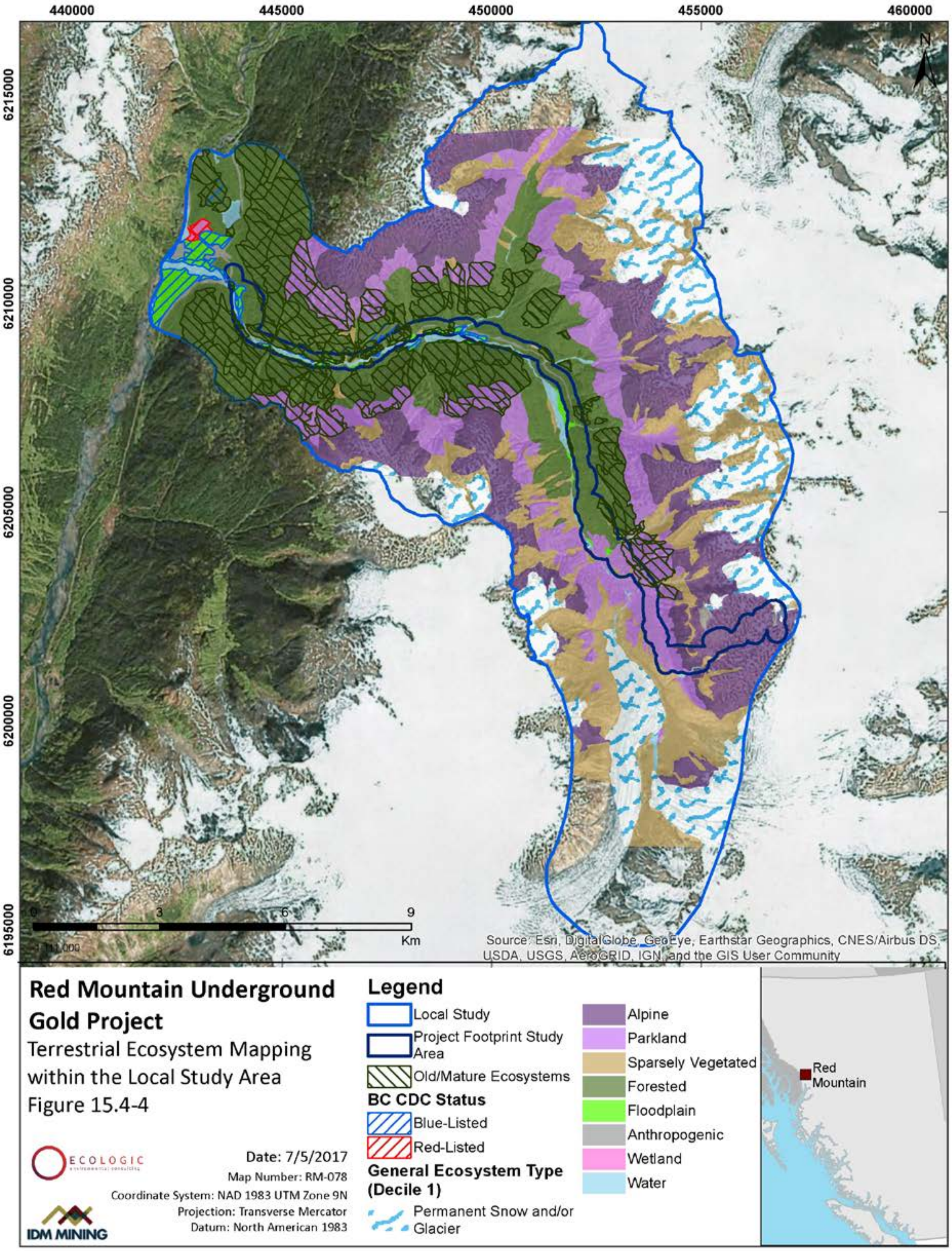
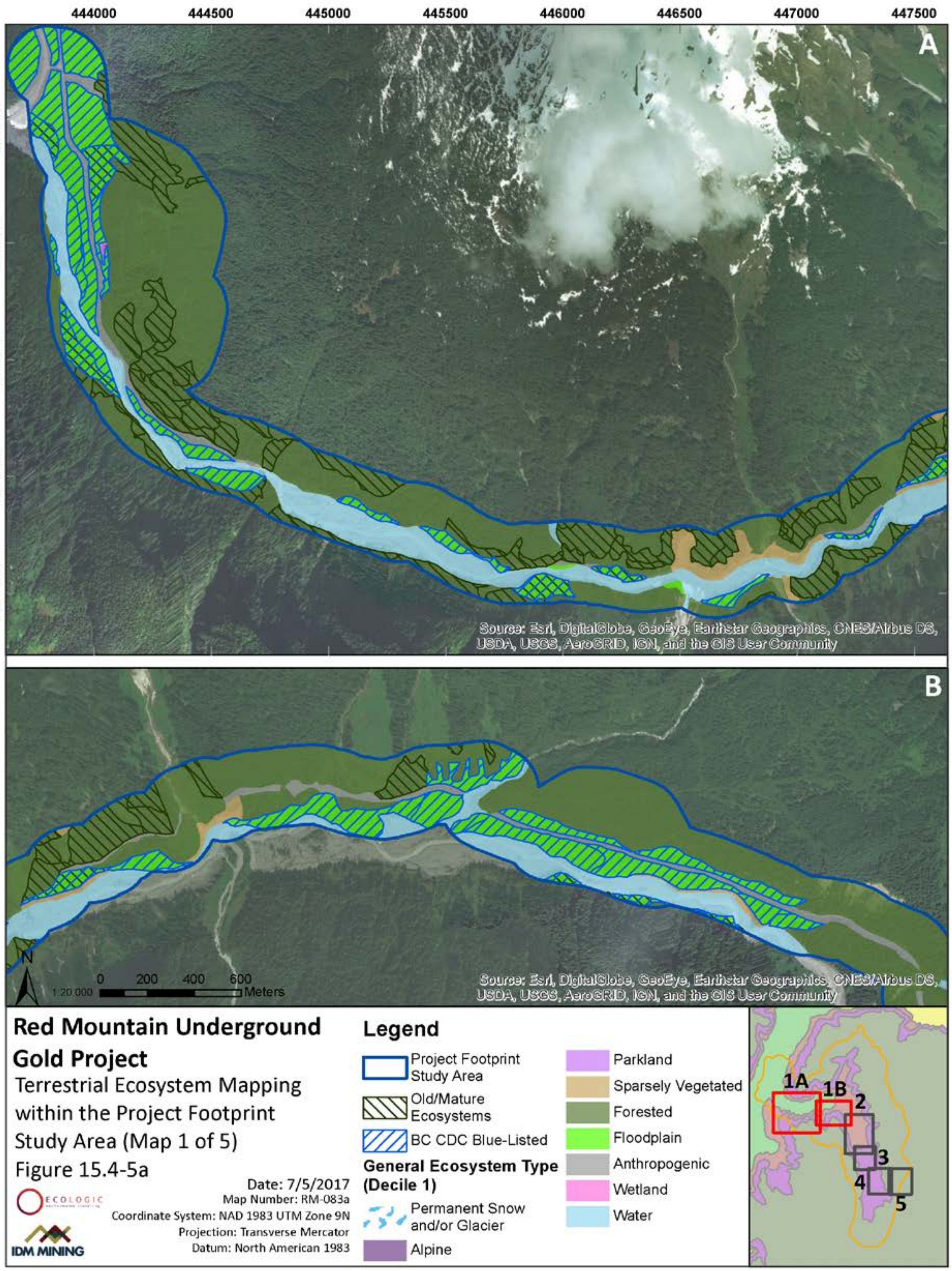
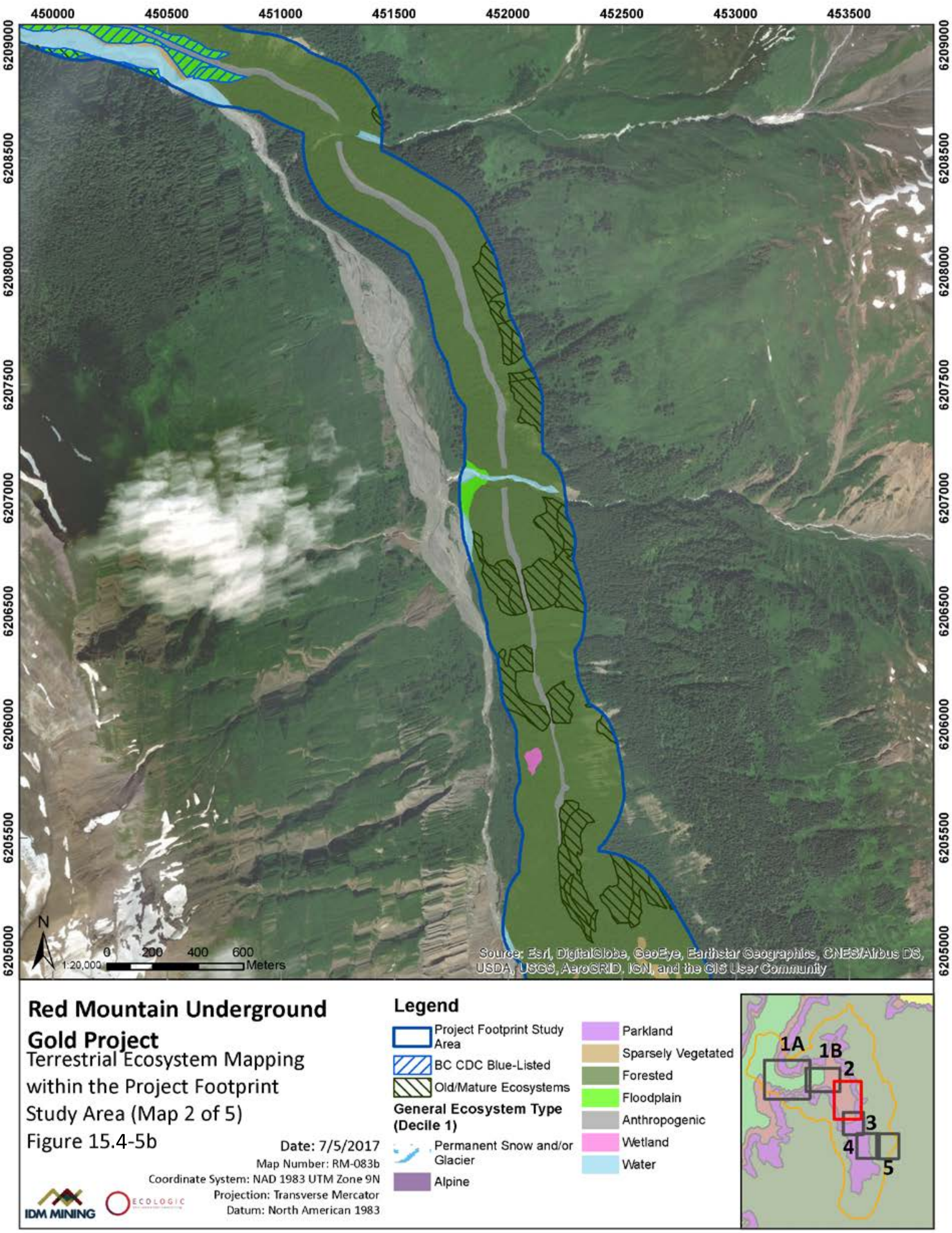


Figure 15.4-5: Terrestrial Ecosystem Mapping within the PFSA

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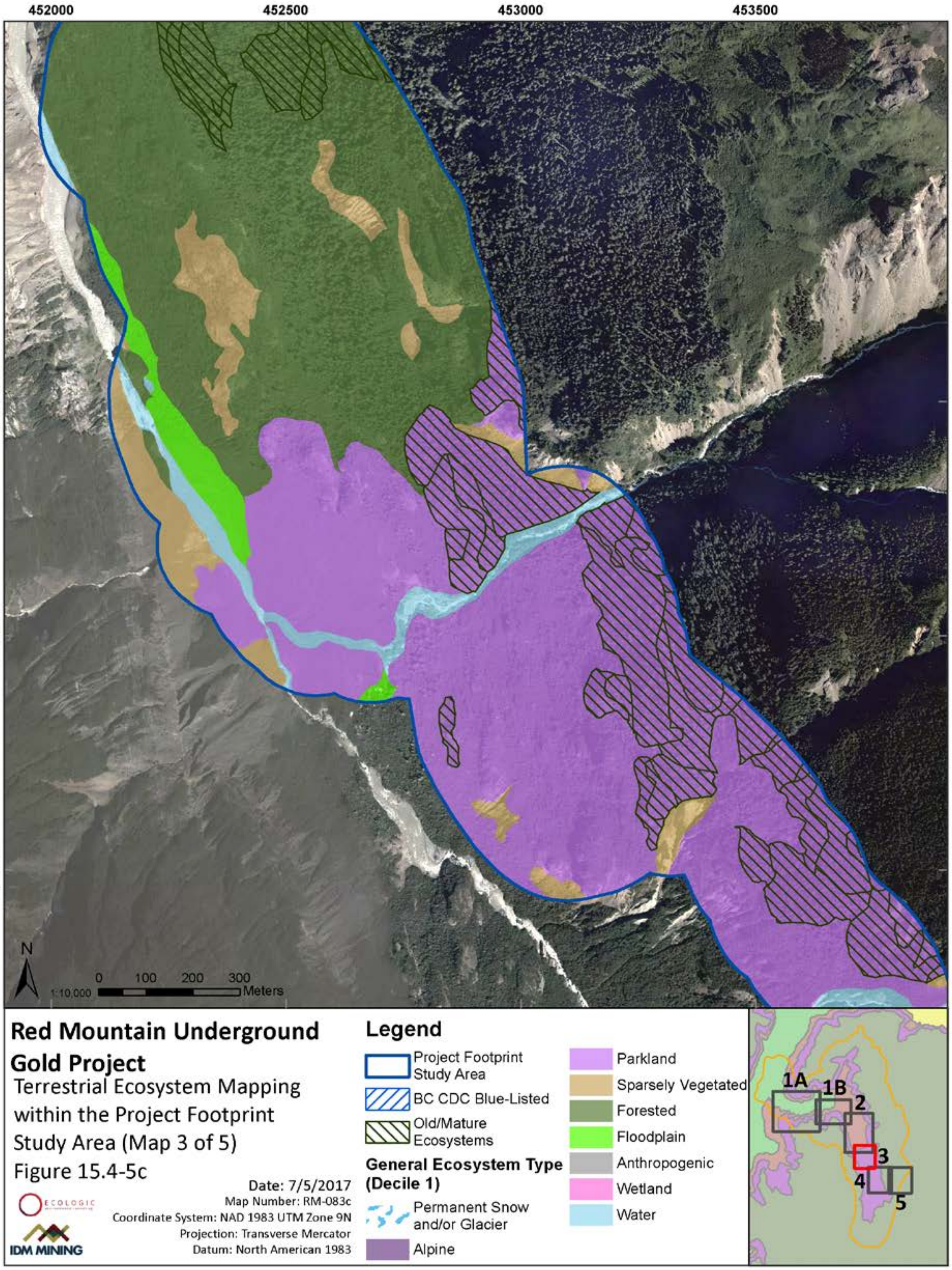
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Red Mountain Underground Gold Project
Terrestrial Ecosystem Mapping within the Project Footprint Study Area (Map 2 of 5)
Figure 15.4-5b
Date: 7/5/2017
Map Number: RM-083b
Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
IDM MINING
ECOLOGIC
Legend
Project Footprint Study Area
BC CDC Blue-Listed
Old/Mature Ecosystems
General Ecosystem Type (Decile 1)
Permanent Snow and/or Glacier
Alpine
Parkland
Sparsely Vegetated
Forested
Floodplain
Anthropogenic
Wetland
Water
1A
1B
2
3
4
5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Red Mountain Underground Gold Project
Terrestrial Ecosystem Mapping within the Project Footprint Study Area (Map 3 of 5)
Figure 15.4-5c
Date: 7/5/2017
Map Number: RM-083c
Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
ECOLOGIC
IDM MINING
Legend
Project Footprint Study Area
BC CDC Blue-Listed
Old/Mature Ecosystems
General Ecosystem Type (Decile 1)
Permanent Snow and/or Glacier
Alpine
Parkland
Sparsely Vegetated
Forested
Floodplain
Anthropogenic
Wetland
Water
1A
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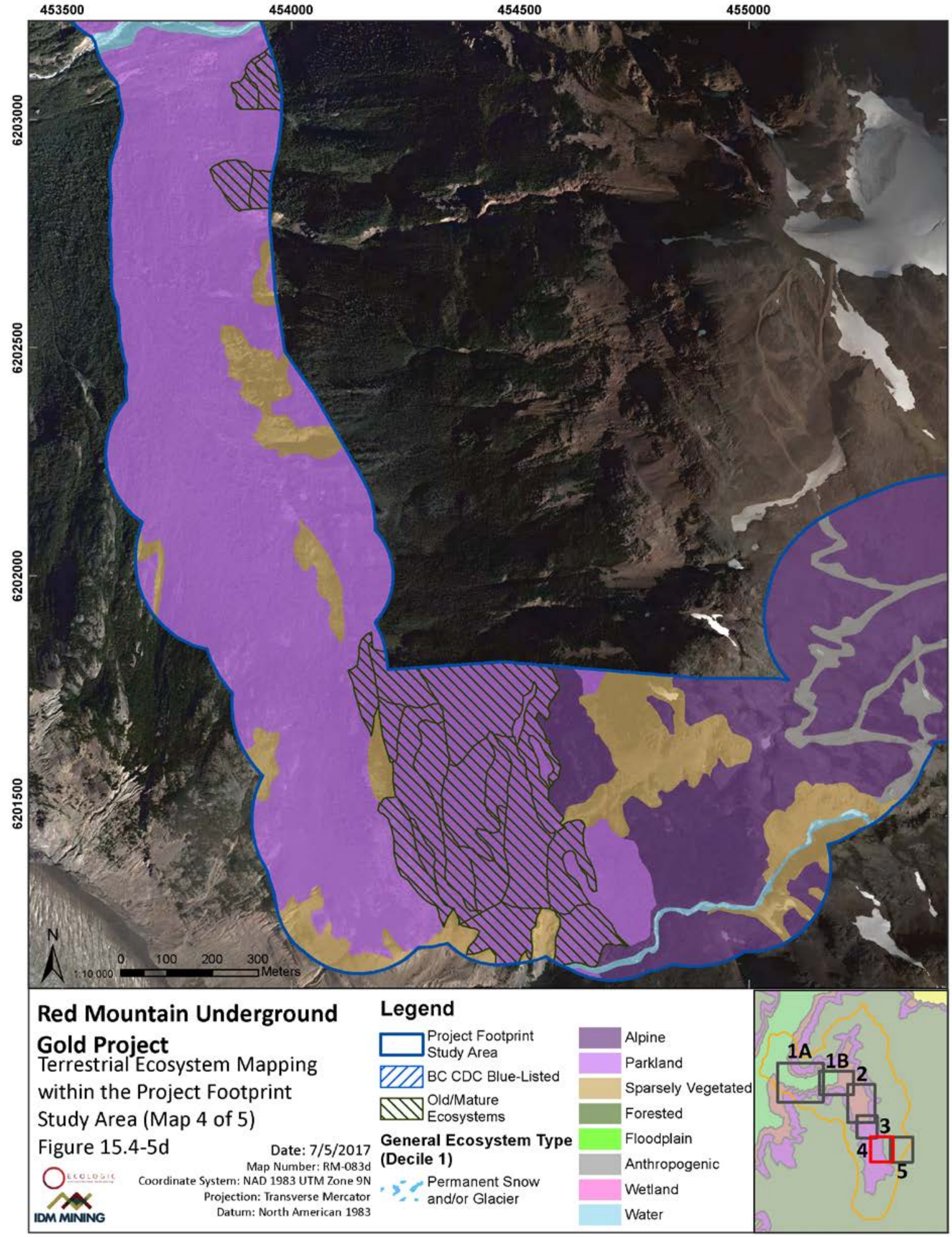
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Red Mountain Underground Gold Project
Terrestrial Ecosystem Mapping within the Project Footprint Study Area (Map 4 of 5)
Figure 15.4-5d
Date: 7/5/2017
Map Number: RM-083d
Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
IDM MINING
Legend
Project Footprint Study Area
BC CDC Blue-Listed
Old/Mature Ecosystems
General Ecosystem Type (Decile 1)
Permanent Snow and/or Glacier
Alpine
Parkland
Sparsely Vegetated
Forested
Floodplain
Anthropogenic
Wetland
Water
1A
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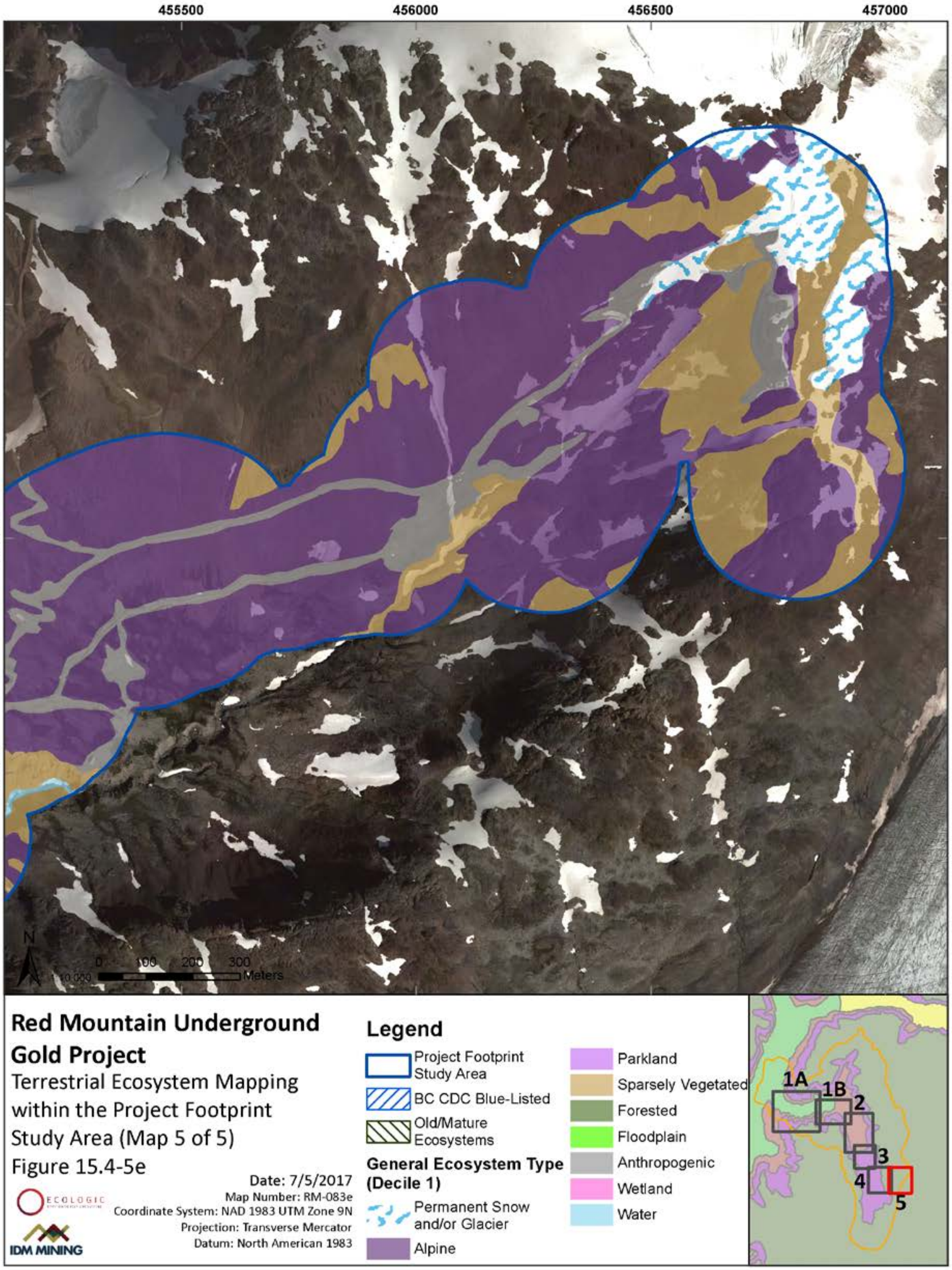
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0 100 200 300 Meters
Red Mountain Underground Gold Project
Terrestrial Ecosystem Mapping within the Project Footprint Study Area (Map 5 of 5)
Figure 15.4-5e
Date: 7/5/2017
Map Number: RM-083e
Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
ECOLOGIC
IDM MINING
Legend
Project Footprint Study Area
BC CDC Blue-Listed
Old/Mature Ecosystems
General Ecosystem Type (Decile 1)
Permanent Snow and/or Glacier
Alpine
Parkland
Sparsely Vegetated
Forested
Floodplain
Anthropogenic
Wetland
Water
1A
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15.4.4.2.1 Alpine and Parkland

Alpine ecosystems are characterized by an absence of trees due to climatic and edaphic conditions associated with higher elevations. Common ecosystems include heath, tundra, herb meadows, and krummholz. Non-vegetated areas, such as permanent snow, ice fields, rock outcrops, and barren soil, are also common. Parkland ecosystems represent the transitional zone in between forested subzones at lower elevations and the true alpine at higher elevations (B.C. Ministry of Forests and Range, 2006). Parkland is often characterized by groupings of trees distributed within krummholz, grasslands, heath, and herb meadows.

Alpine ecosystems are considered sensitive because disturbed alpine vegetation may not recover to pre-disturbance levels, even in the long-term (Forbes, Ebersole, & Strandberg, 2001; Frank & del Moral, 1986; Mingyu, Hens, Xiaokun, & Wulf, 2009). This situation is particularly true of dwarf shrubs and krummholz. Studies have also indicated that disturbed alpine ecosystems may recover to a stable-state community with different species assemblages than were present pre-disturbance (Forbes, 1996; Becker and Pollard, 2016).

Alpine ecosystems are important seasonal habitat for wildlife, providing forage, breeding areas, and escape terrain from predators and insects. For example, alpine ecosystems provide habitat for Blue-listed mountain goat (*Oreamnos americans*), Blue-listed wolverine (*Gulo gulo;* which is also a species of Special Concern federally under the SARA*;* McNay et al., 2009), grizzly bear (*Ursus arctos*), and hoary marmots (*Marmota caligata*).

Alpine ecosystems account for 19.2% of the LSA and 11.1% of the PFSA (Table 15.4-3). Vegetated alpine ecosystems were primarily mapped in the CMAun.

Parkland ecosystems with vegetated units account for 14.1% of the LSA and 18.7% of the PFSA (Table 15.4-4).

Table 15.4-3: Vegetated Alpine Ecosystems Mapped within the LSA and PFSA

BEC Unit	Site Series/Map Code	Ecosystem Description	Structural Stage	LSA Extent (ha)	LSA Extent (%)	PFSA Extent (ha)	PFSA Extent (%)
CMAun	00/Af	Alpine fellfield	1a	1324.9	8.4	59.6	6.2
	00/Ah	Alpine heath	2d	384.2	2.4	17.5	1.8
	00/Am	Alpine meadow	2a	473.2	3.0	-	-
	00/As	Alpine nivation (Late snowbed)	1a	415.4	2.6	0.8	0.1
			2b	19.8	0.1	0.2	<0.1
	00/At	Alpine tundra	2d	203.7	1.3	21.6	2.2
	00/Sc	Shrub carr	3a	7.7	<0.1	-	-
	00/Sk	Krummholz	3a	121.0	0.8	5.0	0.5
			3b	26.0	0.2	2.4	0.2

BEC Unit	Site Series/Map Code	Ecosystem Description	Structural Stage	LSA Extent (ha)	LSA Extent (%)	PFSA Extent (ha)	PFSA Extent (%)
	00/Vh	Avalanche herb meadow	2a	16.3	0.1	-	-
	00/Vs	Avalanche shrub thicket	3a	37.1	0.2	-	-
			3b	7.9	<0.1	-	-
Total				3037.4	19.2	107.0	11.1

Table 15.4-4: Vegetated Parkland Ecosystems Mapped within the LSA and PFSA

BEC Unit	Site Series/Map Code	Ecosystem Description	Structural Stage	LSA Extent (ha)	LSA Extent (%)	PFSA Extent (ha)	PFSA Extent (%)
MHmmp	00/Af	Alpine fellfield	1a	68.2	0.4	-	-
	00/Ah	Alpine heath	2d	23.7	0.1	0.8	0.1
	00/Am	Alpine meadow	2a	212.3	1.3	-	-
	00/At	Alpine tundra	2d	3.8	<0.1	0.9	0.1
	00/PK	Parkland forest	3b	-	-	2.4	0.2
			4	-	-	0.9	0.1
			5	89.7	0.6	29.7	3.1
			6	171.7	1.1	12.6	1.3
			7	281.0	1.8	17.5	1.8
	00/Sc	Shrubland (dry)	2d	-	-	3.4	0.4
			3a	179.4	1.1	13.8	1.4
			3b	93.5	0.6	1.9	0.2
	00/Sk	Krummholz	3a	80.3	0.5	0.2	<0.1
			3b	108.1	0.7	0.5	<0.1
			5	1.1	<0.1	-	-
	00/SW	Shrubland (willow/alder thicket)	3a	-	-	21.0	2.2
			3b	-	-	55.2	5.7
	00/Vh	Avalanche herb meadow	2a	136.8	0.9	0.3	<0.1
	00/Vs	Avalanche shrub thicket	3a	558.9	3.5	10.2	1.1
			3b	203.8	1.3	7.4	0.8

BEC Unit	Site Series/Map Code	Ecosystem Description	Structural Stage	LSA Extent (ha)	LSA Extent (%)	PFSA Extent (ha)	PFSA Extent (%)
	00/Vt	Avalanche treed	3a	6.2	<0.1	-	-
			3b	10.4	0.1	0.1	<0.1
			5	10.8	0.1	-	-
			6	-	-	0.9	0.1
			Total	2239.7	14.1	179.6	18.7

15.4.4.2.2 Old Growth and Mature Forested Ecosystems

Mature forests are defined as stands that have a mature canopy, typically with a distinct second cycle of shade-tolerant trees in the lower canopy. Mature stands typically have a complex vertical structure with distinct layers of tree canopies, normally reflecting tree species. Time since disturbance is typically 80 to 140 years (up to 240 years in cold subzones). Shrub and herb understories are well-developed in open patches. In higher elevation or cold areas (such as the MHmmp), the canopy may be limited to a single layer or be open-spaced or irregular in structure and contain stand characters that are more similar to younger forests (BC Ministry of Forests and Range & BC Ministry of Environment, 2010).

Old forests are defined by stands that have complex structures, including the presence of old trees and snags. Lower canopies and regeneration use the same shade-tolerant species as found in the main canopy. Shrub and herb cover is patchy, ranging from thick cover in openings as old trees fall out, to sparse or absent cover under dense, continuous canopy cover. Large woody debris on the forest floor is always present and occurs in a variety of decomposition stages, including nurse logs. Old forests are considered to occur 140 to 250 years from stand-replacing disturbance, with very old standing occurring at over 400 years from disturbance. Old stands occurring at higher elevation and in cold environments often lack many of the typical old-growth characteristics (BC Ministry of Forests and Range & BC Ministry of Environment, 2010).

The ecological value of mature and old forests is well known, ranging from old-growth dependent species, carbon sequestration, biodiversity, and genetic diversity (Mosseler, Thompson, & Pendrel, 2003; Fredeen, Bois, Janzen, & Sanborn, 2005). Mature to old forests typically have a greater diversity of flora and fauna, including arboreal and underground (soil) species, relative to young stands (Lesica, McCune, Cooper, & Hong, 1991; Qian, Klinka, & Sivak, 1997). Studies have indicated that both the time since disturbance and the structural diversity with old-growth results in a more diverse assemblage of species, often including listed species that require highly specialized habitats (Lesica et al., 1991; McCune, Rosentreter, Ponzetti, & Shaw, 2000).

Mature and old forests account for 15.0% of the LSA and 21.3% of the PFSA (Table 15.4-5) and occur in all but the CMAun. Forested ecosystems from the MHmmp that were mapped as structural stage five (young forest) were included in this category, as they likely represented mature or old trees that will never reach a classic structural stage due to environmental conditions.

Table 15.4-5: Old Growth and Mature Forest Ecosystems Mapped within the LSA and PFSA

BEC Unit	Site Series/Map Code	Ecosystem Description	Structural Stage	LSA Extent (ha)	LSA Extent (%)	PFSA Extent (ha)	PFSA Extent (%)
CWHwm	01/HB	01 - HwSs - Blueberry	6	201.7	1.3	15.8	1.6
			7	161.8	1.0	3.7	0.4
	02/HM	02 - HwSs - Step moss	6	13.6	0.1	-	-
	03/SO	03 - SsHw - Oak fern	6	141.4	0.9	7.3	0.8
			7	228.5	1.4	21.6	2.2
	04/SD	04 - SsHw - Devil's club	6	74.1	0.5	17.7	1.8
			7	78.0	0.5	17.3	1.8
	05/SS	05 - Ss - Salmonberry - high bench floodplain	6	8.2	0.1	5.1	0.5
			7	12.6	0.1	10.4	1.1
	06/CD	06 - Act - Red-osier dogwood - mid bench floodplain	6	1.0	<0.1	2.4	0.2
			7	-	-	1.2	0.1
MHmm1	01/MB	01 - HmBa - Blueberry	6	243.3	1.5	5.4	0.6
			7	280.7	1.8	-	-
	02/MM	02 - HmBa - Mountain-heather	7	0.6	<0.1	-	-
	03/MO	03 - BaHm - Oak fern	6	129.1	0.8	19.2	2.0
			7	67.0	0.4	2.5	0.3
	04/AB	04 - HmBa - Bramble	6	11.6	0.1	-	-
	05/MT	05 - BaHm - Twistedstalk	6	14.4	0.1	14.6	1.5
			7	27.8	0.2	-	-
	06/MD	06 - HmYc - Deer cabbage	7	22.6	0.1	-	-
	07/YH	07 - YcHm - Hellebore	6	23.8	0.2	-	-
			7	39.5	0.2	-	-
	08/YS	08 - HmYc - Sphagnum	6	19.4	0.1	-	-
			7	17.9	0.1	-	-
MHmmp	00/Pk	Parkland forest	5	89.7	0.6	29.7	3.1
			6	171.7	1.1	12.6	1.3
			7	281.0	1.8	17.5	1.8
	00/Vt	Avalanche treed	5	10.8	0.1	-	-
			6	-	-	0.9	0.1
			Total	2371.8	15.0	204.8	21.3

15.4.4.2.3 Floodplain and Wetland Ecosystems

Floodplains are dynamic ecosystems that are classified by their connection (i.e., landscape position) to a river or creek. Provincial guide books group these ecosystems into low, medium, and high-bench floodplain ecosystems. Low-bench floodplains occur in the active floodplain where significant flooding occurs on an annual (or more frequently on small systems with less ability to retain water from large precipitation events) basis. The flooding typically is persistent and results in either scouring or deposition of bed substrate, which largely precludes the establishment of forested ecosystems. They are typically characterized by a sparse to thick cover of shrubs (such as willow, alder, or cottonwood), little to no soil development, and lack of herb or moss cover. Mid-bench floodplains occur at a higher elevation from the river or creek. They experience annual flooding or vertical changes in groundwater levels and are subject to powerful flooding during high water years. Mid-bench floodplains are relatively stable ecosystems that are typically dominated by deciduous trees, such as cottonwood, and have few to no conifer tree species. High-bench floodplains are on largely inactive fluvial plains where regular flooding does not occur and flooding of any kind is rare. They remain connected to the riverine system through seasonal fluctuations in groundwater and typically support conifer and deciduous forests (MacKenzie and Moran 2004).

Floodplains are uncommon in the Project area, accounting for 1.4% of the LSA and 7.6% of the PFSA (Table 15.4-6). Floodplain ecosystems included high, medium, and low bench floodplains; sparsely vegetated gravel bars are not included in the floodplain category. Only the CWHwm had floodplain ecosystems that could be classified to the site series level, as the other BEC units do not have established ecosystem units for floodplains.

Table 15.4-6: Floodplain Ecosystems Mapped within the LSA and PFSA

BEC Unit	Site Series/ Map Code	Ecosystem Description	Structural Stage	LSA Extent (ha)	LSA Extent (%)	PFSA Extent (ha)	PFSA Extent (%)
CWHwm	00/Fl	Low bench floodplain	3a	-	-	0.7	0.1
			3b	-	-	<0.1	<0.1
	05/SS	05 - Ss - Salmonberry - high bench floodplain	3b	1.1	<0.1	0.3	<0.1
			4	3.7	<0.1	5.2	0.5
			5	107.1	0.7	23.5	2.4
			6	8.2	0.1	5.1	0.5
			7	12.6	0.1	10.4	1.1
	06/CD	06 - Act - Red-osier dogwood - mid bench floodplain	3a	2.1	<0.1	-	-
			3b	6.3	<0.1	3.0	0.3
			4	-	-	11.2	1.2
			5	55.0	0.3	5.0	0.5
			6	1.0	<0.1	2.4	0.2
			7	-	-	1.2	0.1

BEC Unit	Site Series/ Map Code	Ecosystem Description	Structural Stage	LSA Extent (ha)	LSA Extent (%)	PFSA Extent (ha)	PFSA Extent (%)
	07/CW	07 - Act - Willow	3a	1.3	<0.1	-	-
			3b	9.6	0.1	-	-
MHmm1	00/Fl	Low bench floodplain	2d	3.6	<0.1	0.3	<0.1
			3a	2.3	<0.1	1.2	0.1
			3b	7.0	<0.1	-	-
	00/Fm	Middle bench floodplain	3b	-	-	3.4	0.4
			4	1.7	<0.1	-	-
MHmmp	00/Fl	Low bench floodplain	3b	0.8	<0.1	0.4	<0.1
	00/Fm	Middle bench floodplain	3b	1.5	<0.1	-	-
			Total	224.8	1.4	73.3	7.6

A wetland is defined as land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation, and various kinds of biological activity that are adapted to a wet environment (Warner and Rubec 1997). Wetland ecosystems are found where soils are saturated by water for enough time that the excess water and resulting low oxygen levels influence the vegetation and soil. The water influence can be either seasonal or year-round and occurs either at or above the soil surface or within the root zone of plants. Wetlands can be found in depressions or areas of flat or undulating terrain.

The development of wetlands is a dynamic function of climate, hydrology, chemistry, geomorphology, and biology (National Wetlands Working Group, 1997). Wetlands are not generally stable ecosystems. They are constantly evolving; this occurs as soils develop and water regimes change, resulting in communities that often contain aspects of different wetland types as well as transitional areas where they are indeterminate between one class or association and another. Therefore, multiple characteristics of wetlands, due to the interaction of various environmental factors, are required to place them in specific classes and associations. Wetlands in Canada are classified based on the Canadian System of Wetland Classification using five classes: bog, fen, marsh, swamp, and shallow open water (National Wetlands Working Group, 1997) and further refined into associations based on the Wetlands of British Columbia (MacKenzie and Moran, 2004).

Wetlands are uncommon in the Project area, accounting for 0.7% of the LSA and 0.1% of the PFSA (Table 15.4-7). Identified wetlands include swamps and fens that were classified to the site series level along with marshes, swamps, fens, bog, and alpine wetlands that could only be classified to the federal wetland class.

Table 15.4-7: Wetland Ecosystems Mapped within the LSA and PFSA

BEC Unit	Site Series/ Map Code	Ecosystem Description	Structural Stage	LSA Extent (ha)	LSA Extent (%)	PFSA Extent (ha)	PFSA Extent (%)
CMAun	00/Wa	Alpine wetland	2b	-	-	0.1	<0.1
CWHwm	00/Wf	Fen wetland	2b	-	-	0.2	<0.1
	00/Wm	Marsh wetland	2b	1.1	<0.1	-	-
	00/Ws	Swamp wetland	2b	0.7	<0.1	-	-
	09/SC	09 - Ss - Skunk cabbage (Ws54 - CwHw - Skunk cabbage)	4	12.4	0.1	-	-
			5	9.5	0.1	-	-
	Wf50/Wf50	Narrow-leaved cotton-grass - Peat-moss	2b	4.5	<0.1	-	-
	Ws51/Ws51	Sitka Willow - Pacific Willow - Skunk Cabbage	3b	9.1	0.1	-	-
MHmm1	00/Wf	Fen wetland	2b	23.0	0.1	0.6	0.1
	08/YS	08 - HmYc - Sphagnum	6	19.4	0.1	-	-
			7	17.9	0.1	-	-
	00/Wa	Alpine wetland	2b	7.4	<0.1	0.1	<0.1
MHmmp	00/Wb	Bog wetland	5	7.2	<0.1	-	-
Total				112.3	0.7	1.0	0.1

15.4.4.3 BC CDC Listed Ecosystems, Plants, Lichens, and Associated Habitat

In BC, at-risk ecosystems are defined as “an extirpated, endangered, or threatened ecosystem or an ecosystem of special concern” (MOE 2016).

At-risk plants are ranked according to factors such as rarity, intrinsic vulnerability, environmental specificity, threats, and long- and short-term trends in population size by the BC CDC.

The BC CDC categorizes at-risk ecosystems and plants as either Red-listed or Blue-listed depending on their rarity, threats, range extent, and level of protection (Table 15.4-8; MOE 2016). Plants and ecosystems that are common and secure within the province are categorized as Yellow-listed.

Table 15.4-8: BC CDC Status Ranks and Definitions

Rank Status	Definition
Red-listed	Plants that have, or are candidates for, Extirpated, Endangered, or Threatened status in BC. Red-listed species and sub-species may be legally designated as or may be considered candidates for legal designation as Extirpated, Endangered, or Threatened under the *Wildlife Act* (1996).
Blue-listed	Plants of "special concern" (formerly vulnerable) status in BC. Elements are of special concern because of characteristics that make them particularly sensitive to human activities or natural events.
Yellow-listed	Plants that are common and demonstrably secure.

In addition to the BC CDC Conservation Rank Status, ecosystems and plant species are assigned a conservation rank by NatureServe. Conservation status assessments are completed to produce conservation status ranks that measure extinction or extirpation risk at three geographic scales: Global (G-Ranks), National (N-Ranks), and Subnational (S-Ranks; Table 15.4-9).

Table 15.4-9: NatureServe Subnational Conservation Status Ranks and Definitions

NatureServe Subnational Rank[1]	Definition	BC CDC Rank Equivalent
S1	Extremely rare at the provincial level; five or fewer occurrences, or very few remaining individuals; critically imperilled and susceptible to extirpation due to a factor of its biology	Red-listed
S2	Rare at the provincial level; 6 to 20 occurrences, or few remaining individuals; imperilled, may be susceptible to extirpation due to some factor of its biology	
S1S2[2]	Extremely rare to rare at the provincial level	
S3	Vulnerable at the provincial level; 21 to 100 occurrences; may be rare and local throughout the province or may occur in a restricted provincial range (may be abundant in some places); may be susceptible to extirpation by large-scale disturbances	Blue-listed
S2S3	Rare to vulnerable at the provincial level	
S3S4	Vulnerable to common at the provincial level	
S4	Common at the provincial level; more than 100 occurrences; generally widespread and abundant but may be rare in parts of its range; apparently secure	Yellow-listed
S5	Very common and demonstrably secure at the provincial level; more than 100 occurrences	

[1]The NatureServe ranks and definitions at the national (N ranks) and global level (G ranks) are available on their website (NatureServe 2015).

[2] A Range Rank (i.e., S2S3) is used when existing information on an element straddles the criteria defining two separate ranks.

Most BC CDC listed ecosystems are forested ecosystems (i.e., mature forest and old forest structural stages) with the exception of wetlands, alpine and grasslands. Younger structural stages that have developed following forest harvesting or other disturbance within these site associations are represented by different plant or seral associations and are generally not considered rare or endangered.

Five BC CDC listed ecosystems were identified and account for 1.7% of the LSA. Two of these occur within the PFSA and account for 7.0% of the PFSA. The listed ecosystems (all occurring within the CWHwm) included two Blue-listed floodplains, one Red-listed and one Blue-listed wetland, and one Blue-listed forested ecosystem (Table 15.4-10).

Table 15.4-10: BC CDC Listed Ecosystems Mapped within the LSA and the PFSA

BEC Unit	Site Series/Map Code	Ecosystem Description	Provincial Status	Structural Stage	LSA Extent (ha)	LSA Extent (%)	PFSA Extent (ha)	PFSA Extent (%)
CWHwm	02/HM	02 - HwSs - Step moss	Blue	5	18.1	0.1	-	-
				6	13.6	0.1	-	-
	05/SS	05 - Ss - Salmonberry - high bench floodplain	Blue	3b	1.1	<0.1	0.3	<0.1
				4	3.7	<0.1	5.2	0.5
				5	107.1	0.7	23.5	2.4
				6	8.2	0.1	5.1	0.5
				7	12.6	0.1	10.4	1.1
	06/CD	06 - Act - Red-osier dogwood - mid bench floodplain	Blue	3a	2.1	<0.1	-	-
				3b	6.3	<0.1	3.0	0.3
				5	55.0	0.3	5.0	0.5
				6	1.0	<0.1	2.4	0.2
				4	-	-	11.2	1.2
				7	-	-	1.2	0.1
	07/CW	07 - Act - Willow	Blue	3a	1.3	<0.1	-	-
				3b	9.6	0.1	-	-
	09/SC	09 - Ss - Skunk cabbage (Ws54 - CwHw - Skunk cabbage)	Blue	4	12.4	0.1	-	-
				5	9.5	0.1	-	-
				3a	-	-	0.4	<0.1
	Ws51/Ws51	Sitka Willow - Pacific Willow - Skunk Cabbage	Red	3b	9.1	0.1	-	-
				Total	270.7	1.7	67.6	7.0

15.4.4.4 Rare Plants, Lichens, and Associated Habitat

A total of 48 occurrences of 42 rare species were recorded during the rare plant surveys, including 8 vascular plant, 19 lichen, and 15 moss and liverwort species (Table 15.4-11, Table 15.4-12, and Table 15.4-13; Figure 15.4-6, Figure 15.4-7, and Figure 15.4-8).

Thirty-five of these species are listed by the BC CDC: three vascular plant, 18 lichen, and 14 moss and liverwort species. None of the species are listed under SARA or by COSEWIC. The remaining seven species (five vascular plants, one lichen, and one moss) are previously undescribed, new discoveries, or not previously known to occur in BC or North America. Several species are considered rare world-wide based on NatureServe (NatureServe 2015); none are listed as rare under SARA. Several species detected in the rare plant survey have a global rank of GU or GNR, which indicates that their level of conservation priority is unknown or undetermined.

Table 15.4-11: Rare Vascular Plants Observed within the LSA

Vascular Plant Species	Common Name	Provincial Conservation Status	BC List Status	Global Conservation Status
Anemone narcissiflora var. *vilocissima*	narcissus-flowered anemone	S1S3	Red	G5T4
Botrychium crenulatum	scalloped moonwort	S2S3	Blue	G3
Botrychium spathulatum	spatulate moonwort	S3	Blue	G3
Micranthes separate		An undescribed species that appears to be rare, limited to the BC Coast Ranges, known from < 10 sites		
Taraxacum amarum		Previously undocumented species, not represented among any previous herbarium specimens, likely to be rare		
Taraxacum sp. nov. *(short)*		Previously undocumented species, not represented among any previous herbarium specimens, likely to be rare		
Taraxacum sp. nov. *(tall)*		Previously undocumented species, not represented among any previous herbarium specimens, likely to be rare		
Taraxacum speculorum		Previously undocumented species, not represented among any previous herbarium specimens, likely to be rare		

Table 15.4-12: Rare Lichens Observed within the LSA

Lichen Species	Common Name	Provincial Conservation Status	BC List Status	Global Conservation Status
Baeomyces carneus	florke scale beret lichen	S1	Red	GNR
Bryoria nitidula	horsehair lichen	S2S3	Blue	G5
Cetraria nigricans	blackened Iceland lichen	S3	Blue	G5
Cladonia coccifera	Madame pixie lichen	S1	Red	G5
Cladonia macrophylla	fig-leaved pixie lichen	S2	Red	GNR
Cladonia pseudalcicornis	big-foot lichen	S2S3	Blue	GNR
Collema ceraniscum	pincushion tarpaper lichen	S1	Red	GNR
Collema crispum	crinkled pulp lichen	S1	Red	GNR
Fuscopannaria ahlneri	corrugated shingles lichen	S2S3	Blue	G4G5
Heterodermia unknown sp.		A species not previously noted from North America		
Leptogidium dendriscum		S3	Blue	G3G5
Leptogium tenuissimum	birdnest jellyskin lichen	S2?	Red	GNR
Lobaria oregana	lettuce lichen	S3	Blue	G4G5
Lobaria retigera	smoker's lung lichen	S3	Blue	GNR
Nephroma isidiosum	peppered kidney lichen	S3	Blue	G3G5
Placynthium asperellum	Lilliput ink lichen	S3?	Blue	G4G5
Santessoniella arctophila	Arctic dust bunnies lichen	S1	Red	GNR
Stereocaulon botryosum	cauliflower foam lichen	S2	Red	G4
Umbilicaria lambii	windward rocktripe lichen	S3	Blue	G2G4

Table 15.4-13: Rare Moss and Liverwort Observed within the LSA

Moss or Liverwort Species	Common Name	Provincial Conservation Status	BC List Status	Global Conservation Status
Cinclidium stygium	sooty cupola moss	S3	Blue	G5
Grimmia atrata	Grimmia dry rock moss	New discovery for British Columbia, known to be a rare species elsewhere		G5?
Grimmia donniana	Donn's grimmia moss	S2S3	Blue	G4G5
Imbribryum gemmiparum	bud-tipped bryum	S2S3	Blue	G3G5
Mielichhoferia elongata	Mielichhofer's copper moss	S1S2	Red	G4TNR
Mielichhoferia mielichhoferiana	-	S2	Red	G4T2T3
Nardia compressa	compressed flapwort	S3	Blue	G4G5
Niphotrichum pygmaeum	pygmy racomitrium moss	S3	Blue	GU
Peltolepis quadrata		S2	Red	G4
Pohlia cardotii	Cardot's nodding moss	S3	Blue	G2G3
Pohlia erecta	erect nodding moss	S1	Red	G3G5
Pohlia pacifica	Pacific pohlia moss	S1S2	Red	GU
Ptychostomum inclinatum		S3	Blue	G5?
Sauteria alpina	snow lungwort	S3	Blue	G4?
Schistidium venetum	bluish bloom moss	S1	Red	GNR

Figure 15.4-6: Occurrences of Rare Vascular Plants within the LSA

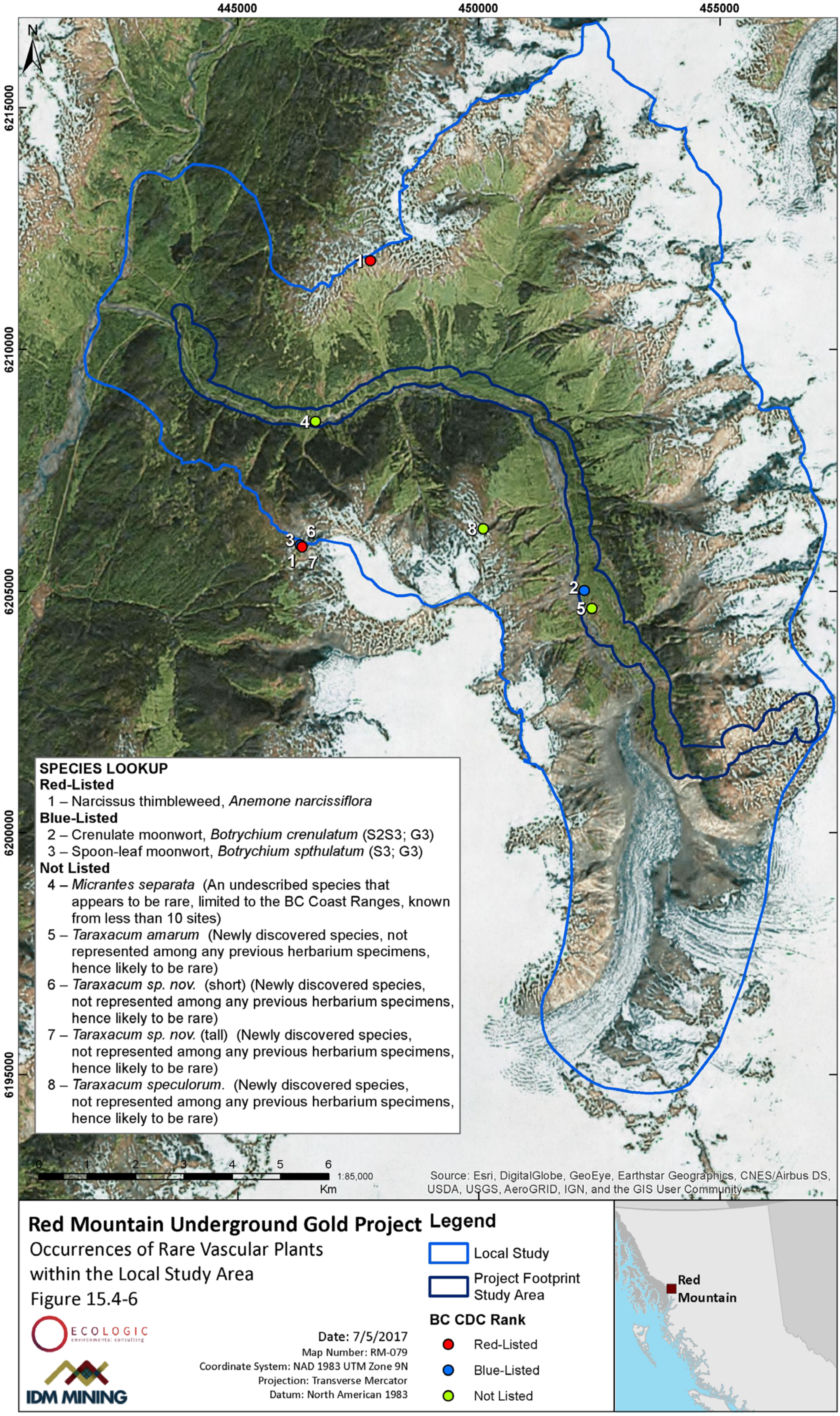


Figure 15.4-7: Occurrences of Rare Lichen within the LSA

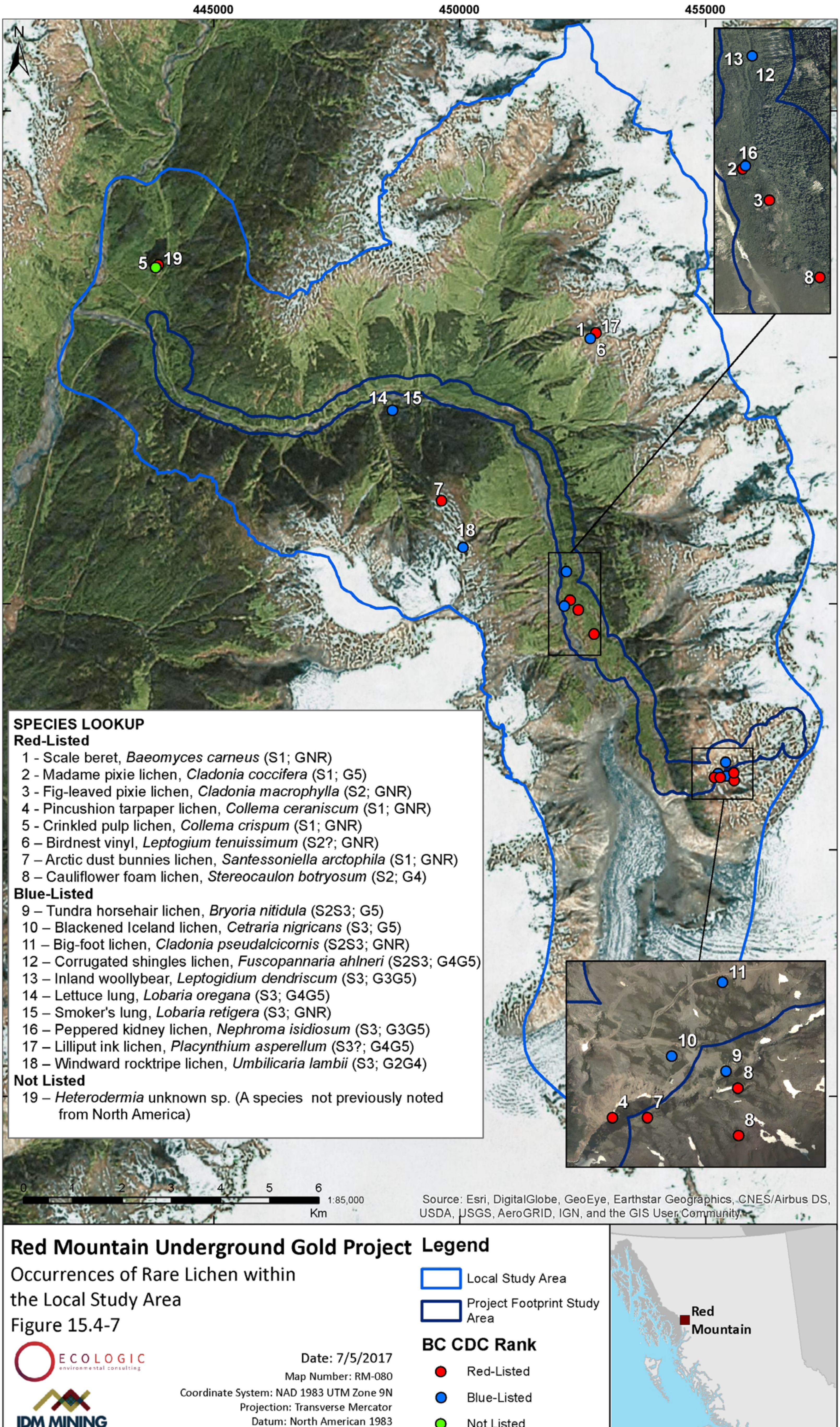
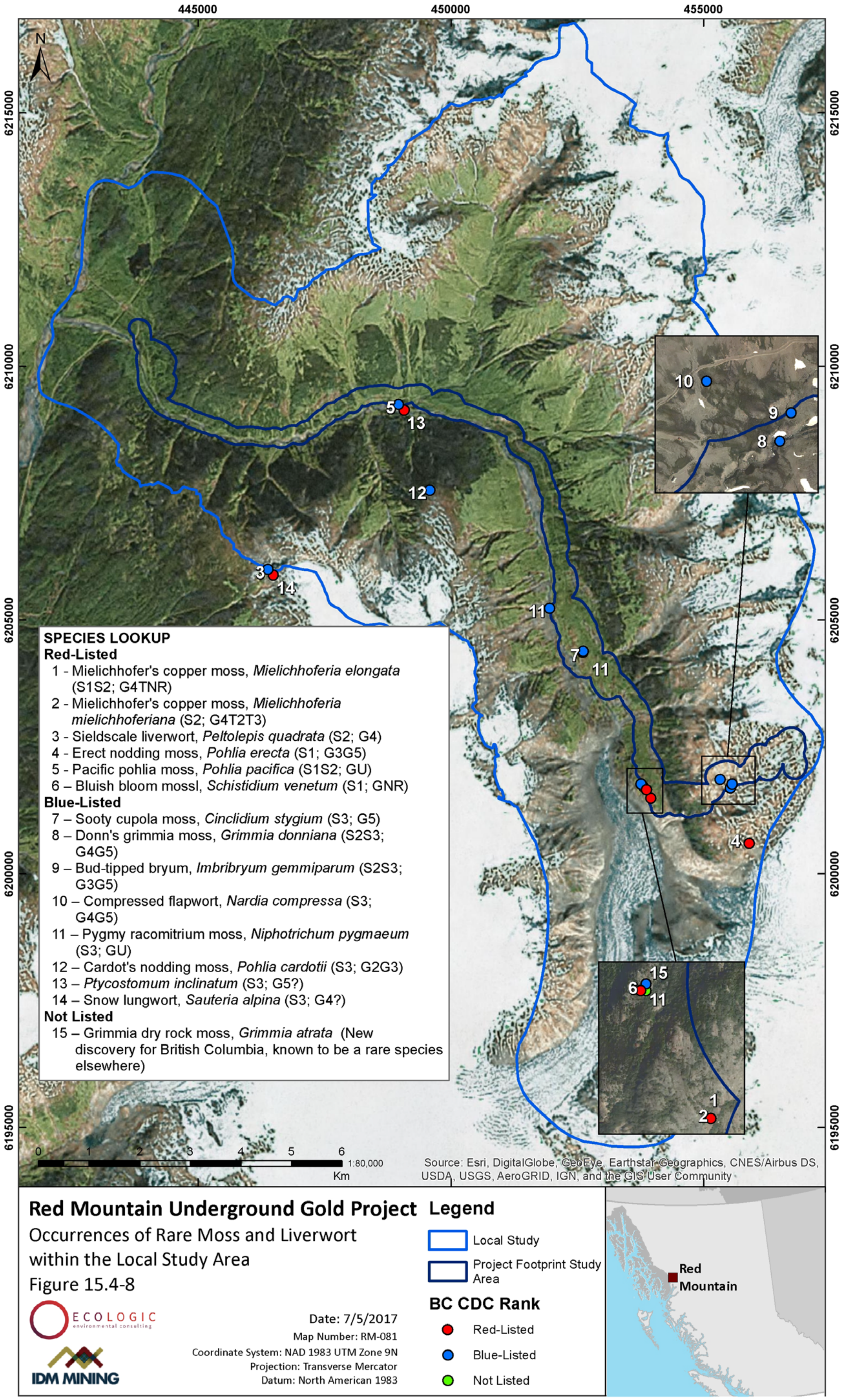


Figure 15.4-8: Occurrences of Rare Moss and Liverwort within the LSA



15.5 Potential Effects

The evaluation of Project effects on Vegetation and Ecosystems VCs takes into consideration the interconnections that occur across the landscape, information from regional, provincial, and federal regulators, Aboriginal Groups, stakeholders, and local communities and the guiding principles outlined in the NSSRMP (FLNRO 2012).

15.5.1 Methods

Key Project-related interactions with Vegetation and Ecosystems VCs were determined through a screening evaluation of proposed Project components and activities in relation to the Vegetation and Ecosystems VCs within the LSA. Key Project-related interactions and the likelihood of the interaction were determined by overlaying the spatial layers of the Project footprint (with the disturbance buffer of 150 m) to the TEM and known occurrences of rare plants and lichens.

Based on the results of the screening evaluation, any possible interactions between the Project and a Vegetation and Ecosystems VC were carried forward into the assessment to determine the effects of the interaction on the VC.

15.5.2 Project Interactions

The Project will interact with Ecologically Valuable Soils, Alpine and Parkland Ecosystems, Old Growth and Mature Forested Ecosystems, Floodplain and Wetland Ecosystems, BC CDC Listed Ecosystems, and Rare Plant, Lichens, and Associated Habitat during the Construction, Operation, and Closure and Reclamation Phases of the Project. The potential effects and pathway(s) of interaction include the following:

1. Loss and alteration of soil quality and quantity through soil stripping, handling, stockpiling, and dust effects;
2. Loss of ecosystem function, abundance, and/or distribution through surface clearing;
3. Alteration of ecosystem function through edge effects and fragmentation, alteration of hydrological connectivity, dust effects, and introduction and/or spread of invasive plant species;
4. Loss of known occurrences of rare plant and/or lichen habitat through surface clearing; and
5. Alteration of rare plant and/or lichen habitat due to edge effects and fragmentation, alteration of hydrological connectivity, dust effects, and introduction and/or spread of invasive plant species.

The Project is composed of two main areas of activity with interconnecting Access and Haul Roads: the Mine Site with an underground mine and dual portal access (the Upper Portal and the Lower Portal) at the upper elevations of Red Mountain (1,950 masl); and Bromley

Humps, situated in the Bitter Creek valley (500 masl), with a Process Plant and Tailings Management Facility (TMF).

The interactions of Project-related proposed physical works and activities with Vegetation and Ecosystems VCs are summarized by Project phase in the following sections and by Project component in Table 15.5-1.

Table 15.5-1: Potential Project Interactions, Vegetation and Ecosystems

Project Component or Activity	Valued Component	Potential Effect / Pathway of Interaction with VC
Construction Phase		
Construction Access Road and Haul Road from Highway 37A to the Upper Portal	Ecologically Valuable Soils Alpine and Parkland Ecosystems Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems BC CDC Listed Ecosystems Rare Plants, Lichens, and Associated Habitat	Loss and alteration of soils. Loss and alteration of vegetation and ecosystems through surface disturbance, edge effects, fragmentation, alteration of hydrological connectivity, fugitive dust, and introduction of invasive plants. Loss and alteration of rare plants and lichens through surface disturbance, edge effects, fragmentation, alteration of hydrological connectivity, fugitive dust, and introduction of invasive plants.
Install Powerline from substation tie-in to the Lower Portal laydown area	Ecologically Valuable Soils Alpine and Parkland Ecosystems Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems BC CDC Listed Ecosystems	Loss and alteration of soils. Loss and alteration of vegetation and ecosystems through surface disturbance, edge effects, fragmentation, and introduction of invasive plants.
Construct Mine Site water management infrastructure, including talus quarries and the portal collection pond, dewatering systems, and water diversion, collection and discharge ditches and swales.	Alpine and Parkland Ecosystems	Loss and alteration of vegetation and ecosystems through surface disturbance and introduction of invasive plants.
Construct other Mine Site ancillary buildings and facilities	Alpine and Parkland Ecosystems Rare Plants, Lichens, and Associated Habitat	Loss and alteration of vegetation and ecosystems through surface disturbance, edge effects, fragmentation, and introduction of invasive plants. Loss and alteration of rare plants and lichens through surface disturbance, edge effects, fragmentation, alteration of hydrological connectivity, fugitive dust, and introduction of invasive plants.

Project Component or Activity	Valued Component	Potential Effect / Pathway of Interaction with VC
Temporarily stockpile ore at the Mine Site	Alpine and Parkland Ecosystems	Alteration of vegetation and ecosystems through surface disturbance and introduction of invasive plants
Transport and deposit waste rock to the Waste Rock Storage Area	Alpine and Parkland Ecosystems	Alteration of vegetation and ecosystems though fugitive dust and introduction of invasive plants
Clear and prepare the TMF basin and Process Plant site pad	Ecologically Valuable Soils Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems Rare Plants, Lichens, and Associated Habitat	Loss and alteration of soils Loss and alteration of vegetation and ecosystems through surface disturbance, edge effects, fragmentation, and introduction of invasive plants Loss and alteration of rare plants and lichens through surface disturbance, edge effects, fragmentation, alteration of hydrological connectivity, fugitive dust, and introduction of invasive plants.
Clear and prepare the TMF basin and Process Plant site pad	Ecologically Valuable Soils Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems Rare Plants, Lichens, and Associated Habitat	Loss and alteration of soils Loss and alteration of vegetation and ecosystems through surface disturbance, edge effects, fragmentation, and introduction of invasive plants Loss and alteration of rare plants and lichens through surface disturbance, edge effects, fragmentation, alteration of hydrological connectivity, fugitive dust, and introduction of invasive plants.
Excavate rock and till from the TMF basin and local borrows / quarries for construction activities (e.g. dam construction for the TMF)	Ecologically Valuable Soils Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems BC CDC Listed Ecosystems Rare Plants, Lichens, and Associated Habitat	Loss and alteration of soils Loss and alteration of vegetation and ecosystems through surface disturbance, edge effects, and introduction of invasive plants Loss and alteration of rare plants and lichens through surface disturbance, edge effects, fragmentation, alteration of hydrological connectivity, fugitive dust, and introduction of invasive plants.

Project Component or Activity	Valued Component	Potential Effect / Pathway of Interaction with VC
Establish water management facilities including diversion ditches for the TMF and Process Plant	Ecologically Valuable Soils Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems Rare Plants, Lichens, and Associated Habitat	Loss and alteration of soils Loss and alteration of vegetation and ecosystems through surface disturbance, edge effects, and introduction of invasive plants Loss and alteration of rare plants and lichens through surface disturbance, edge effects, fragmentation, alteration of hydrological connectivity, fugitive dust, and introduction of invasive plants.
Construct the TMF	Ecologically Valuable Soils Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems Rare Plants, Lichens, and Associated Habitat	Loss and alteration of soils Loss and alteration of vegetation and ecosystems through surface disturbance, edge effects, and introduction of invasive plants Loss and alteration of rare plants and lichens through surface disturbance, edge effects, fragmentation, alteration of hydrological connectivity, fugitive dust, and introduction of invasive plants.
Construct the Process Plant and Run of Mine Stockpile location	Ecologically Valuable Soils Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems Rare Plants, Lichens, and Associated Habitat	Loss and alteration of soils Loss and alteration of vegetation and ecosystems through surface disturbance, edge effects, and introduction of invasive plants Loss and alteration of rare plants and lichens through surface disturbance, edge effects, fragmentation, alteration of hydrological connectivity, fugitive dust, and introduction of invasive plants.
Construct water treatment facilities and test facilities at Bromley Humps	Ecologically Valuable Soils Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems Rare Plants, Lichens, and Associated Habitat	Loss and alteration of soils Loss and alteration of vegetation and ecosystems through surface disturbance, edge effects, and introduction of invasive plants Loss and alteration of rare plants and lichens through surface disturbance, edge effects, fragmentation, alteration of hydrological connectivity, fugitive dust, and introduction of invasive plants.

Project Component or Activity	Valued Component	Potential Effect / Pathway of Interaction with VC
Construct Bromley Humps ancillary buildings and facilities	Ecologically Valuable Soils Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems Rare Plants, Lichens, and Associated Habitat	Loss and alteration of soils Loss of ecosystems and vegetation through surface clearing Loss and alteration of rare plants and lichens through surface disturbance, edge effects, fragmentation, alteration of hydrological connectivity, fugitive dust, and introduction of invasive plants.
Commence milling to ramp up to full production	Rare Plants, Lichens, and Associated Habitat	Alteration of rare plants and lichens due to dust deposition.
Operation Phase		
Use Access Road for personnel transport, haulage, and delivery of goods	Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems BC CDC Listed Ecosystems Rare Plants, Lichens, and Associated Habitat	Alteration of vegetation (including rare plants and lichens) from fugitive dust and the introduction and spread of invasive species.
Discharge of water from underground facilities	Floodplain and Wetland Ecosystems	Alteration of vegetation and ecosystems through changes in hydrology.
Haul waste rock from the declines to the Waste Rock Storage Area for disposal (waste rock transport and storage)	Alpine and Parkland Ecosystems	Alteration of vegetation and ecosystems through fugitive dust and the introduction and spread of invasive plants.
Extract ore from the underground load-haul-dump and transport to Bromley Humps to Run of Mine Stockpile (ore transport and storage)	Old Growth and Mature Forested Ecosystems Alpine and Parkland Ecosystems	Alteration of vegetation and ecosystems through fugitive dust.
Treat and discharge, as necessary, excess water from the TMF	Floodplain and Wetland Ecosystems	Alteration of vegetation and ecosystems through changes in hydrology.
Temporarily store hazardous substances including fuel, explosives, and mine supplies	Alpine and Parkland Ecosystems	Alteration of vegetation and ecosystems through the introduction and spread of invasive plants.
Progressively reclaim disturbed areas no longer required for the Project	Ecologically Valuable Soils Alpine and Parkland Ecosystems Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems BC CDC Listed Ecosystems Rare Plants, Lichens, and Associated Habitat	Alteration of soils Alteration of vegetation (including rare plants and lichens) from introduction and spread of invasive species.

Project Component or Activity	Valued Component	Potential Effect / Pathway of Interaction with VC
Closure and Reclamation Phase		
Use and maintain Access Road for personnel transport, haulage, and removal of decommissioned components until road is decommissioned and reclaimed.	Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems BC CDC Listed Ecosystems Rare Plants, Lichens, and Associated Habitat	Alteration of vegetation (including rare plants and lichens) from introduction or spread of invasive species and fugitive dust
Decommission and reclaim Lower Portal area and Powerline	Alpine and Parkland Ecosystems Rare Plants, Lichens, and Associated Habitat	Alteration of vegetation (including rare plants and lichens) from introduction or spread of invasive species.
Decommission and reclaim Haul Road	Alpine and Parkland Ecosystems Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems Rare Plants, Lichens, and Associated Habitat	Alteration of vegetation (including rare plants and lichens) from introduction or spread of invasive species.
Decommission and reclaim all remaining mine infrastructure (Mine Site and Bromley Humps, except TMF) in accordance with the Closure and Reclamation Plan	Ecologically Valuable Soils Alpine and Parkland Ecosystems Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems BC CDC Listed Ecosystems Rare Plants, Lichens, and Associated Habitat	Alteration of soils Alteration of vegetation (including rare plants and lichens) from introduction or spread of invasive species.
Treat and discharge water from the TMF	Floodplain and Wetland Ecosystems	Alteration of ecosystems from changes in hydrology and surface water quality.
Decommission and reclaim Access Road	Old Growth and Mature Forested Ecosystems Floodplain and Wetland Ecosystems BC CDC Listed Ecosystems Rare Plants, Lichens, and Associated Habitat	Alteration of vegetation (including rare plants and lichens) from introduction or spread of invasive species.

15.5.2.1 Construction

Construction activities will interact with Vegetation and Ecosystems VCs through surface disturbance that will include clearing vegetation and removing topsoil, stockpiling overburden and topsoil, and through traffic associated with the transport of people, goods, and materials. Specifically, Project infrastructure and activities will interact with Vegetation and Ecosystems VCs through development of the following:

- Re-activation and use of the Access Road from Highway 37A to Bromley Humps;
- Construction of the TMF and the Process Plant at Bromley Humps;

- Construction and use of the Haul Road from the Process Plant at Bromley Humps to the underground mine;
- Construction and extraction of materials from the Borrow and Topsoil Storage Area;
- Clearing associated with the creation of the right of way for the 138-kV Powerline from Highway 37A to the underground mine;
- Clearing and installation of the Powerline towers along the full length of the line; and
- Withdrawal of water for dust suppression and construction activities.

15.5.2.2 Operation

Operation activities will interact with Vegetation and Ecosystems VCs through the ongoing use and maintenance of Project components and through water withdrawal and stockpiling associated with mining, including the following:

- Ongoing use and maintenance of the Access and Haul Roads;
- Ongoing vegetation maintenance under the Powerline;
- Use of the Treated Effluent Discharge Access;
- Waste rock, ore, and soil stockpiling;
- Withdrawal of water for industrial water requirements, Process Plant, TMF, ongoing exploration activities, road building, and other activities; and
- Discharge of water from the underground facilities.

15.5.2.3 Closure and Reclamation

Closure and Reclamation activities will interact with Vegetation and Ecosystems VCs through:

- Decommissioning of the Process Plant, TMF, ancillary buildings, and facilities;
- Land reclamation and removal of water treatment facilities; and
- Soil handling and revegetation of proposed reclaimed areas.

15.5.2.4 Post-Closure

There are no anticipated interactions between Post-Closure Phase activities (i.e., flooding of the underground workings and post-closure environmental monitoring) and Vegetation and Ecosystems VCs. There will be no road access to the Project; all access will be via helicopter.

15.5.3 Discussion of Potential Effects

Project-related effects on Vegetation and Ecosystems VCs will occur primarily in areas of direct disturbance where soils and vegetation will be cleared during Construction. Additional effects could occur in areas immediately adjacent to cleared areas due to soil compaction, soil contamination, alteration of hydrological connectivity, creation of edges and fragmentation, dust deposition, and introduction and potential spread of invasive plants during the life of the Project.

15.5.3.1 Key Effects on Ecologically Valuable Soils

15.5.3.1.1 Direct Loss of Ecologically Valuable Soils

Soil loss (i.e., direct removal of soils) occurs during construction of Project components, including the construction of the TMF, the Access and Haul Roads, Borrow Pit, and stockpiles. Soil can be lost by burying of productive soils with rock and other materials, and admixing (i.e., incorporating soils with less productive materials, such as coarse woody debris and subsurface horizons). Direct soil loss refers to the soil associated with the direct Project footprint with the addition of a 50 m buffer on non-road infrastructure to account for changes in orientation, laydown areas, and other variances that may occur. The assessment assumes that any soil loss is associated with the direct Project footprint (Figure 15.1-1).

Soil loss can also occur via erosion. Soil erosion rates within the Bitter Creek valley are elevated due to recent glacial retreat. Glacial retreat leaves behind un-vegetated sediments and over-steepened side slopes that continue to erode until the natural angle of repose is achieved and vegetation cover is established. The greatest potential for Project-related increases in soil loss will occur during the Project Construction and Closure and Reclamation Phases due to the amount of ground disturbance and exposed soil surfaces. Once vegetation is removed, soil erosion and slope failure are more likely due to the loss of vegetation, which reduces the energy of rainfall (splash erosion) and breaks up the surface so running water does not obtain an erosive velocity.

The Project will result in the loss of 47.6 ha of high-value Ecologically Valuable Soils, 79.1 ha of moderate-value Ecologically Valuable Soils, and 82.6 ha of low-value Ecologically Valuable Soils (Table 15.5-2). The majority of this is associated with the Access Road, Haul Road, Quarry, and Powerline.

This is considered a conservative estimate of soil loss, as some of this soil may be eligible for salvage (Volume 2, Chapter 5). As well, the 50 m buffer around Project components will not be subject to full soil loss. Details regarding the assessment of loss of soil quantity are located in the Landforms and Natural Landscapes Effects Assessment (Volume 3, Chapter 9).

15.5.3.1.2 Alteration of Soil Quality

Alteration of soil quality can occur through two pathways: soil compaction and soil contamination.

Soil Compaction

Soil compaction is the compression of soil material and subsequent loss of pore space, which leads to degradation of soil fertility. It is caused by the use of heavy equipment during construction activities. Degradation associated with soil compaction is dependent on both innate soil characteristics of soil (texture, coarse fragment, degree of aggregation, organic matter) and edaphic conditions at the time of disturbance (soil moisture content, presence of frozen layers) (Gomez, Powers and Singer 2002). Soil compaction can have numerous effects, including reduced plant growth due to restrictions in root growth, water absorption, and nutrient availability (Kozlowski 1999). As water is not easily adsorbed into the soil matrix, surface runoff can increase over compacted soils, leading to losses of soil (Luce and Black 1999). Key ecological functions, such as site stability, productivity, nutrient cycling, carbon storage, water regulation, and wildlife habitat, may be also affected depending on the severity of the compaction and the soil type affected.

Soil Contamination

Soil contamination can occur during mining operations from a number of pathways. These include from spills of fluids, such as fuel, aerial deposition of metals in dust, soil acidification due to emissions from diesel engines, and transportation of metals by surface and groundwater, often in association with the weathering of acid-generating competent bedrock and surficial materials. Miscellaneous spills or accidents involving the release of fuel or chemicals are discussed separately as waste management and spill prevention in the Spill Contingency Plan (Chapter 29).

Fugitive Dust

Rock material present in the LSA and PFSA contains metals that could be liberated during mining operations and cause potential contamination issues. Dust-releasing mining operations include blasting, crushing, and road use. The primary potential source of dust contamination of soils from mining operations is from road use, as the milling operations will be carried out inside buildings. This dust is referred to as “fugitive dust” to distinguish it from dust that comes out of a vent or stack and as such is not a by-product of burning. Deposition of dust is also expected to be one of the pathways of potential degradation of vegetation.

Fugitive dust arises when fine granular material is propelled into the air to be transported and deposited at some other locale. How far dust travels depends on the magnitude of the disturbance force and the characteristics of the granular material. Depending on the source, deposition of dust can lead to increased soil contamination with metals, changes in soil salinity, or ecosystem eutrophication with nutrients. Sulphide-containing rocks can result in the deposition of sulphides on surface soil tiers, which can result in the acidification of the soils.

Fugitive dust can contain heavy metals, if those metals are present in the material used in construction, especially road construction. Heavy metals constitute an ill-defined group of inorganic chemical hazards, which commonly include lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), and nickel (Ni) (GWRTAC 1997). Vehicle traffic can result in the mobilization of these metals, which can then settle on soil and vegetation. The behavior of these metals in the soil environment is highly dependent on both the metal speciation and the soil environment. Unlike organic contaminants, which are oxidized to carbon oxide by microbial activity, most metals do not undergo microbial or chemical degradation. As a result, their total concentration in soils increases with additional inputs and persists for extended periods.

The detailed discussion of dust emission, distribution, and deposition patterns within the LSA and the assessment of dust effects on air quality are presented in the Air Quality Effects Assessment (Volume 3, Chapter 7).

Soil Acidification and Eutrophication

Atmospheric deposition of substances capable of altering the soil environment and directly and indirectly affecting vegetation commonly occurs during mine operations. Mining operations, when involving the use of diesel engines, will emit nitrogen oxides (NOx) and sulfur dioxide (SO_2) that can directly impair soil function and directly and indirectly affect vegetation. These substances can be carried in precipitation (wet deposition) or fall as dry deposition. They can fall on soil, standing water, and vegetation. Direct effects on soils include reductions in pH, loss of base cations (Ca^{2+}, Mg^{2+} and K^{+}), and mobilization of metals.

Nitrogen compound deposition results in temporary eutrophication of the soil (fertilization), which induces short-term increases in productivity and changes in vegetation community, often resulting in increases in invasive species establishment (Stephens 2010). If, upon deposition, nitrate (NO_3^{-}) is not taken up by plants, it can leach through and out of the rooting zone. As nitrate is negatively charged, it takes a base cation with it, which reduces the buffering capacity of the soil, further decreasing the soil pH. Sulphate compound deposition contributes to soil acidification as it is a proton donor (H^{+}) to the soil environment. If the soil is base deficient and cannot neutralize the added proton, a buildup of H^{+} will occur, lowering the soil pH.

Alterations of soil pH leads to changes in soil biochemical function, and can result in the liberation of metals that were previously immobile. This can result in changes to the bioavailability of toxic chemicals and affect the overall ability of the ecosystem to function. The rate of acidification is highly dependent on both the rate of input and soil characteristics, including surface soil pH, $CaCO_3$ equivalence, clay content, soil organic matter content, coarse fragment content, and native rock characteristics, which determine soil buffering capacity (Reuss, Cosby, and Wright 1987; Galloway 1995).

15.5.3.1.3 Quantification of Loss and Alteration of Ecologically Valuable Soils

Loss of Ecologically Valuable Soils quality is due to the combined effects of soil compaction, dust effects, and potential acidification. The majority of the degradation is due to dust accumulation. Modelling results show that acidification potential due to Project activities is very low. None of the modelled locations showed an exceedance of the Ambient Air Quality Standard (AAQA) guidelines. According to modelling, acid deposition associated with the Project is minimal. This is an expected result as the Project is primarily run by electricity and has no combustion sources except for tailpipe emissions from trucks and other heavy equipment.

The Project is expected to result in the alteration of 214.6 ha of high-value Ecologically Valuable Soils, 325.1 ha of moderate-value Ecologically Valuable Soils, and 250.2 ha of low-value Ecologically Valuable Soils (Table 15.5-2; Figure 15.5-1a through Figure 15.5-1e). Details regarding the assessment of alteration of soil quality are located in the Landforms and Natural Landscapes Effects Assessment (Volume 3, Chapter 9).

Table 15.5-2: Loss and Alteration of Ecologically Valuable Soils by Project Component

	Ecologically Valuable	Loss Area (ha)	Degradation Area (ha)
Access Road	High	13.1	106.9
	Moderate	7.1	99.1
	Poor	5.8	55.6
	No	8.9	78.0
	Total	34.9	339.6
Borrow	High	4.6	1.3
	Moderate	11.0	13.8
	Poor	1.5	3.3
	No	0.1	2.2
	Total	17.2	20.6
Haul Road	High	5.4	32.6
	Moderate	14.7	76.5
	Poor	10.5	62.4
	No	5.6	22.8
	N/A	1.7	7.4
	Total	37.8	201.6
Lower Portal	High	1.0	0.5
	Moderate	2.1	3.5
	Poor	-	0.4
	No	-	0.5
	N/A	-	1.7
	Total	3.2	6.5
Process Plant	High	0.8	2.1
	Moderate	0.9	2.3
	Poor	5.2	4.2
	No	1.4	2.0
	Total	8.2	10.6

		Ecologically Valuable	Loss Area (ha)	Degradation Area (ha)
Quarry	Rock Quarry	High	8.4	3.7
		Moderate	9.3	12.3
		Poor	21.1	11.8
		No	3.4	1.6
		Total	42.3	29.4
	Talus Quarry	High	2.8	3.4
		Moderate	9.5	10.3
		Poor	0.2	1.7
		No	1.8	0.6
		N/A	-	0.3
		Total	14.2	16.2
TMF		High	2.5	7.0
		Moderate	10.4	13.0
		Poor	28.4	18.8
		No	6.6	5.0
		N/A	-	0.4
		Total	47.8	44.1
Powerline		High	8.0	5.5
		Moderate	8.3	9.5
		Poor	7.3	4.5
		No	3.1	3.0
		Total	26.6	22.5
Upper Portal		High	0.1	1.2
		Moderate	2.5	1.7
		No	1.8	0.1
		N/A	2.1	3.2
		Total	6.5	6.2
Treated Effluent Discharge Access		High	-	2.5
		Moderate	0.3	0.5
		Poor	0.1	1.2
		No	0.1	0.7
		Total	0.5	4.9
Temporary Waste Rock Storage Area (WRSA)		High	-	0.4
		Moderate	2.2	3.5
		No	0.3	1.2
		N/A	0.1	0.5

	Ecologically Valuable	Loss Area (ha)	Degradation Area (ha)
	Total	2.6	5.7
Topsoil Storage Area	High	0.8	0.1
	Moderate	1.0	0.1
	Poor	2.5	3.8
	No	0.4	2.4
	Total	4.6	6.4

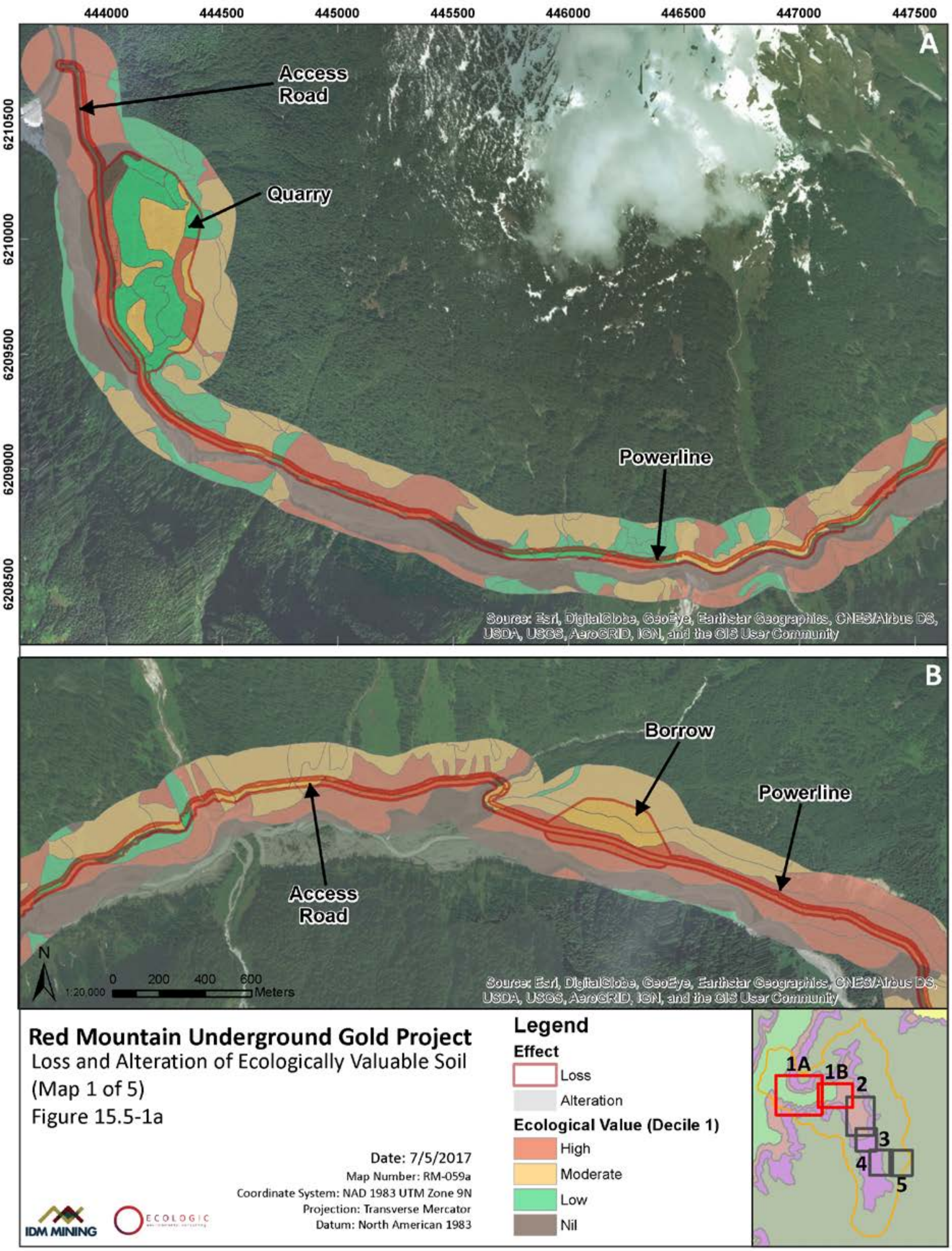
15.5.3.1.4 Local Study Area Context of Ecologically Valuable Soils Loss and Alteration

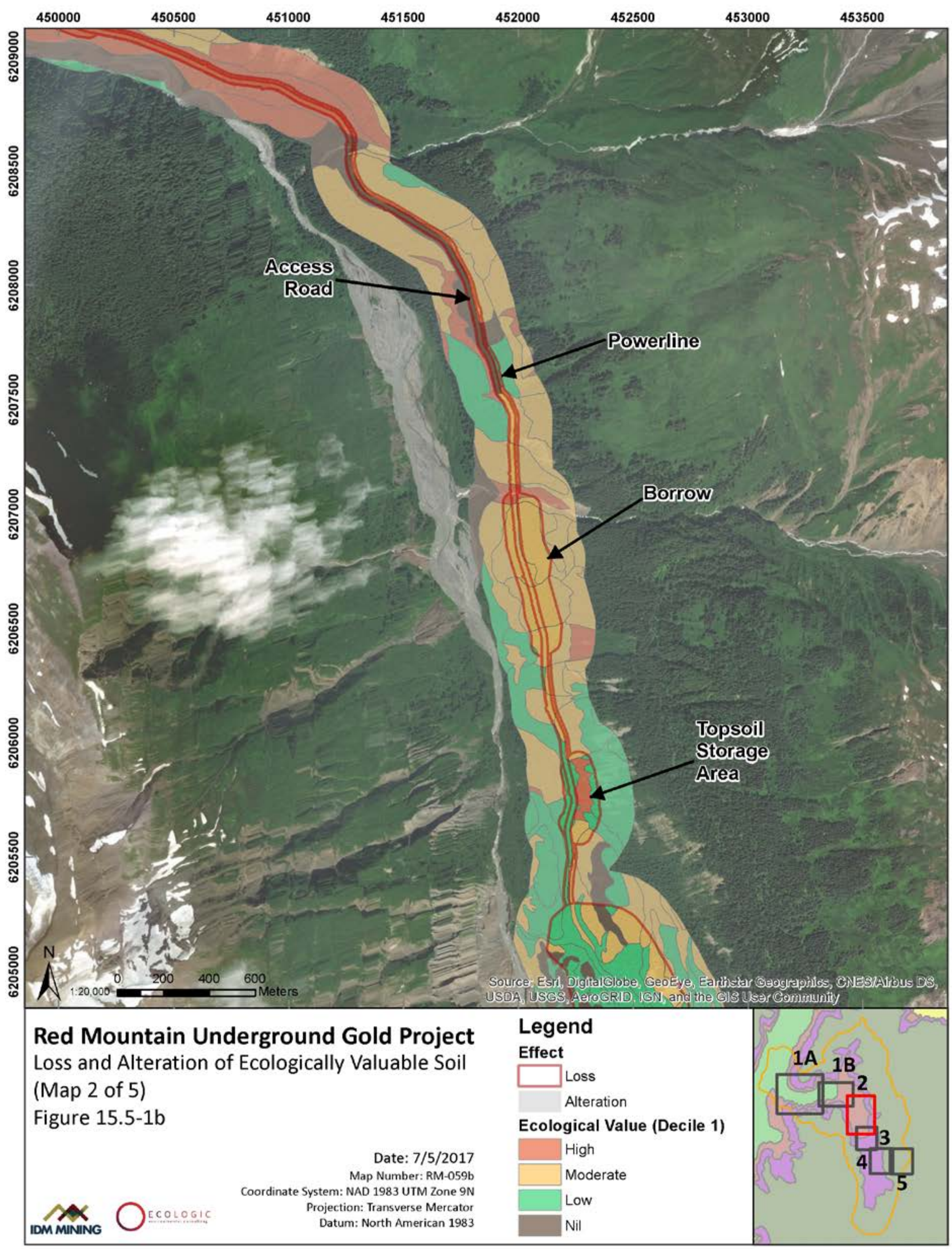
To understand how these spatial areas of loss and alteration within the PFSA relate to the LSA, it is useful to compare lost soil to the amount of soil in the LSA. As detailed soil mapping was not carried out for the LSA, terrain mapping was used as a surrogate of soil, as the development of Ecologically Valuable Soils is closely associated with the type of surficial material.

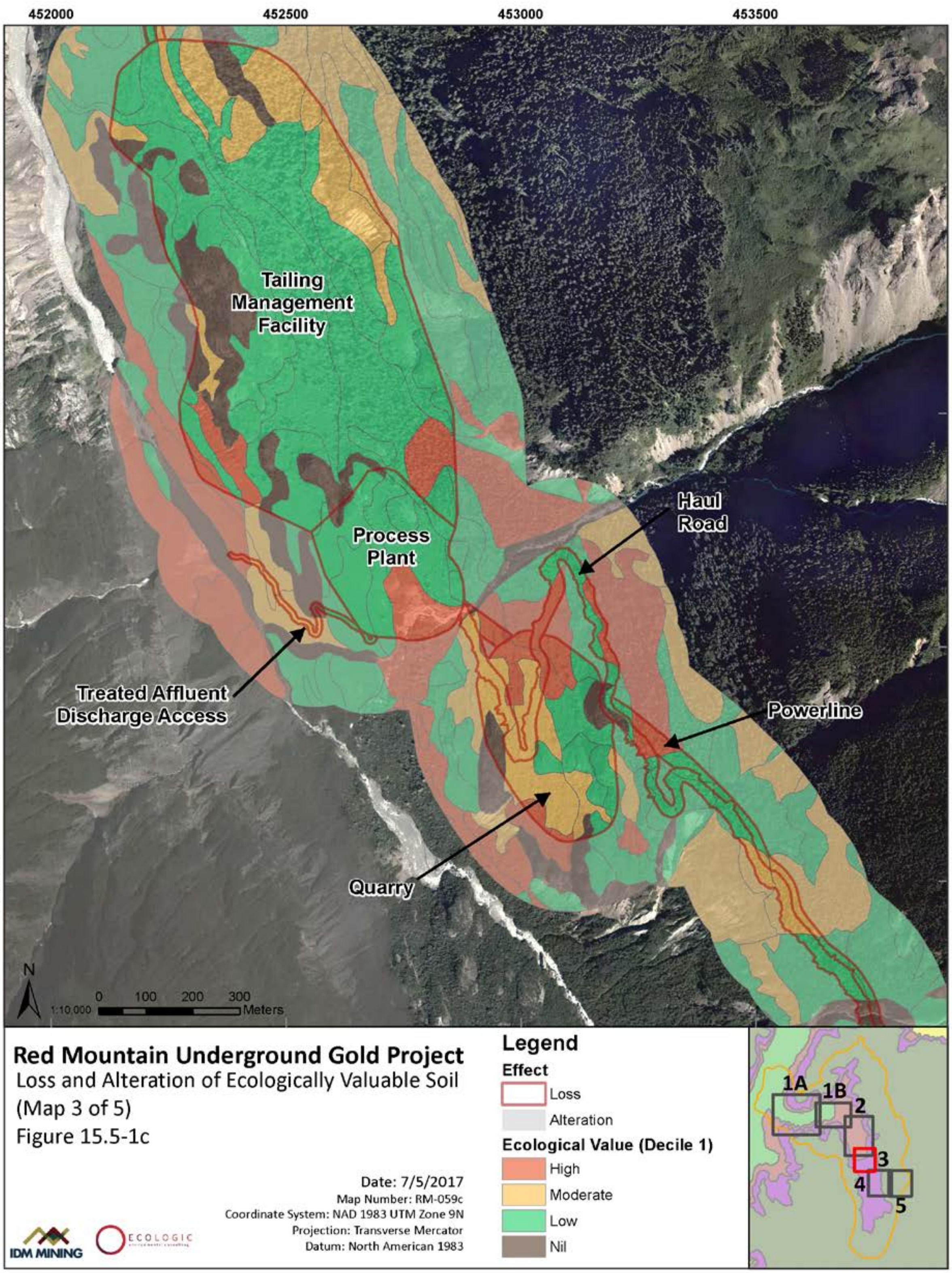
Table 15.5-3 summarizes the amount of each surficial material type in the LSA and PFSA. Surficial materials glaciocolluvium, colluvium, glaciofluvial, fluvial, moraine and organic are all associated with the development of Ecologically Valuable Soils, while anthropogenic, bedrock, ice, and water features are not. The material labelled “not classified” is located in a high-elevation area well away from Project components, and is predominately ice and rock. It is labelled as such because the imagery in this location was of such quality that differentiation was not possible.

Approximately 9,337.6 ha (58.9%) of the LSA is covered in surficial materials that are associated with Ecologically Valuable Soils. This compares with 830.9 ha (86.5%) of the PFSA, which has surficial materials associated with Ecologically Valuable Soils. This difference is because the PFSA is located largely in the lower sections of the Bitter Creek valley and has little in the way of ice and less exposed rock.

Figure 15.5-1: Loss and Alteration of Ecologically Valuable Soil




450000
450500
451000
451500
452000
452500
453000
453500
6209000
6208500
6208000
6207500
6207000
6206500
6206000
6205500
6205000
Access Road
Powerline
Borrow
Topsoil Storage Area
N
1:20,000
0 200 400 600 Meters
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Red Mountain Underground Gold Project
Loss and Alteration of Ecologically Valuable Soil
(Map 2 of 5)
Figure 15.5-1b
Date: 7/5/2017
Map Number: RM-059b
Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
IDM MINING
ECOLOGIC
Legend
Effect
Loss
Alteration
Ecological Value (Decile 1)
High
Moderate
Low
Nil
1A
1B
2
3
4
5


452000
452500
453000
453500
6205000
6204500
6204000
6203500
Tailing Management Facility
Process Plant
Haul Road
Treated Affluent Discharge Access
Powerline
Quarry
N
1:10,000
0 100 200 300 Meters
Red Mountain Underground Gold Project
Loss and Alteration of Ecologically Valuable Soil
(Map 3 of 5)
Figure 15.5-1c
Date: 7/5/2017
Map Number: RM-059c
Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
IDM MINING
ECOLOGIC
Legend
Effect
Loss
Alteration
Ecological Value (Decile 1)
High
Moderate
Low
Nil
1A
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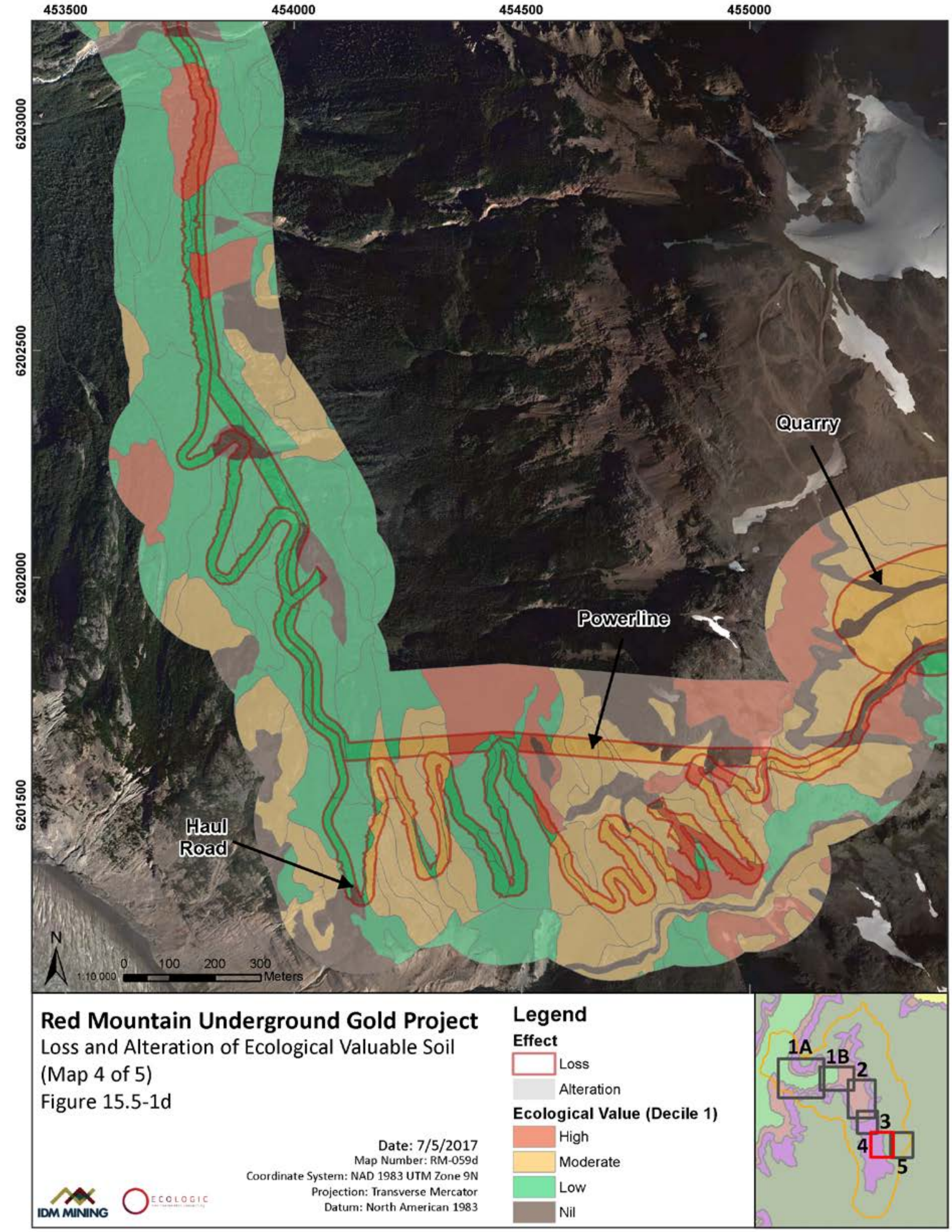
453500
454000
454500
455000
6203000
6202500
6202000
6201500
Quarry
Powerline
Haul Road
N
1:10,000
0 100 200 300 Meters
Red Mountain Underground Gold Project
Loss and Alteration of Ecological Valuable Soil
(Map 4 of 5)
Figure 15.5-1d
Date: 7/5/2017
Map Number: RM-059d
Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
IDM MINING
ECOLOGIC
Legend
Effect
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Alteration
Ecological Value (Decile 1)
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1A
1B
2
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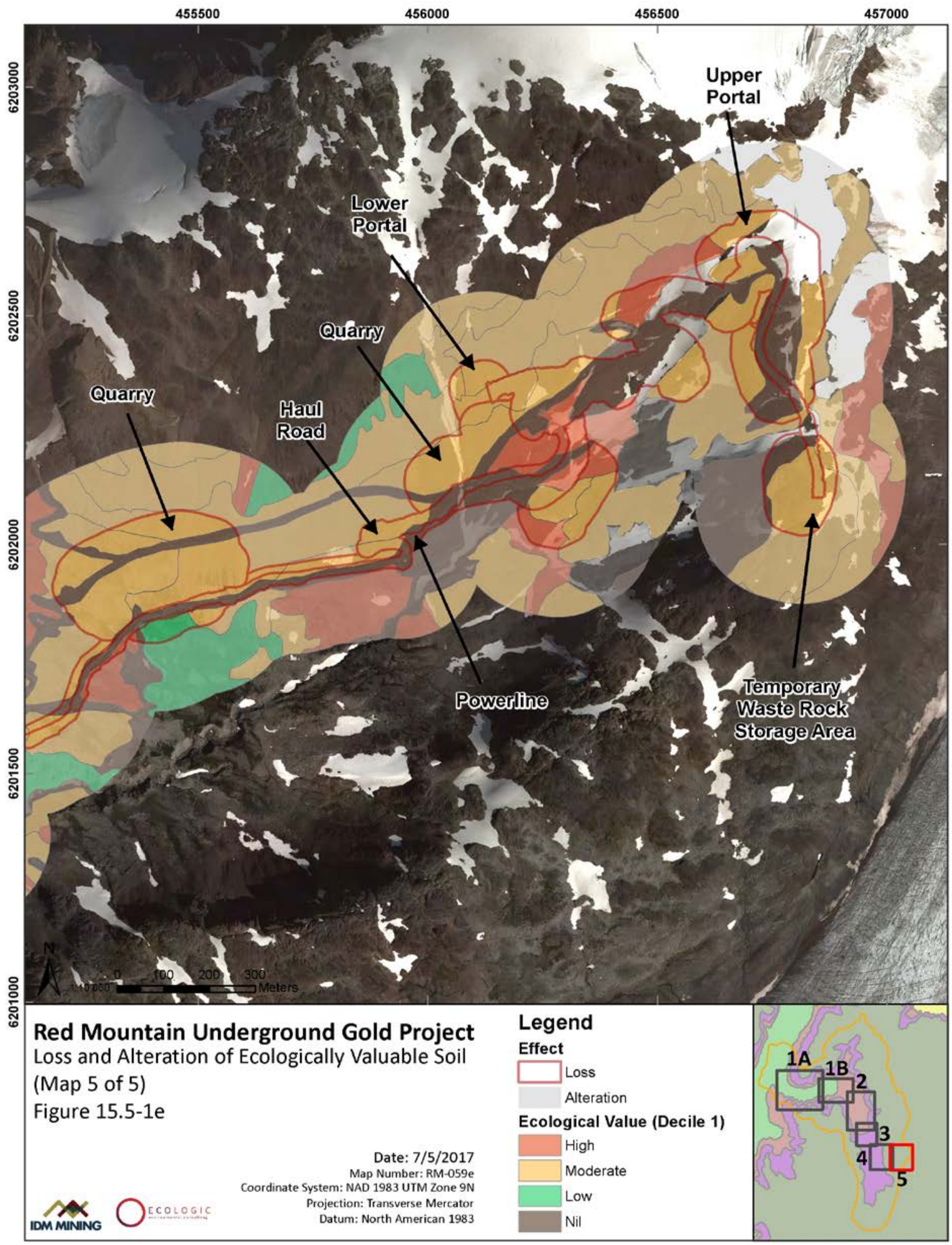


Red Mountain Underground Gold Project
Loss and Alteration of Ecologically Valuable Soil (Map 5 of 5)
Figure 15.5-1e

The loss of 209.3 ha of Ecologically Valuable Soils is the equivalent of 2.2% of the land base within the LSA that is associated with surficial materials capable of supporting Ecologically Valuable Soils. Degradation is associated with 6.2% of the LSA.

For the Bitter Creek valley, the use of terrain as a surrogate for Ecologically Valuable Soils is defensible, as the percent of terrain classified as supporting soil development is 86.5% (Table 15.5-3), while the percent of the spatial area of SMUs classified as ecologically valuable is 82.2%.

Table 15.5-3: Comparison of Surficial Material Type in the LSA and PFSA

Surficial Material	Map Code	LSA		PFSA	
		Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Anthropogenic	A	1.5	<0.1	24.1	2.5
Bedrock	R	2,346.1	14.8	96.5	10.0
Glaciocolluvial	CG	-	-	48.0	5.0
Colluvium	C	3,255.2	20.5	358.7	37.3
Fluvial	F	488.8	3.1	161.4	16.8
Glaciofluvial	FG	251.1	1.6	41.2	4.3
Ice	I	2,360.2	14.9	6.9	0.7
Moraine	M	5,342.5	33.7	221.1	23.0
Not Classified	NC	1,793.5	11.3	-	-
Organic	O	-	-	0.5	0.1
Undifferentiated materials	U	1.5	<0.1	-	-
Water Features (small)	OW,PO,N	19.5	0.1	2.3	0.2
Total		**15,859.9**	**100**	**960.7**	**100**
Total Potential Ecological Valuable Soils	**CG,C,F,FG,M,O**	**9,337.6**	**58.9%**	**830.9**	**86.5%**

Note: Values may not sum to total shown because of rounding. Areal extents reported are based on 1:20,000 scale for the entire LSA and 1:5,000 scale for the entire PFSA.

15.5.3.2 Key Effects on Vegetation and Ecosystems

Two types of potential effects are applicable to all of the ecosystems listed as Vegetation and Ecosystems VCs: the loss of ecosystem function, abundance, and/or distribution; and the alteration of ecosystem function, abundance, and/or distribution. It is important to discuss these potential effects separately as it more easily facilitates the development and implementation of mitigation. However, where warranted, these two potential effects will be analyzed as a single potential residual effect.

15.5.3.2.1 Loss of Ecosystem Function, Abundance, and/or Distribution

Surface clearing removes the above- and below-ground portion of vegetation cover, which is known to influence the abiotic and biotic conditions of soils. Abiotic factors such as such as soil moisture, nutrients, and pH are some of the most important drivers of species composition in alpine areas, for example, where the vegetation cover is relatively sparse (Klanderud et. al. 2015). Surface disturbance can also have biotic effects on the genetics of population, on species, and on ecosystems, and their effects can accumulate over space and time (Hooper et. al 2005; Nave et al. 2010; Duguid and Ashton 2013). Surface disturbance created through timber harvesting results in changes to forest structure and composition (Lavoie and Sirois, 1998; Brassard et al., 2008; Fleming et al., 2014 in Bartels 2016) and influences soil properties, thereby altering ecosystem productivity and function.

Vegetation cover also plays a key role in the stabilization of soils (Cerdà, 1999; Chiaradia, Vergani, & Bischetti, 2016; van Hall, Cammeraat, Keesstra, & Zorn, 2017 in Hudek et al. 2016) and influences a site's ability to provide ecosystem services such as wildlife habitat (Lindenmayer and Noss 2006).

15.5.3.2.2 Alteration of Ecosystem Function, Abundance, and/or Distribution

Alteration of Hydrological Connectivity

Hydrologic changes from the Access Road, Powerline, and other Project components are expected to have a limited effect on most of the mapped floodplain ecosystems. The majority of the Access Road and Powerline that will be located on floodplains follows the existing road route. Is it reasonable to expect that the new road and Powerline construction will not create new hydrological changes along the old route and may improve hydrological connectivity through the placement of new culverts and bridges.

There is the potential for the creation of localized areas with water table changes that may result in novel ecosystem types and changes in vegetation communities (Smerdon et al. 2009). Clearing of forested areas on steep terrain may also result in increased runoff and slope stability issues (Smerdon et al. 2009).

Physical alterations, such as the expansion of the Haul Road, could disconnect floodplain ecosystems from the rivers and creeks in areas of new development, which could result in localized ecological degradation and a reduction in a variety of ecological services (Ickes et al. 2005). Floodplain ecosystems are highly dependent on hydrological connections to creeks and rivers. Creeks and rivers provide regular flooding, groundwater, nutrients, and the exchange of biotic material (Ickes et al. 2005). The connection to the river system is considered to be essential for ecological health and viability of floodplain ecosystems and contributes to floodplains being one of the most productive and biodiverse ecosystem types in a given landscape (Ickes et al. 2005; Junk et al. 1989).

A reduction in surface or groundwater flows to downslope wetlands may alter soil moisture regimes and result in a shift within the community from hydrophilic species to more terrestrial species.

Edge Effects and Fragmentation

Edge effects and fragmentation has been minimized by re-using the existing old road for a large portion of the Access Road, thereby reducing the number and extent of clearing within intact ecosystems.

Edge effects and fragmentation are expected to occur at the site level as a result of multiple Project components (Access Road, Borrow, Process Plant, Quarry, TMF, Topsoil Storage Area, and Powerline) that will bisect mature and old forests stands.

Edge effects are expected to occur wherever forests are cleared and interior regions of a forest stand (including floodplain forests) are exposed. The changes created by edge effects vary considerably and are dependent on site conditions, local weather, aspect, and numerous other factors. Studies indicate that effects in light, temperature, and moisture typically occur from 50 to 140 m from the edge (Matlack 1993; Chen et al. 1995), while stands that occur on warm southern aspects may experience effects as far as 240 m from the edge (Chen et al. 1995). Edge effects are also amplified in smaller fragments, as the proportion of edge versus interior is increased (Matlack 1993).

Edge effects can influence how far wind penetrates into the interior of the forest, thereby altering evaporation rates and biological processes, such as seed dispersal (Chan et al. 1995). These changes can alter plant communities within the forest as environmental conditions change; shade-intolerant species generally increase, including those that are invasive species (Murphy and Lovett-Doust 2004).

Linear developments also have the potential to fragment habitat. Fragmentation occurs when a given ecosystem is effectively split into two or more smaller communities. While fragmentation affects species differently, depending on specific biological needs, it has the potential to negatively affect many species (Kolb and Diekmann 2005). Negative effects are more pronounced on species or groups of species that have limited dispersal abilities (Kolb and Diekmann 2005; Esseen and Renhorn 1998).

Introduction and/or Spread of Invasive Plant Species

Clearing, construction of proposed Project components, and ongoing operation of the Project have the potential to introduce invasive plant species to the area throughout the Project Construction, Operation, and Closure and Reclamation Phases. Invasive species are regarded as one of the main causes of the loss in biodiversity, and they have the ability to affect plant community composition and function (Didham et al. 2005; Hejda, Pysek and Jarosik 2009) at the site level.

Equipment and people involved in construction are the primary vectors for the introduction of invasive species, particularly large earth-moving equipment. Initial construction of the Access Road, Haul Road, Powerline, quarries, and borrows will result in the creation of un-vegetated areas with exposed soil. The abundance of exposed soil after construction results in the ideal habitat for the establishment of exotic and invasive plant species (Greenberg 1997). The clearing of native vegetation and any alterations to physical habitat may also result in the remaining plant communities becoming stressed and less resilient to disease and the establishment of exotic species (Trombulak and Frissell 2000).

The ability of most invasive species to become established in undisturbed ecosystems is generally low, as existing habitat is occupied by native species, and most invasive plants are pioneer species that exploit disturbed areas where there is limited resource competition from native vegetation (Davis et al. 2000; Arellano-Cataldo and Smith-Ramírez 2016).

Recent studies suggest that alpine ecosystems are not inherently resistant to invasions, and that there has been a substantial increase of invasive plants in Arctic and alpine ecosystems (Morgan & Carnegie, 2009; Alexander et al., 2011; McDougall et al., 2011; Ware et al., 2012).

Equally important are any erosion control methods used in exposed areas. Species selection in reclamation revegetation mixes is important to avoid the unintentional spread of invasive grasses, as well as the use of straw bales and other natural products that have the potential to include seeds of exotic or invasive species (Trombulak and Frissell 2000; Beyers 2004).

15.5.3.2.3 Quantification of Potential Effects to Alpine and Parkland Ecosystems

The Project is expected to result in the loss of 9.0 ha and alteration of up to 36.4 ha of Alpine Ecosystems through construction activities (Table 15.5-4; Figure 15.5-2).

The majority of the loss will occur in alpine heath (Ah) and alpine tundra (At) ecosystems as a result of vegetation clearing, soil salvage, and site preparation along the Haul Road and at the Quarry. Alpine heath and tundra ecosystems will also be removed as a result of construction of the Lower Portal, deposition of material at the Temporary Waste Stockpile, and construction of the Upper Portal. Incremental losses are expected during the Project Closure and Reclamation Phase due to slope stabilization, re-contouring, re-vegetation, and reclamation maintenance activities.

Figure 15.5-2: Loss and Alteration of Alpine Ecosystems

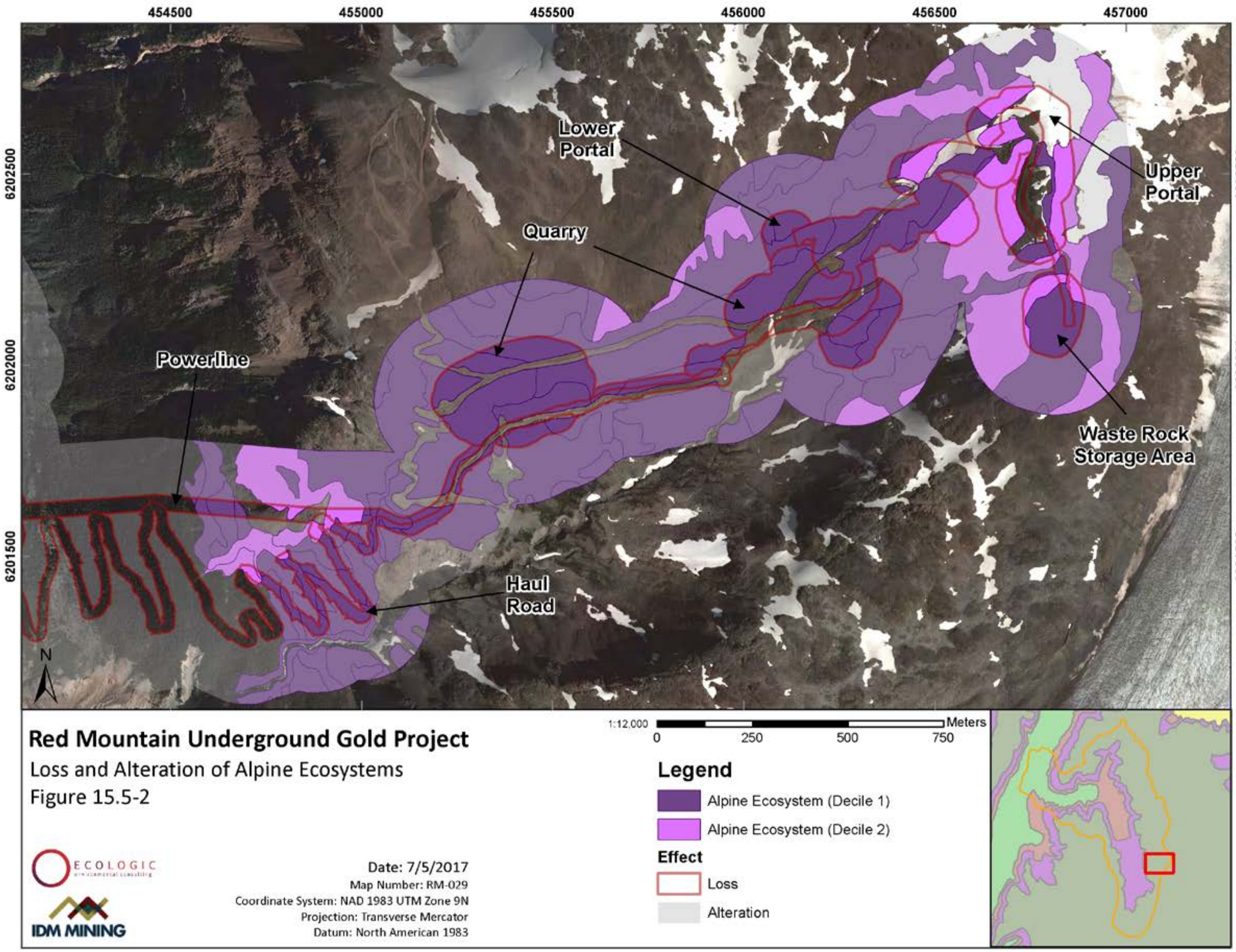
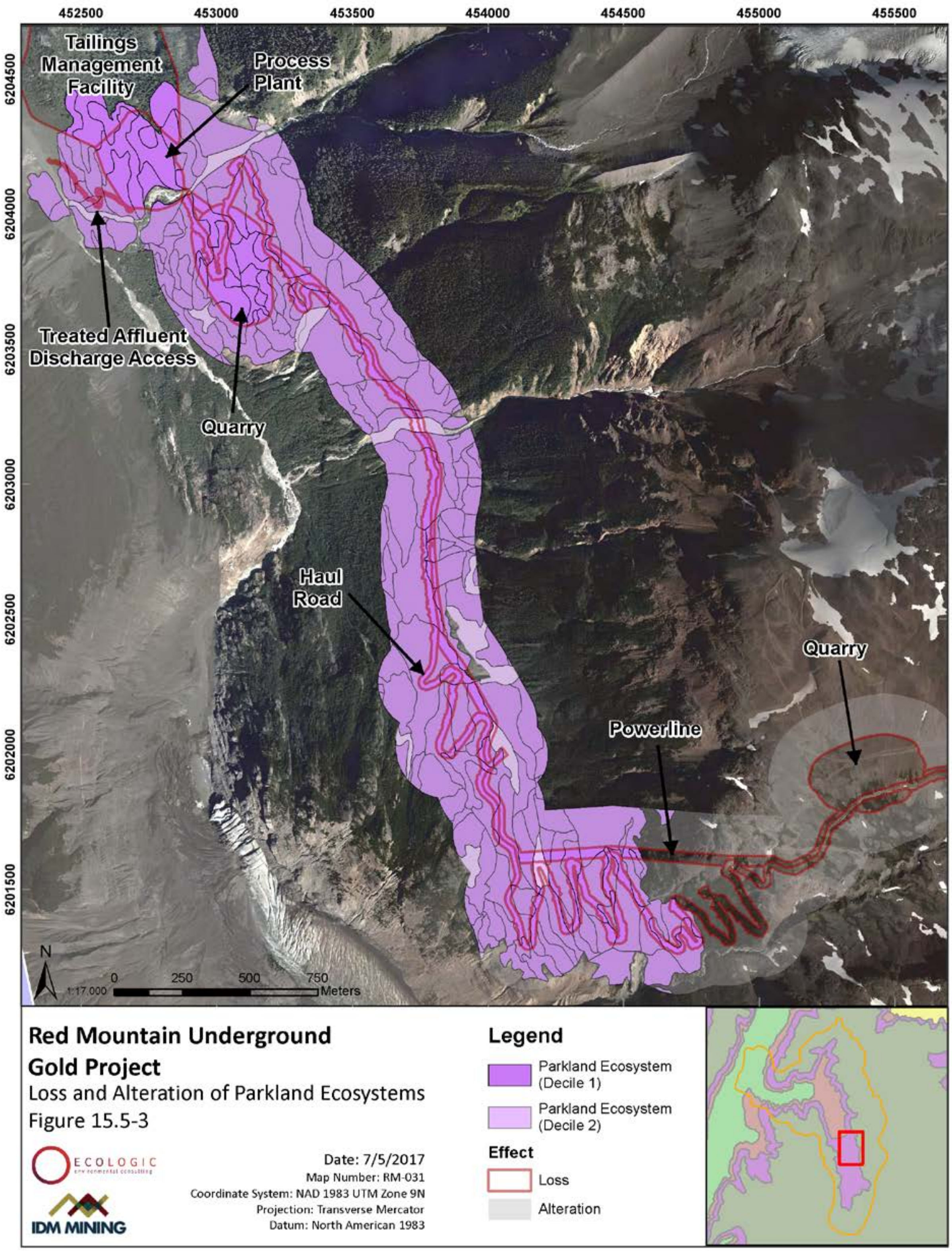


Table 15.5-4: Loss and Alteration of Alpine Ecosystems

Project Component	BGC Zone	Map Code	Ecosystem Name	Structural Stage	Loss	Alteration
Haul Road	CMAun	Ah	Alpine Heath	2d	1.3	10.2
		As	Alpine Nivation (Late Snowbed)	1a	0.2	0.3
				2b	-	<0.1
		At	Alpine Tundra	2d	0.7	10.5
		Sk	Krummholz	3a	0.9	3.5
				3b	0.8	1.6
Haul Road Total					**3.9**	**26.1**
Lower Portal	CMAun	As	Alpine Nivation (Late Snowbed)	1a	0.1	-
		At	Alpine Tundra	2d	0.6	0.6
Lower Portal Total					**0.7**	**0.6**
Quarry	CMAun	Ah	Alpine Heath	2d	1.9	2.0
		As	Alpine Nivation (Late Snowbed)	1a	0.3	-
				2b	-	0.1
		At	Alpine Tundra	2d	1.4	6.2
Quarry Total					**3.6**	**8.4**
Temporary Waste Rock Storage Area	CMAun	Ah	Alpine Heath	2d	0.5	0.5
		At	Alpine Tundra	2d	-	0.1
Temporary Waste Rock Storage Area Total					**0.5**	**0.6**
Powerline	CMAun	Sk	Krummholz	3a	0.2	0.3
Powerline Total					**0.2**	**0.3**
Upper Portal	CMAun	At	Alpine Tundra	2d	-	0.3
Upper Portal Total					**-**	**0.3**
Grand Total					**9.0**	**36.4**

In addition to the effects on Alpine ecosystems, the Project is expected to result in the loss of 33.3 ha and alteration of up to 129.2 ha of parkland ecosystems (Figure 15.5-3; Table 15.5-5). The lower elevation portion of the Haul Road will bisect several parkland communities, predominantly parkland forests (PK; 8 ha) that are comprised of mountain open stands of hemlock and subalpine fir and early seral willow/alder dominated shrublands (SW; 8 ha). Construction of the Haul Road will result in an increase of vehicular traffic and could degrade adjacent ecosystems through compaction, dust deposition, and the introduction of invasive plants. Construction activities at the Quarry and Process Plant, including clearing and stripping the organic and surficial materials, will result in the loss of approximately 9 ha and 6 ha, respectively. The majority of the ecosystems are early seral shrub dominated sites (SW; 11 ha and Sc; 4 ha) or parkland forest (2 ha).

Figure 15.5-3: Loss and Alteration of Parkland Ecosystems



Modelling results show that acidification potential due to Project activities is very low. None of the modelled locations showed an exceedance of the AAQA guidelines. According to modelling, acid deposition associated with the Project is minimal. This is an expected result as the Project is primarily run by electricity and has no combustion sources except for tailpipe emissions from trucks and other heavy equipment.

Table 15.5-5: Loss and Alteration of Parkland Ecosystems

Project Component or Activity	BGC Unit	Map Code	Ecosystem Name	Structural Stage	Loss	Alteration
Treated Effluent Discharge Access	MHmmp	PK	Parkland Forest	3b	-	<0.1
				4	0.1	-
		Sc	Shrubland	2d	<0.1	<0.1
				3a	-	0.7
		SW	Shrubland (willow/alder thicket)	3a	-	<0.1
				3b	0.4	1.1
		Vs	Avalanche Shrub Thicket	3a	-	0.4
Treated Effluent Discharge Access Total					0.5	2.3
Haul Road	MHmmp	Ah	Alpine Heath	2d	0.3	0.5
		At	Alpine Tundra	2d	-	0.9
		PK	Parkland Forest	3b	0.4	1.5
				5	3.0	18.0
				6	1.0	7.1
				4	-	<0.1
				7	3.7	13.0
		Sc	Shrubland	2d	0.1	0.6
				3a	0.4	7.2
				3b	<0.1	0.6
		Sk	Krummholz	3b	-	0.4
		SW	Shrubland (willow/alder thicket)	3a	2.9	15.2
				3b	5.0	28.6
		Vh	Avalanche Herb Meadow	2a	-	0.2
		Vs	Avalanche Shrub Thicket	3a	1.0	7.8
				3b	0.2	5.9
		Vt	Avalanche Treed	3b	-	0.1
				6	-	0.8

Project Component or Activity	BGC Unit	Map Code	Ecosystem Name	Structural Stage	Loss	Alteration
Haul Road Total					18.1	108.2
Process Plant	MHmmp	PK	Parkland Forest	3b	-	0.2
				5	1.0	1.5
				6	0.1	0.2
				4	0.4	0.3
		Sc	Shrubland	2d	-	0.7
				3a	1.6	1.1
				3b	0.3	-
		SW	Shrubland (willow/alder thicket)	3a	0.4	0.4
				3b	2.4	4.8
Process Plant Total					6.2	9.1
Quarry	MHmmp	PK	Parkland Forest	5	0.8	-
				4	-	0.1
		Sc	Shrubland	2d	0.4	1.0
				3a	1.0	1.0
				3b	0.4	<0.1
		SW	Shrubland (willow/alder thicket)	3a	-	0.3
				3b	6.0	2.4
Quarry Total					8.5	4.9
TMF	MHmmp	PK	Parkland Forest	5	0.7	1.4
				6	1.2	2.0
		Sc	Shrubland	2d	0.4	0.3
				3a	0.7	-
				3b	-	0.5
		SW	Shrubland (willow/alder thicket)	3b	1.7	1.3
TMF Total					4.6	5.5
Powerline	MHmmp	At	Alpine Tundra	2d	-	<0.1
		PK	Parkland Forest	3b	-	-
				5	-	2.0
				6	-	0.3
				7	-	0.4

Project Component or Activity	BGC Unit	Map Code	Ecosystem Name	Structural Stage	Loss	Alteration
		Sc	Shrubland	3a	-	0.1
				3b	-	-
		Sk	Krummholz	3a	-	0.2
				3b	-	-
		SW	Shrubland (willow/alder thicket)	3a	-	-
				3b	-	<0.1
		Vh	Avalanche Herb Meadow	2a	-	0.1
		Vs	Avalanche Shrub Thicket	3a	-	0.5
				3b	-	1.0
		Vt	Avalanche Treed	3b	-	<0.1
				6	-	0.1
Powerline Total					-	4.7
Total					33.3	129.2

15.5.3.2.4 Quantification of Potential Effects to Old Growth and Mature Forested Ecosystems

The Project is expected to result in the loss of 25.7 ha and alteration of up to 99.3 ha of old and mature forest ecosystems (excluding mature and old floodplain and parkland forests) through construction activities (Table 15.5-6; Figure 15.5-4).

The loss and alteration areas include six ecosystem units (three from the MHmm1 and three from the CWHwm). Total area of loss per ecosystem ranges from 1.1 to 7.7 ha (with the largest loss occurring in the MHmm1 03 - BaHm - Oak fern ecosystem), while alterations range from 4.8 up to 31.6 ha (with the largest amount of potential alteration occurring in the CWHwm 04 - SsHw - Devil's club ecosystem). Both loss and alteration areas are largely due to small portions (with 18 of the 24 mapped polygons containing less than 1.0 ha of mature or old forest) of numerous ecosystems being disturbed by multiple Project components (Access Road, Borrow, Process Plant, Quarry, TMF, Topsoil Storage Area, and Powerline). The Process Plant and TMF will create the largest areas of loss (5.9 and 7.3 ha respectively), while the Access Road will create the largest are of alteration (75.2 ha).

Figure 15.5-4: Loss and Alteration of Old Growth and Mature Forested Ecosystems

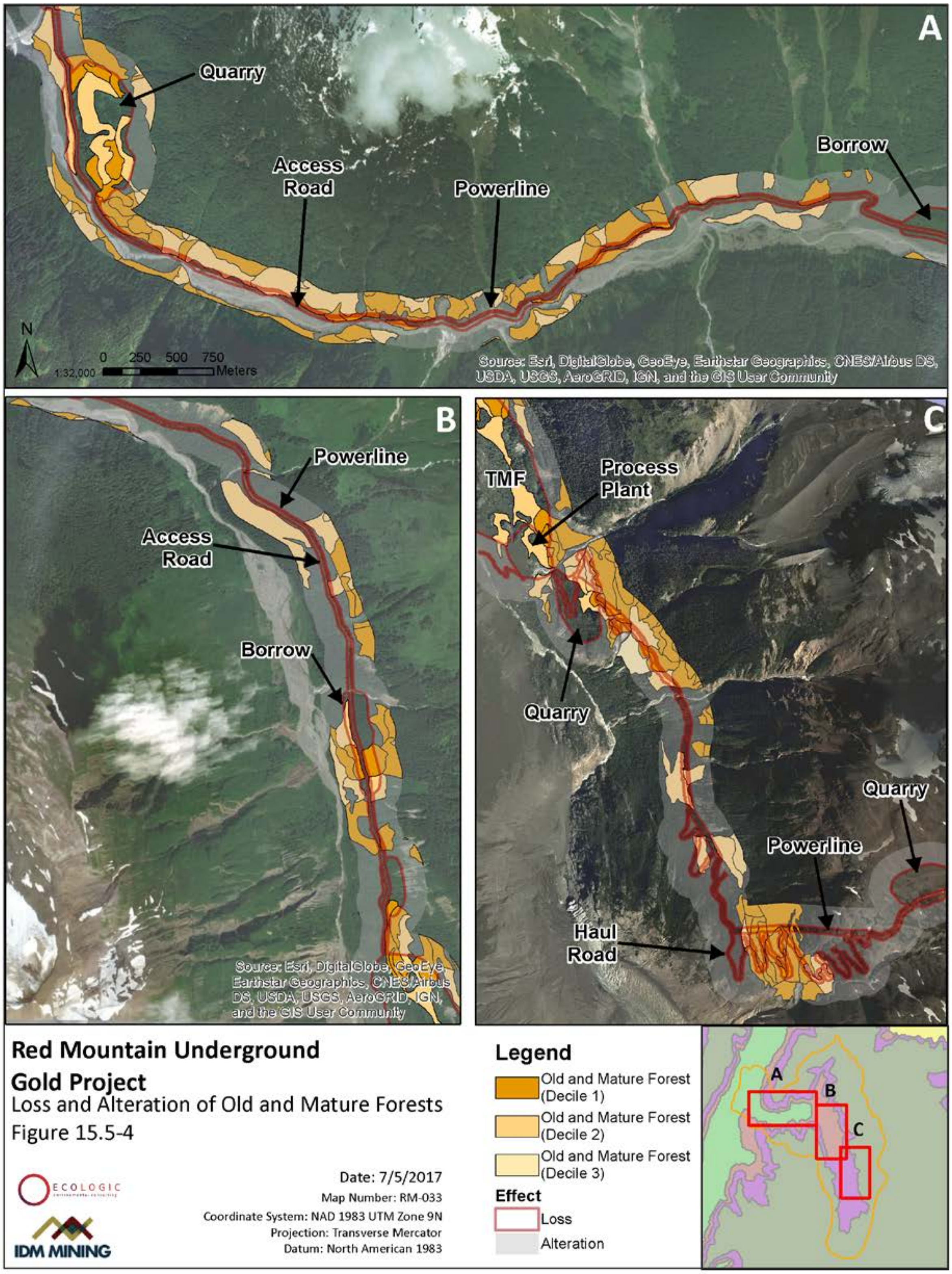


Table 15.5-6: Loss and Alteration of Old Growth and Mature Forested Ecosystems

Project Component or Activity	BGC Unit	Map Code	Ecosystem Name	Structural Stage	Loss	Alteration
Access Road	CWHwm	HB	01 - HwSs - Blueberry	6	-	5.1
				7	0.1	1.6
		SO	03 - SsHw - Oak fern	6	0.4	5.3
				7	1.0	15.3
		SD	04 - SsHw - Devil's club	6	0.6	14.1
				7	0.4	14.3
	MHmm1	MB	01 - HmBa - Blueberry	6	-	0.3
		MO	03 - BaHm - Oak fern	6	0.1	5.6
				7	-	2.1
		MT	05 - BaHm - Twistedstalk	6	0.3	11.4
				7	-	<0.1
Access Road Total					**2.9**	**75.2**
Borrow	CWHwm	SD	04 - SsHw - Devil's club	6	-	0.1
				7	-	0.2
	MHmm1	MB	01 - HmBa - Blueberry	6	-	1.0
		MO	03 - BaHm - Oak fern	6	0.1	3.2
		MT	05 - BaHm - Twistedstalk	6	2.3	<0.1
Borrow Total					**2.4**	**4.6**
	CWHwm	HB	01 - HwSs - Blueberry	6	5.8	3.6
Process Plant	MHmm1	MO	03 - BaHm - Oak fern	6	0.1	-
Process Plant Total					**5.9**	**3.6**
Quarry	CWHwm	HB	01 - HwSs - Blueberry	7	0.1	1.7
		SO	03 - SsHw - Oak fern	6	0.5	0.1
				7	1.1	2.2
		SD	04 - SsHw - Devil's club	6	1.2	0.4
				7	-	1.0
Quarry Total					**1.7**	**3.3**

Project Component or Activity	BGC Unit	Map Code	Ecosystem Name	Structural Stage	Loss	Alteration
Tailings Management Facility	MHmm1	MB	01 - HmBa - Blueberry	6	1.1	2.4
		MO	03 - BaHm - Oak fern	6	6.1	2.3
Tailings Management Facility Total					**7.3**	**4.8**
Topsoil Storage Area	MHmm1	MB	01 - HmBa - Blueberry	6	-	0.4
		MO	03 - BaHm - Oak fern	6	0.8	-
Topsoil Storage Area					**0.8**	**0.4**
Powerline	CWHwm	HB	01 - HwSs - Blueberry	6	-	1.3
				7	0.1	<0.1
		SO	03 - SsHw - Oak fern	6	0.7	0.4
				7	0.9	1.0
		SD	04 - SsHw - Devil's club	6	0.7	0.6
				7	0.6	0.7
	MHmm1	MB	01 - HmBa - Blueberry	6	-	0.1
		MO	03 - BaHm - Oak fern	6	0.4	0.3
				7	-	0.4
		MT	05 - BaHm - Twistedstalk	6	0.2	0.4
				7	-	<0.1
Powerline Total					**3.6**	**5.3**
Grand Total					**25.7**	**99.3**

15.5.3.2.5 Quantification of Potential Effects to Floodplain and Wetland Ecosystems

The Project is expected to result in the loss of 15.9 ha and alteration of up to 57.4 ha of Floodplain Ecosystems through construction activities (Table 15.5-7; Figure 15.5-5). The floodplain forests include structural stages ranging from pole sapling to mature and include mid-bench (CD) and high bench (SS) ecosystems.

The loss and alteration areas include two forested floodplain ecosystems in the CWHwm; SS (Ss - Salmonberry - high bench floodplain) and CD (Act - Red-osier dogwood - mid bench floodplain), both of which are also Blue-listed ecosystems. The Project will result in the loss of 9.6 ha and alteration of up to 34.8 ha of the CWHwm SS floodplain and the loss of 5.5 ha and alteration 17.2 ha of the CWHwm CD floodplain. Loss and alteration areas include multiple Project components (Access Road, Borrow, Quarry, and Powerline) with the alterations associated with the Access Road the largest effect (49.6 ha).

Loss and alteration areas also occur in the CWHwm, MHmm1, and MHmmp on low- and mid-bench floodplains; however, there are no recognized floodplain ecosystem units that describe these communities. These sites are dominated by early seral species, including Sitka alder (*Alnus viridis* ssp. *sinuata*), cottonwood (*Populus balsamifera*), Drummond's mountain avens (*Dryas drummondii*), and willow species (*Salix* spp.). All of the unclassified low bench and the majority of the mid-bench floodplains are located in areas where regular disturbance (e.g., seasonal flooding and associated with avalanche tracks along small drainages) is common. The Project will result in the loss of 0.7 ha and alteration 5.4 ha of unclassified mid- and low-bench floodplains from the construction of multiple Project components (Access Road, Treated Effluent Discharge Access, Haul Road, Process Plant, TMF, Powerline, and Borrow).

Effects will vary by ecosystem type, with mid- and high-bench floodplains being less resilient to change. While low-bench floodplains are adapted to disturbance through regular and seasonal flood events; mid-bench ecosystems experience less frequent and powerful flood events, and high-bench systems rarely flood. Loss and alterations to the SS high-bench floodplains and CD mid-bench floodplains are expected to be longer-lasting, while surface disturbance to the unclassified long-bench systems are expected to result in shorter-term effects.

Figure 15.5-5: Loss and Alteration of Floodplains

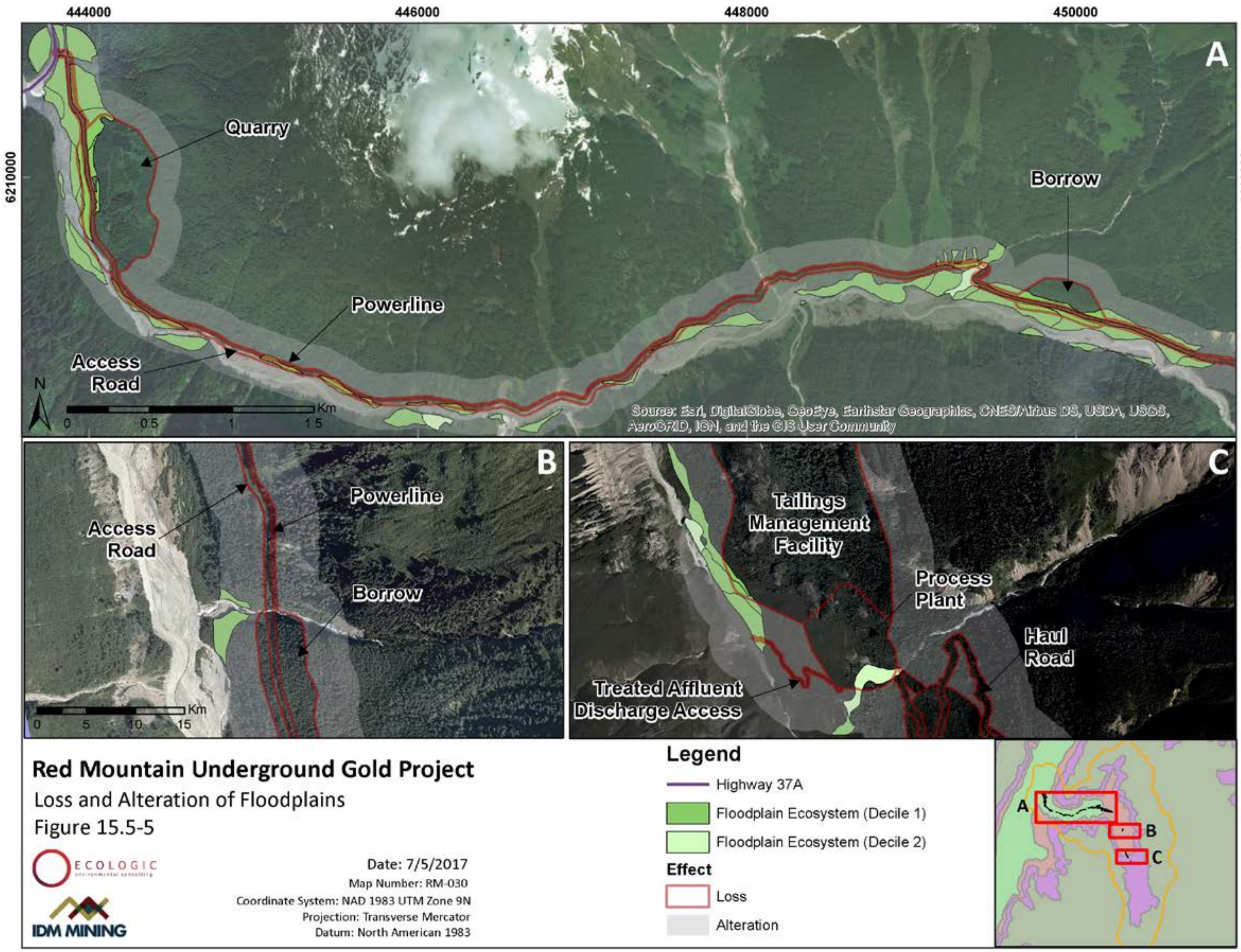


Table 15.5-7: Loss and Alteration of Floodplain Ecosystems

Project Component	BGC Zone	Map Code	Ecosystem Name	Structural Stage	Loss	Alteration
Access Road	CWHwm	CD	06 - Act - Red-osier dogwood – mid-bench floodplain	3b	-	2.8
				4	0.4	7.7
				5	1.1	3.4
				6	0.4	1.9
				7	-	1.1
		Fl	Low bench floodplain	3a	0.1	0.6
				3b	-	<0.1
		SS	05 - Ss - Salmonberry – high-bench floodplain	3b	0.1	0.2
				4	0.4	3.7
				5	1.7	16.8
				6	0.1	2.3
				7	0.3	9.6
	MHmm1	Fm	Middle-bench floodplain	3b	-	0.7
Access Road Total					**4.5**	**50.9**
Treated Effluent Discharge Access	MHmm1	Fl	Low-bench floodplain	2d	<0.1	<0.1
				3a	<0.1	<0.1
				3b	-	0.1
Treated Effluent Discharge Access Total					**<0.1**	**0.1**
Borrow	CWHwm	CD	06 - Act - Red-osier dogwood – mid-bench floodplain	4	2.2	-
		SS	05 - Ss - Salmonberry – high-bench floodplain	4	1.0	-
				6	-	0.7
	MHmm1	Fm	Middle-bench floodplain	3b	-	0.5
Borrow Total					**3.2**	**1.3**
Haul Road	MHmmp	Fl	Low-bench floodplain	3b	<0.1	-
Haul Road Total					**<0.1**	**-**
Process Plant	MHmmp	Fl	Low-bench floodplain	3b	0.2	0.2
Process Plant Total					**0.2**	**0.2**

Project Component	BGC Zone	Map Code	Ecosystem Name	Structural Stage	Loss	Alteration
Quarry	CWHwm	CD	06 - Act - Red-osier dogwood – mid-bench floodplain	3b	0.2	-
				5	0.1	0.2
		SS	05 - Ss - Salmonberry – high-bench floodplain	5	2.9	<0.1
				6	1.8	0.1
				7	-	0.4
Quarry Total					**5.0**	**0.7**
TMF	MHmm1	Fl	Low-bench floodplain	2d	-	0.3
TMF				3a	<0.1	1.1
TMF		Fm	Middle-bench floodplain	3b	0.3	1.9
TMF Total					**0.4**	**3.2**
Powerline	CWHwm	CD	06 - Act - Red-osier dogwood – mid-bench floodplain	4	0.9	<0.01
				5	0.3	-
				6	<0.1	<0.0
				7	<0.1	<0.0
		Fl	Low-bench floodplain	3a	<0.1	<0.1
		SS	05 - Ss - Salmonberry – high-bench floodplain	3b	<0.1	-
				4	0.1	-
				5	1.1	0.9
				6	0.2	<0.1
				7	<0.1	<0.1
	MHmmp	Fl	Low-bench floodplain	3b	<0.1	-
Powerline Total					**2.7**	**1.0**
Total					**15.9**	**57.4**

1. Blue text indicates Blue-listed ecosystems.

Three wetlands will be affected by clearing associated with Project construction, and an additional wetland is located in the area of potential alteration (Table 15.5-8; Figure 15.5-6). A small fen near the north end of the LSA between the Access Road, Powerline, and Quarry may be affected by alteration caused by clearing and road construction. The fen was not sampled during the 2016 field season, so its classification and functional extent is not known. Its location, immediately adjacent to the old overgrown road, also indicates that it may have been modified of created by the hydrological changes of the old road. TEM indicates that 0.6 ha of the wetland is within the alteration area of the Access Road.

Small alpine wetlands located at the transition from MHmmp to CMAun may be affected by construction of the Haul Road. The proposed Haul Road is expected to result in the loss (0.1 ha) and alteration (0.2 ha) of these wetlands, however pre-construction surveys may result in alignment changes to eliminate the disturbance.

The Access Road has the potential to affect the 0.6 ha horsetail fen (west of the topsoil storage area) located in the MHmm1. The Access Road route is proposed about 60 m upslope of the wetland along the existing old overgrown road, and is situated along the toe of the slope that feeds the wetland.

Table 15.5-8: Loss and Alteration of Wetland Ecosystems

Project Component or Activity	BGC Unit	Map Code	Ecosystem Name	Structural Stage	Loss	Alteration
Access Road	MHmm1	Wf	Fen Wetland	2b	-	0.6
Access Road Total					-	**0.6**
Haul Road	CMAun	Wa	Alpine wetland	2b	0.1	0.1
	MHmmp	Wa	Alpine Wetland	2b	<0.1	0.1
Haul Road Total					**0.1**	**0.1**
Quarry	CWHwm	Wf	Fen Wetland	2b	0.2	-
Quarry Total					**0.2**	**<0.1**
Grand Total					**0.3**	**0.7**

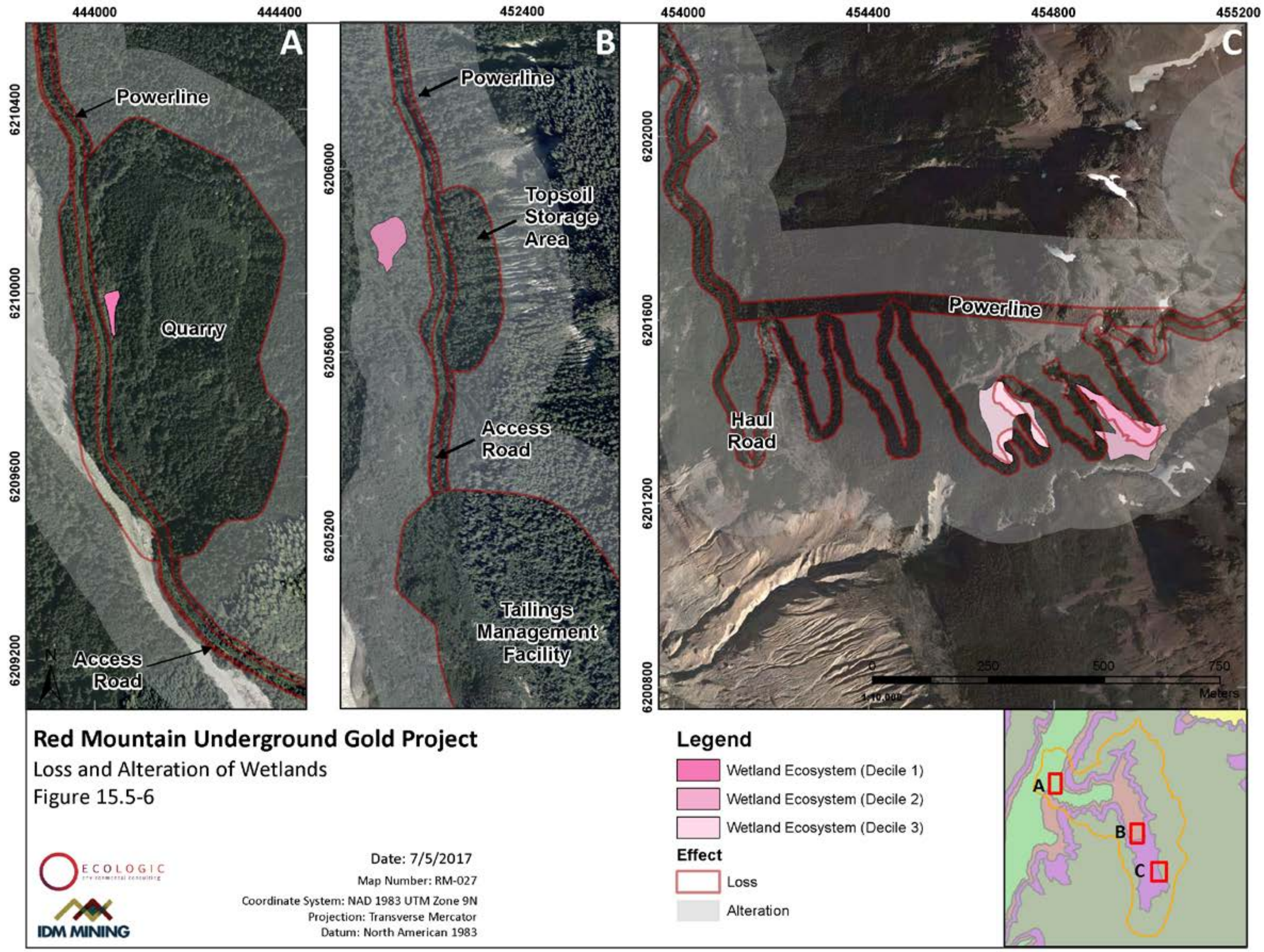
15.5.3.2.6 Quantification of Potential Effects to BC CDC Listed Ecosystems

The Project is expected to result in the loss and alteration of two at-risk Blue-listed ecosystems: the 06 - Act - Red-osier dogwood – mid-bench floodplain (CD) and the 05 - Ss - Salmonberry - high bench floodplain (SS). The Project will result in a loss of 1.9 ha and alteration of up to 6.7 ha of the 06 - Act - Red-osier dogwood – mid-bench floodplain (CD) ecosystem and loss of 8.1 ha and alteration of up to 30.9 ha of the 05 - Ss - Salmonberry – high-bench floodplain (SS) ecosystem.

Floodplain ecosystems, in particular at-risk floodplains, are ecologically important because they provide uncommon assemblages of vegetation species and support specific processes and specialist species that are absent in less diverse ecosystems (Ward et. al., 1999). Loss or alteration of Blue-listed ecosystems has implications for biodiversity within the LSA as these ecosystems are also uncommon with the study area.

The majority of the loss will occur due to the construction of the Quarry and the Access Road. Additional effects may occur as a result of the daylighting of certain ecosystems, which could alter the moisture, light, and temperature conditions at the site.

Figure 15.5-6: Loss and Alteration of Wetlands



15.5.3.3 Key Effects on Rare Plants, Lichens, and Associated Habitat

Key effects on Rare Plants, Lichens, and Associated Habitat were assessed using the detailed Project footprint. The detailed Project design was selected for the analysis to gain a better understanding of the fine-scale features that may be lost or altered by Project components or activities. The detailed Project design includes the proposed Project footprint and a 50 m buffer applied to accommodate for changes earlier on in the process as well as the 150 m buffer applied to determine potential alteration due to dust, invasive plants, and other factors.

Key effects on Rare Plants, Lichens, and Associated Habitat were assessed in relation to the measurement indicators of loss or alteration to known occurrences of rare lichens and plants and in relation to the potential loss of biodiversity relative to current conditions.

15.5.3.3.1 Loss of Rare Plants, Lichens and Associated Habitat

Potential loss of Rare Plants, Lichens, and Associated Habitat is expected to occur due to construction of the Process Plant, TMF, Quarry, Haul Road, Access Road, and Powerline (Figure 15.5-7).

A Red-listed lichen (cauliflower foam, *Stereocaulon botryosum*), Blue-listed moss (sooty cupola, *Cinclidium stygium*), and Blue-listed lichen (pygmy racomitrium, *Niphotrichum pygmaeum*) are located within the footprint of the Process Plant and will be directly affected by clearing activities (Table 15.5-9).

The Red-listed lichen (fig-leaved pixie lichen, *Cladonia macrophylla*) and a previously undocumented vascular plant (*Taraxacum amarum*) are located on the upper portion of Bromley Humps, the natural topographical containment for the TMF. Based on the current design, *C. macrophylla* and *T. amarum* will not be directly affected by the creation of the TMF. *C. macrophylla* was noted to occur within a 1 x 1 m area, and *T. amarum* was noted within seepage areas occurring sporadically throughout Bromley Humps.

Two Blue-listed lichens (corrugated shingles [*Fuscopannaria ahln*eri], and *Leptogidium dendriscum*) occur within a 1 x 1 m area within the gully adjacent to the proposed Access Road and Powerline. These lichens could be removed as a result of clearing activities associated with the expansion of the Access Road

A Blue-listed lichen (big-foot lichen, *Cladonia pseudalcicornis*) and a Blue-listed liverwort (compressed flapwort, *Nardia compressa*) occur within the 50 m buffer alongside the Haul Road and Quarry. The *C. pseudalcicornis* population was noted to occur within an alpine heath (Ah) ecosystems, the extent of which is unknown. The *N. compressa* population was noted to occur within a mineral spring outflow in the alpine heath that extends approximately 5 x 20 m and is located adjacent to the propose Haul Road.

Table 15.5-9: Loss and Alteration of Rare Plants, Lichens, and Associated Habitat

Project Component	Effect	Life Form	Common Name	Scientific Name	NatureServe Provincial Status	BC CDC Listing	NatureServe Global Status
Process Plant	Loss	Moss	sooty cupola moss	*Cinclidium stygium*	S3	Blue	G5
Process Plant		Moss	pygmy racomitrium	*Niphotrichum pygmaeum*	S3	Blue	GU
Process Plant		Lichen	cauliflower foam	*Stereocaulon botryosum*	S2	Red	G4
TMF		Lichen	fig-leaved pixie	*Cladonia macrophylla*	S2	Red	GNR
TMF		Vascular plant	-	*Taraxacum amarum*	Previously undocumented species, not represented among any previous herbarium specimens, likely to be rare		
Quarry		Lichen	big-foot lichen	*Cladonia pseudalcicornis*	S2S3	Blue	GNR
Quarry		Liverwort	compressed flapwort	*Nardia compressa*	S3	Blue	G4G5
Access Road		Lichen	corrugated shingles	*Fuscopannaria ahlneri*	S2S3	Blue	G4G5
Access Road		Lichen	-	*Leptogidium dendriscum*	S3	Blue	G3G5
Quarry	Alteration	Moss	bud-tipped bryum	*Imbribryum gemmiparum*	S2S3	Blue	G3G5
Access Road		Vascular plant	-	*Micranthes separata*	An undescribed species that appears to be rare, limited to the BC Coast Ranges, known from < 10 sites		
Haul Road		Lichen	blackened Iceland	*Cetraria nigricans*	S3	Blue	G5
Haul Road		Lichen	pincushion tarpaper	*Collema ceraniscum*	S1	Red	GNR
TMF		Lichen	madame pixie	*Cladonia coccifera*	S1	Red	G5
TMF		Vascular plant	scalloped moonwort	*Botrychium crenulatum*	S2S3	Blue	G3
TMF		Moss	pygmy racomitrium	*Niphotrichum pygmaeum*	S3	Blue	GU

15.5.3.3.2 Alteration of Rare Plants, Lichens, and Associated Habitat

Based upon modelled dust deposition (Volume 3, Chapter 7) there is potential alteration of Rare Plants, Lichens, and Associated Habitat due to dust deposition associated with construction of the Quarry as well as from use of the Access and Haul Road. However, dust deposition rates do not exceed at any location the AAQA guideline of 1.7 milligrams per squared decametre per day ($mg/dm^2/day$). Since, in particular, lichens can be very sensitive to dust effects, non-exceedance of this guideline level does not necessarily mean the absence of effects.

Dust deposition in rare plant and lichen locations ranged from 0.56 to 0.74 $mg/dm^2/day$. This compares to a background dust level of 0.56 $mg/dm^2/day$. *Niphotrichum pygmaeum* is subject to the highest modelled deposition rate of 0.74 $mg/dm^2/day$. Table 15.5-10 presents the rates of modelled dust deposition at the location of each identified rare plant and lichen (Figure 15.5-8).

Table 15.5-11 shows the modelled level of input of NO_2 and SO_2 during operations. Based upon modelling, it is unlikely that acidification due to deposition of NO_2 and SO_2 will affect Rare Plants, Lichens, or Associated Habitat. While NO_2 and SO_2 are modelled to be above baseline during operations, the rates of input into the atmosphere fall well below AAQA guidelines.

Table 15.5-10: Dust Deposition at Rare Plant and Lichen Locations

Receptor Description	Background Dustfall ($mg/dm^2/day$)	Final Maximum Dry Deposition ($mg/dm^2/day$)	Final Maximum Wet Deposition ($mg/dm^2/day$)	Final Maximum Total Dust Fall ($mg/dm^2/day$)	AAQO ($mg/dm^2/day$)
Collema ceraniscum Nyl.	0.56	0.65	0.58	0.65	1.7
Pohlia erecta (Limpr.) H.Lindb.	0.56	0.57	0.56	0.57	1.7
Stereocaulon botryosum Ach.	0.56	0.59	0.57	0.59	1.7
Santessoniella arctophila (Th.Fr.) Henssen	0.56	0.61	0.57	0.61	1.7
Stereocaulon botryosum Ach.	0.56	0.59	0.57	0.59	1.7
Mielichhoferia elongata (Hoppe & Hornsch.) Nees & Hornsch.	0.56	0.63	0.57	0.63	1.7
Mielichhoferia mielichhoferiana (Funck) Loeske	0.56	0.63	0.57	0.63	1.7
Bryoria nitidula (Th. Fr.) Brodo & D. Hawksw.	0.56	0.60	0.57	0.60	1.7
Cetraria nigricans Nyl.	0.56	0.63	0.58	0.63	1.7
Grimmia atrata Miel. ex Hornsch.	0.56	0.61	0.57	0.61	1.7
Schistidium venetum H.H.Blom	0.56	0.61	0.57	0.61	1.7
Niphotrichum pygmaeum (Frisvoll) Bednarek-Ochyra & Ochyra	0.56	0.61	0.57	0.61	1.7
Imbribryum gemmiparum (De Not.) J.R. Spence? (needs verification)	0.56	0.60	0.57	0.60	1.7
Cinclidium stygium Sw.	0.56	0.72	0.73	0.72	1.7
Niphotrichum pygmaeum (Frisvoll) Bednarek-Ochyra & Ochyra	0.56	0.74	0.70	0.74	1.7
Stereocaulon botryosum Ach.	0.56	0.74	0.70	0.74	1.7
Cladonia macrophylla (Schaer.) Stenh.	0.56	0.60	0.60	0.60	1.7
Cladonia coccifera (L.) Willd.	0.56	0.58	0.58	0.58	1.7
Botrychium crenulatum W.H.Wagner	0.56	0.58	0.58	0.58	1.7
Niphotrichum pygmaeum (Frisvoll) Bednarek-Ochyra & Ochyra	0.56	0.57	0.58	0.57	1.7

Receptor Description	Background Dustfall (mg/dm^2/day)	Final Maximum Dry Deposition (mg/dm^2/day)	Final Maximum Wet Deposition (mg/dm^2/day)	Final Maximum Total Dust Fall (mg/dm^2/day)	AAQO (mg/dm^2/day)
Fuscopannaria ahlneri (P.M.Jørg.) P.M.Jørg.	0.56	0.58	0.59	0.58	1.7
Leptogidium dendriscum (Nyl.) Nyl.	0.56	0.58	0.59	0.58	1.7
Taraxacum sp. nov. (short)	0.56	0.56	0.56	0.56	1.7
Botrychium spathulatum W.H.Wagner	0.56	0.56	0.56	0.56	1.7
Umbilicaria lambii Imshaug	0.56	0.56	0.56	0.56	1.7
Taraxacum speculorum Björk ined.	0.56	0.56	0.56	0.56	1.7
Lobaria retigera (Bory) Trevis.	0.56	0.56	0.56	0.56	1.7
Santessoniella arctophila (Th.Fr.) Henssen	0.56	0.56	0.56	0.56	1.7
Pohlia pacifica A.J.Shaw	0.56	0.56	0.56	0.56	1.7
Ptychostomum inclinatum (Sw. ex Brid.) J.R.Spence	0.56	0.56	0.56	0.56	1.7
Baeomyces carneus Flörke	0.56	0.56	0.56	0.56	1.7
Leptogium tenuissimum (Dicks.) Körb.	0.56	0.56	0.56	0.56	1.7
Placynthium asperellum (Ach.) Trevisan	0.56	0.56	0.56	0.56	1.7
Collema crispum (Hudson) F. H. Wigg. cfr.	0.56	0.56	0.56	0.56	1.7
Heterodermia unknown sp.	0.56	0.56	0.56	0.56	1.7
Grimmia donniana Sm.	0.56	0.60	0.57	0.60	1.7
Micranthes separataBjörk ined.	0.56	0.56	0.56	0.56	1.7
Taraxacum sp. nov. (tall)	0.56	0.56	0.56	0.56	1.7
Peltolepis quadrata (Saut.) K.Müller	0.56	0.56	0.56	0.56	1.7
Sauteria alpina (Nees) Nees	0.56	0.56	0.56	0.56	1.7
Nardia compressa (Hook.) Gray	0.56	0.64	0.58	0.64	1.7

Receptor Description	Background Dustfall ($mg/dm^2/day$)	Final Maximum Dry Deposition ($mg/dm^2/day$)	Final Maximum Wet Deposition ($mg/dm^2/day$)	Final Maximum Total Dust Fall ($mg/dm^2/day$)	AAQO ($mg/dm^2/day$)
Pohlia cardotii (Renauld) Broth.	0.56	0.56	0.56	0.56	1.7
Taraxacum amarum Björk ined.	0.56	0.59	0.59	0.59	1.7
Cladonia pseudalcicornis Asahina	0.56	0.65	0.58	0.65	1.7
Nephroma isidiosum (Nyl.) Gyeln.	0.56	0.58	0.58	0.58	1.7
Lobaria oregana (Tuck.) Müll.Arg.	0.56	0.56	0.56	0.56	1.7
Anemone narcissiflora var. vilosissima (DC.) Hultén	0.56	0.56	0.56	0.56	1.7
Anemone narcissiflora var. vilosissima (DC.) Hultén	0.56	0.56	0.56	0.56	1.7

Table 15.5-11: Deposition of NO_2 and SO_2 at Rare Plant and Lichen Locations

Receptor Description	NO_2 Final Maximum Concentration (µg/m^3)	NO_2 Background (µg/m^3)	% change from Baseline	NO_2 AAQO (µg/m^3)	Final Maximum Concentration (µg/m^3)	SO_2 Background Concentration (µg/m^3)	% change from Baseline	SO_2 AAQO (µg/m^3)
Collema ceraniscum	8.16	5	63.3%	60	2.4	2.0	8.7%	13
Pohlia erecta	6.5645	5	31.3%	60	2.2	2.0	4.2%	13
Stereocaulon botryosum	7.9639	5	59.3%	60	2.4	2.0	8.1%	13
Santessoniella arctophila	8.2285	5	64.6%	60	2.4	2.0	8.9%	13
Stereocaulon botryosum	8.8932	5	77.9%	60	2.5	2.0	10.7%	13
Mielichhoferia elongata	6.2954	5	25.9%	60	2.2	2.0	3.4%	13
Mielichhoferia mielichhoferiana	6.2954	5	25.9%	60	2.2	2.0	3.4%	13
Bryoria nitidula	9.3615	5	87.2%	60	2.6	2.0	12.1%	13
Cetraria nigricans	9.8506	5	97.0%	60	2.7	2.0	13.4%	13
Grimmia atrata	6.3282	5	26.6%	60	2.2	2.0	3.5%	13
Schistidium venetum	6.3282	5	26.6%	60	2.2	2.0	3.5%	13
Niphotrichum pygmaeum	6.3315	5	26.6%	60	2.2	2.0	3.5%	13
Imbribryum gemmiparum	11.2276	5	124.6%	60	2.9	2.0	17.3%	13
Cinclidium stygium	9.4035	5	88.1%	60	2.2	2.0	4.0%	13
Niphotrichum pygmaeum	11.751	5	135.0%	60	2.2	2.0	3.6%	13
Stereocaulon botryosum	11.751	5	135.0%	60	2.2	2.0	3.6%	13
Cladonia macrophylla	5.81489	5	16.3%	60	2.1	2.0	2.3%	13
Cladonia coccifera	5.62878	5	12.6%	60	2.1	2.0	1.7%	13
Botrychium crenulatum	5.62879	5	12.6%	60	2.1	2.0	1.7%	13

Receptor Description	NO_2 Final Maximum Concentration (µg/m^3)	NO_2 Background (µg/m^3)	% change from Baseline	NO_2 AAQO (µg/m^3)	Final Maximum Concentration (µg/m^3)	SO_2 Background Concentration (µg/m^3)	% change from Baseline	SO_2 AAQO (µg/m^3)
Niphotrichum pygmaeum	5.54388	5	10.9%	60	2.1	2.0	1.4%	13
Fuscopannaria ahlneri.	5.43952	5	8.8%	60	2.1	2.0	1.1%	13
Leptogidium dendriscum	5.43952	5	8.8%	60	2.1	2.0	1.1%	13
Taraxacum sp. nov. (short)	5.074794	5	1.5%	60	2.0	2.0	0.2%	13
Botrychium spathulatum	5.074624	5	1.5%	60	2.0	2.0	0.2%	13
Umbilicaria lambii Imshaug	5.15246	5	3.0%	60	2.0	2.0	0.4%	13
Taraxacum speculorum	5.1512	5	3.0%	60	2.0	2.0	0.4%	13
Lobaria retigera	5.16884	5	3.4%	60	2.0	2.0	0.4%	13
Santessoniella arctophila	5.13598	5	2.7%	60	2.0	2.0	0.3%	13
Pohlia pacifica	5.18955	5	3.8%	60	2.0	2.0	0.5%	13
Ptychostomum inclinatum	5.18955	5	3.8%	60	2.0	2.0	0.5%	13
Baeomyces carneus	5.10068	5	2.0%	60	2.0	2.0	0.2%	13
Leptogium tenuissimum	5.10068	5	2.0%	60	2.0	2.0	0.2%	13
Placynthium asperellum	5.10068	5	2.0%	60	2.0	2.0	0.2%	13
Collema crispum	5.047226	5	0.9%	60	2.0	2.0	0.1%	13
Heterodermia unknown sp.	5.047226	5	0.9%	60	2.0	2.0	0.1%	13
Grimmia donniana	10.1327	5	102.7%	60	2.7	2.0	14.2%	13
Micranthes separata	5.099727	5	2.0%	60	2.0	2.0	0.2%	13
Taraxacum sp. nov.	5.074794	5	1.5%	60	2.0	2.0	0.2%	13
Peltolepis quadrata	5.075746	5	1.5%	60	2.0	2.0	0.2%	13
Sauteria alpina	5.075746	5	1.5%	60	2.	2.0	0.2%	13
Nardia compressa	12.7921	5	155.8%	60	3.1	2.0	21.6%	13

Receptor Description	NO_2 Final Maximum Concentration (µg/m^3)	NO_2 Background (µg/m^3)	% change from Baseline	NO_2 AAQO (µg/m^3)	Final Maximum Concentration (µg/m^3)	SO_2 Background Concentration (µg/m^3)	% change from Baseline	SO_2 AAQO (µg/m^3)
Pohlia cardotii	5.15128	5	3.0%	60	2.0	2.0	0.4%	13
Taraxacum amarum	5.72679	5	14.5%	60	2.1	2.0	1.9%	13
Cladonia pseudalcicornis Asahina	13.7033	5	174.1%	60	3.2	2.0	24.1%	13
Nephroma isidiosum	5.62878	5	12.6%	60	2.1	2.0	1.7%	13
Lobaria oregana.	5.16884	5	3.4%	60	2.0	2.0	0.4%	13
Anemone narcissiflora var. vilosissima	5.074794	5	1.5%	60	2.0	2.0	0.2%	13
Anemone narcissiflora var. vilosissima	5.09291	5	1.9%	60	2.0	2.0	0.2%	13

Figure 15.5-7: Loss and Alteration of Rare Plants and Lichen

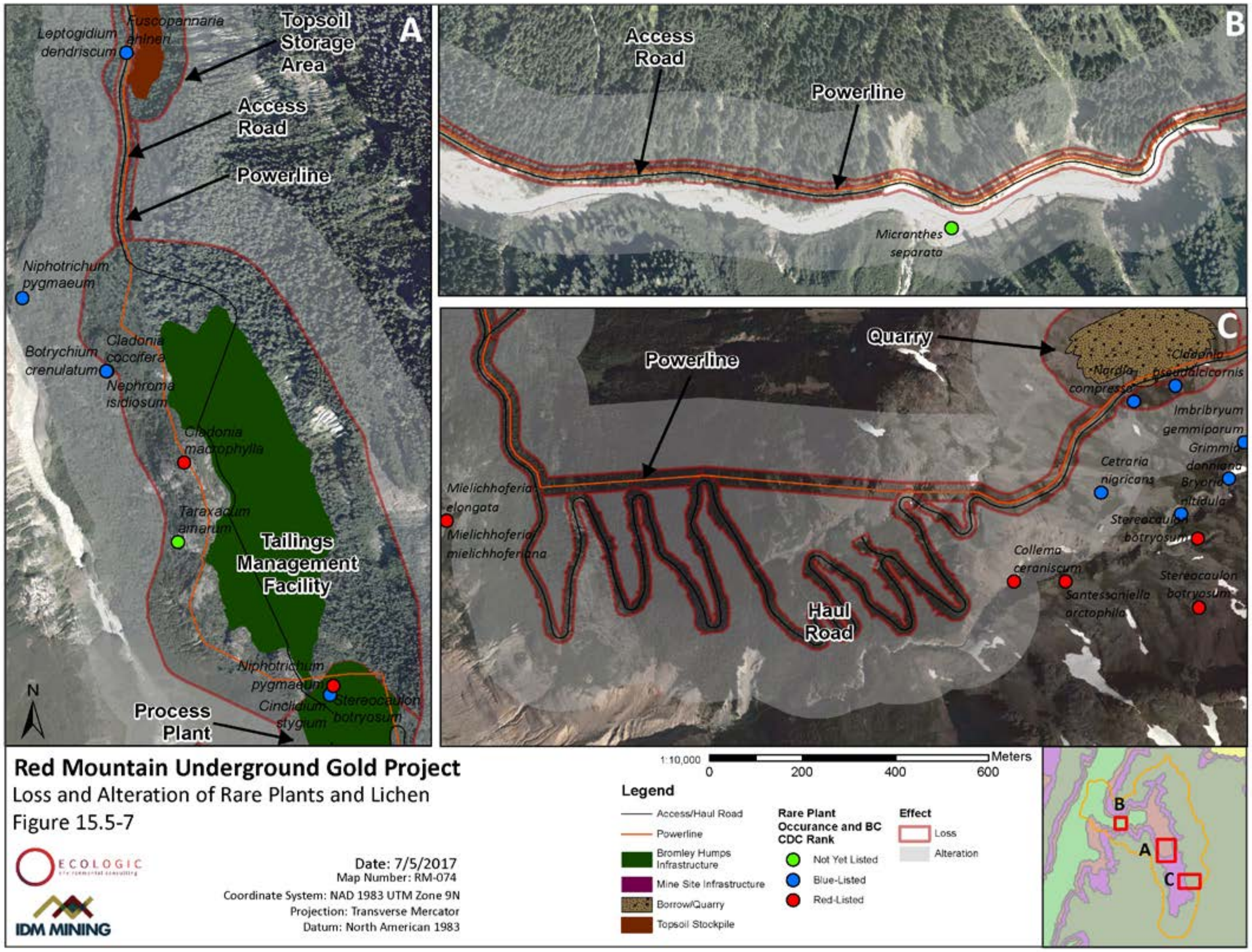
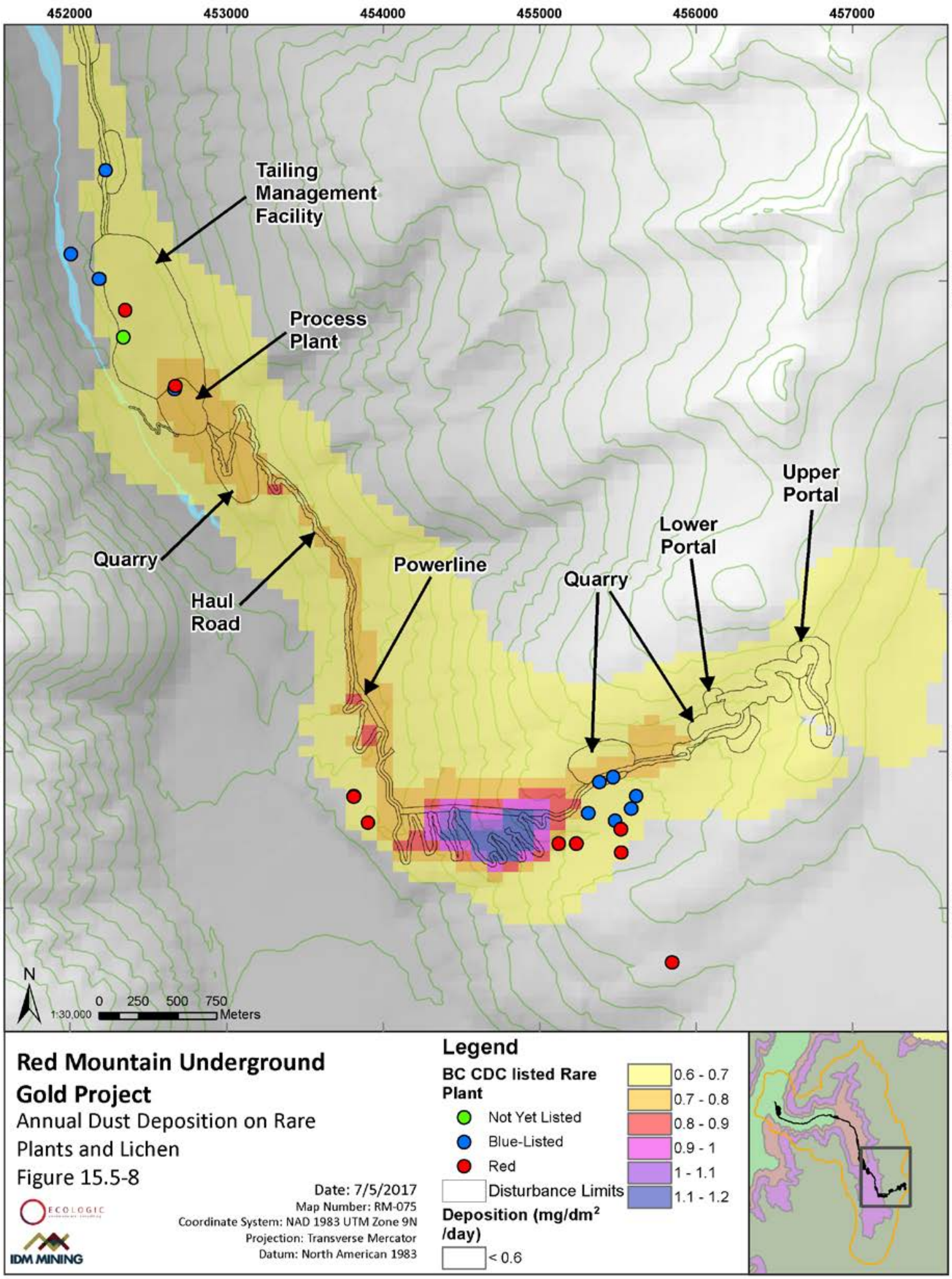


Figure 15.5-8: Annual Dust Deposition on Rare Plants and Lichens



15.5.4 Summary of Potential Effects

Table 15.5-12 provides a summary of the potential effects on Vegetation and Ecosystems VCs; a summary of potential effects to Rare Plants, Lichens, and Associated Habitat is provided in Table 15.5-13. Each VC is indicated in terms of the totals mapped in the LSA and the total loss and alteration within the PFSA. The LSA totals have been modified so only those ecosystems assessed in the PFSA loss and alterations areas are included.

BC CDC Listed Ecosystems and floodplains are expected to have the most notable loss and alterations, with the Project removing 7.7% and altering 25.5% of the total mapped area within the LSA. Floodplains will experience a similar change (as both of the listed ecosystems are floodplains), with the Project removing 7.1% and altering 26.4% of the total mapped in the LSA. These results are expected as the nature of the LSA (a steep-sloped watershed) results in a small amount of floodplain ecosystems and the location of the Project components in the valley bottom.

Table 15.5-12: Summary of Potential Effects to Vegetation and Ecosystem VCs

VC	LSA Totals		PFSA Totals				LSA (% PFSA of LSA totals)	
	LSA (ha)	LSA (%)	Loss (ha)	Loss (%)	Alteration (ha)	Alteration (%)	Loss (%)	Alteration (%)
Ecologically Valuable Soils	9,337	58.9	209.3	21.8	580.6	60.4	2.2	5.7
Alpine Ecosystems	1644.3	10.4	9.0	0.9	36.4	3.8	0.5	2.2
Parkland Ecosystems	2239.7	14.1	33.3	3.5	129.2	13.4	1.5	5.8
Old Growth and Mature Forested Ecosystems	1647.8	10.4	25.7	2.7	99.3	10.3	1.6	6.0
Floodplains	224.8	1.4	15.9	1.7	57.4	6	7.1	25.5
Wetland Ecosystems	31.5	0.2	0.3	<0.1	0.7	0.1	1.0	2.2
BC CDC Listed Ecosystems	197.1	1.2	15.2	1.6	52.1	5.4	7.7	26.4

One Red-listed lichen, one Blue-listed moss, and one Blue-listed lichen are located within the proposed Process Plant footprint and may be removed during clearing and construction activities (Table 15.5-13).

Two Red-listed lichens, three Blue-listed lichens, one Blue-listed liverwort, and one previously undocumented vascular plant are located within the 50 m area buffer surrounding the Project footprint and could be removed depending on the final citing of infrastructure.

One Red-listed lichen, one Blue-listed vascular plant, one previously undocumented vascular plant, and two Blue-listed lichens located within the 150 m alteration buffer and may be affected by changes to the ecological conditions surrounding the rare plant and lichen habitat.

Table 15.5-13: Summary of Potential Effects to Rare Plants and Lichens

BC CDC RANK	Common Name	Scientific Name	Project Effect	
			Loss	Alteration
Red-Listed	cauliflower foam	*Stereocaulon botryosum*	X	
	fig-leaved pixie	*Cladonia macrophylla*	X	
	pincushion tarpaper	*Collema ceraniscum*		X
	Madame pixie	*Cladonia coccifera*		X
Blue-Listed	sooty cupola moss	*Cinclidium stygium*	X	
	pygmy racomitrium	*Niphotrichum pygmaeum*	X	
	big-foot lichen	*Cladonia pseudalcicornis*	X	
	compressed Flapwort	*Nardia compressa*	X	
	corrugated shingles	*Fuscopannaria ahlneri*	X	
	bud-tipped bryum	*Imbribryum gemmiparum*		X
		Micranthes separata		X
	blackened Iceland	*Cetraria nigricans*		X
	scalloped moonwort	*Botrychium crenulatum*		X
	pygmy racomitrium	*Niphotrichum pygmaeum*		X
Undocumented within the province-new discovery	-	*Taraxacum amarum*	X	

15.6 Mitigation Measures

Management of Project-related effects on Vegetation and Ecosystems VCs were determined in accordance with the key mitigation approaches outlined in the Effects Assessment Methodology (Volume 3, Chapter 6) and the Procedures for Mitigating Impacts on Environmental Values (Environmental Mitigation Procedures; BC MOE 2012).

15.6.1 Key Mitigation Approaches

Results from the review of best management practices, guidance documents, and mitigation measures conducted for similar projects, as well as professional judgment for the Project-specific effects and most suitable management measures, were considered in determining the mitigation measures. The approach to the identification of mitigation measures subscribed to the mitigation hierarchy, as described in the Environmental Mitigation Policy for British Columbia (http://www.env.gov.bc.ca/emop/). The mitigation hierarchy follows the guidance that all feasible measures at one level are considered before moving to the next level. Technical and economic feasibility constraints dictated the highest level on the hierarchy that could be achieved for each potential effect and the identification of mitigation measures for managing these effects. The need for any proposed compensation or offset is identified where required, along with the management plan where the scope of such compensation or offset is described.

Specific mitigation measures were identified and compiled for each category of potential effect on Vegetation and Ecosystem VCs and presented in this section. For the purposes of this assessment, mitigation measures included any action or project design feature that will reduce or eliminate effects to Vegetation and Ecosystems. Four broad categories of mitigation and management approaches identified for Vegetation and Ecosystems VCs include:

- Optimizing Alternatives;
- Design Mitigation; and
- Guidelines and Best Management Practices (BMPs).

15.6.1.1 Optimizing Alternatives

Optimizing alternatives includes:

- Conducting a tailings alternatives assessment (Volume 2, Chapter 4);
- Optimizing the design of the Access Road and Haul Road to minimize the distance travelled, which will reduce noise, dust, and emissions associated with construction and operations;
- Developing an underground mine, thereby minimizing surface clearing and dust emissions; and
- Using existing roads or rights-of-way as much as possible, thus reducing new surface disturbances to the ecosystems and plants.

15.6.1.2 Design Mitigation

Design mitigation includes:

- Minimizing cut-and-fill in areas with metal leaching/acid rock drainage (ML/ARD) potential;

- Re-routing the Access Road to avoid wetlands; and
- Developing objectives of closure plans for reclaimed areas to establish site conditions that allow for realistic and operationally feasible ecological trajectories and that take into consideration ecosystem function and wildlife habitat objectives.

15.6.1.3 Guidelines and Best Management Practices

Table 15.6-1 outlines applicable guideline and BMPs relevant to the management of Vegetation and Ecosystems VCs.

Table 15.6-1: Best Management Practices for Vegetation and Ecosystem Valued Components

Best Management Practice Document	Agency	Jurisdiction	Description
Guide to Weeds in British Columbia (2002)	BC Ministry of Agriculture Food and Fisheries	Provincial	This field guide provides guidance for identification of invasive plants common to BC.
Best Management Practices Riparian Management for Small Streams (2017).	BC Timber Sales	Provincial	A guide for prescribing and applying suitable riparian management practices along small streams (S4, S5, and S6 class).
Invasive Species Strategy for British Columbia (2012).	Invasive Species Council of British Columbia	Provincial	A guide for providing provincial coordination for the management of invasive species.
Invasive Species Council of BC website (T.I.P.S. brochures).	Invasive Species Council of British Columbia	Provincial	This website includes the identification of key plant species, with pictures and habitat and management information.
Best Practices for Managing Invasive Plants Along Roadsides: A Pocket Guide for British Columbia's Maintenance Contractors	Invasive Species Council of British Columbia 2008-2013.	Provincial	This guidebook provides information on the identification and management of invasive plants, with an emphasis on minimizing the spread and transport.
Health, Safety and Reclamation Code for Mines in British Columbia (2017)	Ministry of Energy and Mines	Provincial	The Code (BC MEMPR 2008) requires that the environmental protection of land and water resources, as well as the reclamation of disturbed land be planned in advance and that plans follows the standards outlined by the Code. The Code specifies standards (Reclamation and Closure, Part 10) that must be achieved during mining activities and requires regular site inspections and annual reporting.

Best Management Practice Document	Agency	Jurisdiction	Description
Develop with Care Environmental Guidelines for Urban and Rural Land Development in British Columbia (BC MOE 2014).	Ministry of Environment	Provincial	This guidebook outlines pertinent legislation and development guidelines to protect environmentally valuable features and habitats.
Wetland Ways: Interim Guidelines for Wetland Protection and Conservation in British Columbia (2009).	Ministry of Environment	Provincial	This document provides guidance on the protection and management of wetland ecosystems in BC.
The Handbook for Pesticide Applicators and Dispensers (2005)	Ministry of Environment	Provincial	This handbook provides detailed methodology for treatment activities and includes measures (including designation of pesticide-free and no-treatment zones) to protect waterbodies and riparian areas.
Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia (2014)	Ministry of Environment	Provincial	This guideline provides various relevant management recommendations such as avoidance of ecosystems listed by the BC Conservation Data Centre and management or riparian habitat.
Procedures for Mitigating Impact on Environmental Values (2014)	Ministry of Environment	Provincial	A policy document (with associated procedures) that, in part, is intended to provide guidance on the development of hierarchical mitigation plans (i.e., avoid, minimize, restore, offset).
Towards an Environmental Mitigation and Offsetting Policy for British Columbia: A Discussion Paper (2010)	Ministry of Environment	Provincial	Provides a framework to consider when setting mitigation strategies for rare organisms and habitats.
British Columbia Conservation Data Centre	Ministry of Environment	Provincial	The BC CDC provides a centralized and scientific source of information on the status, locations, and level of protection of these organisms and ecosystems.
Forest Practices Code Riparian Management Area Guidebook (BC MOF 1995)	Ministry of Forests	Provincial	This guidebook provides recommendations for management zones around riparian and wetland areas.
Standards and Best Practices for Instream Works (2004)	Ministry of Water, Land, and Air Protection	Provincial	A guide to best practices for instream works
Northwest Invasive Plant Council Strategic Plan (2015)	Northwest Invasive Plant Council	Provincial	Provides information on invasive plant management support and coordination to include education and outreach, inventory, treatments and monitoring.

Best Management Practice Document	Agency	Jurisdiction	Description
NWIPC 2017 Target Invasive Plant List	Northwest Invasive Plant Council (NWIPC)	Provincial	This document provides a comprehensive list of invasive plants targeted for treatment across the NWIPC operating area.
Invasive Plants Identification Field Guide (2008)	Province of BC	Provincial	This field guide was developed to help non-experts identify invasive plants throughout BC.
Canadian Biodiversity Strategy (1995)	Ministry of Supply and Services Canada	Federal	Provides guidance on the conservation of biodiversity and use of biological resources in a sustainable manner on a national level.
Federal Policy on Wetland Conservation (2014)	Canadian Wildlife Service and Environment Canada	Federal	The Federal Policy on Wetland Conservation provides a coordinated federal approach to wetland conservation. This policy provides direction on wetland management, legislation, and related policies and programs that support wetland conservation on federal lands and waters.
Operational Statement: Maintenance of Riparian Vegetation in Existing Rights-of-Way (2010)	Department of Fisheries	Federal	This statement, applicable to freshwater systems within BC and Yukon Territory, applies only to existing ROWs at the location where they intersect and cross a waterbody. It outlines measures to protect fish and fish habitat when maintaining riparian vegetation to ensure compliance with the *Fisheries Act* (1985c).
An Invasive Alien Species Strategy for Canada (2004)	Government of Canada	Federal	This strategy states that all levels of government have roles and responsibilities in regulating and managing invasive species.

15.6.2 Project Mitigation Measures

Project mitigation measures are part of a comprehensive approach to environmental protection, which includes optimizing alternatives, design mitigation, guidelines, and best management practices. Optimizing alternatives and design mitigation allow for the avoidance of negative effects, and is the most effective form of mitigation. For example, minimizing the clearing of old growth forests minimizes the impacts to functions that these areas provide. If project design requires removal old growth forests, then active mitigation activities are employed to reduce the impacts to soils and water, and revegetation strategies are employed to allow for the establishment of an appropriate ecological trajectory.

Avoidance of effects to ecosystem and vegetation VCs will be empathized at all times during Construction, Operations, Closure and Reclamation, and Post-Closure. Examples of mitigation by avoidance includes designs of the Access and Haul roads that minimize new disturbance to reduce effects on adjacent ecosystems, minimizing cuts in ML/ARD material to reduce acidification and contamination of soils and supported ecosystems, avoiding unique features such as wetlands and cliff faces to avoid impacts to unique vegetation communities, and the establishment of flagged exclusions for identified rare plant communities.

Where effects cannot be avoided through design, mitigation measures will be used to reduce the impact of the effects. Such measures include carrying out clearing activities during windows where on-the-ground conditions are such that impacts to soils are minimized, establishing appropriate setbacks and buffers around riparian areas, minimize through dust control the migration of fugitive dust throughout the Project area, establish windbreaks around ecologically valuable soil stockpiles to limit dust deposition, and carrying out inspections and removal of invasive plants.

Mitigation measures that will be employed to minimize or avoid the following potential Project effects on Vegetation and Ecosystem VCs are summarized in Table 15.6-2: Proposed Mitigation Measures and Their Effectiveness and detailed in Chapter 29.26, including:

- Loss and alteration of soil quality and quantity through soil stripping, handling, stockpiling and dust effects;
- Loss of ecosystem function, abundance and/or distribution through surface clearing
- Alteration of ecosystem function, abundance, and/or distribution through dust effects, fragmentation, edge effects, and invasive plant introduction;
- Loss of known occurrences of rare plants or lichens and/or habitat through surface clearing; and
- Alteration of known occurrences of rare plants or lichens or habitat through edge effects, dust deposition and introduction and spread of invasive plants.

15.6.3 Environmental Management and Monitoring Plans

Effects to ecosystem abundance, distribution, and ecosystem function will be avoided and minimized through a Vegetation and Ecosystems Management Plan (VEMP; Volume 5, Chapter 29).

The purpose of the VEMP is to provide environmentally responsible, realistic, and operationally feasible guidance for management for Vegetation and Ecosystems VCs during the Construction, Operation, and Closure and Reclamation Phases of the proposed Project.

The VEMP provides guidance for Vegetation and Ecosystems VCs identified during IDM’s consultation efforts with local, regional, provincial, and federal regulators, Aboriginal Groups, stakeholders, and the public.

The VEMP is coordinated with the following applicable management plans (Chapter 29) to avoid and minimize effects to Vegetation and Ecosystems VCs:

- Reclamation and Closure Plan (Chapter 5);
- Air Quality and Dust Management Plan;
- Aquatic Effects Management and Response Plan;
- Erosion and Sediment Control Plan;
- Terrain and Soil Management Plan; and
- Wildlife Management Plan.

Monitoring will identify which mitigation approaches are effective and also identify inadequacies in specific methods or management. Monitoring the success or failure of the measures will assist in identification of opportunities for responsive management to emerging negative trends.

Adaptive management principles and strategies will be implemented in the event that original predictions of effects and mitigation effectiveness are not as expected. Adaptive management will include consideration of monitoring results, management reviews, incident investigations, shared traditional or local knowledge, new or improved scientific methods, regulatory changes, or other Project-related changes. Mitigation and monitoring strategies for Vegetation and Ecosystem VCs will be updated to maintain consistency with management plans and best management practices that may become available during the life of the Project. Key stakeholders, Aboriginal Groups, and government agencies will be involved, as appropriate, in developing effective strategies and additional mitigation measures.

15.6.4 Effectiveness of Mitigation Measures

The anticipated effectiveness of mitigation measures to minimize adverse effects is evaluated and classified as follows within this section:

- Low effectiveness: Proposed measure is experimental, or has not been applied in similar circumstances.

- Moderate effectiveness: Proposed measure has been successfully implemented, but perhaps not in a directly comparable situation.

- High effectiveness: Proposed measure has been successfully applied in similar situations.

- Unknown effectiveness: Proposed measure has unknown effectiveness because it has not been implemented elsewhere in a comparable project or environment.

The key measures proposed for mitigating potential effects on the Vegetation and Ecosystem VCs, along with mitigation effectiveness and uncertainty are outlined in Table 15.6-2. This table also identifies the residual effects that will be carried forward for residual effects characterization and significance determination.

In general, mitigation measures have moderate (i.e., the effect is moderately changed) or high (i.e., the effect is practically eliminated) effectiveness ratings. Optimizing alternatives and design mitigation are measures that are immediately effective in reducing the effects to Vegetation and Ecosystem VCs while BMPs may or may not have an associated time lag between implementation and effectiveness. Restoration activities take time to mitigate the effects to Vegetation and Ecosystem VCs.

The proposed mitigation measures include standard measures that are known to be effective (based on relevant/applicable experience with other mining projects), and therefore the uncertainty associated with their use is low. Any uncertainty associated with the effectiveness of the proposed mitigation measures will be addressed through the Vegetation and Ecosystem Management Plan (Volume 5, Chapter 29). If monitoring indicates that effectiveness of mitigation measures is lower than predicted, further mitigation may be required as per adaptive management strategies outlined in the Vegetation and Ecosystem Management Plan.

Table 15.6-2: Proposed Mitigation Measures and Their Effectiveness

VC/IC	Potential Effects	Mitigation Measures	Rationale	Applicable Phase(s)	Effectiveness[1]	Uncertainty[2]	Residual Effect
Ecologically Valuable Soil	Loss and alteration of soil quality and quantity through soil stripping, handling, stockpiling, and dust effects	The design of the Access Road and Haul Road has been optimized to minimize the distance travelled, which will reduce dust associated with Construction and Operation	Reduces the loss and alteration of soil quantity and quality	Construction, Operation, Closure and Reclamation	Moderate (Proposed measures will minimize effect over the short, medium, and long term; however, losses will still occur)	Moderate (Setting realistic reclamation goals that take into consideration the ecology of the area will improve the likelihood of reinstating ecosystem function over time)	Yes
		The design of the Access Road optimizes the utilization of the existing forestry road to avoid and minimize new disturbance.					
		The clearing of soils will be minimized to the extent possible, and avoided where practicable, for unique features identified by Qualified Environmental Professionals (QEPs), including exposed bedrock and cliffs					
		Minimize cut-and-fill in areas with ML/ARD potential. Where possible, organic soils will be salvaged and stored separately from mineral soils.					
		Soil handling procedures will be developed specific to sensitive ecosystems. High quality soils will be identified and stockpiled.	Development of ecosystem-specific measures will allow for focused effects reduction. Stockpiling of valuable soil allow for better planning during reclamation				
		Implement ecosystem-based revegetation and progressive reclamation promptly to minimize erosion potential and to facilitate initiation of successional ecological processes					
		Conduct regular inspections to ensure drainage, erosion, and sediment control measures are effective and functioning properly; all necessary repairs and adjustments will be conducted in a timely manner	Regular inspections allows for corrective actions which will reduce impacts of sediments to stream course				
Alpine and Parkland Ecosystems; Old Growth and Mature Forested Ecosystems; Floodplains and Wetlands Ecosystems; BC CDC Listed Ecosystems	Loss of ecosystem function, abundance and/or distribution through surface clearing	The clearing of vegetation will be minimized to the extent possible, and avoided where practicable, for unique features identified by QEPs, including wetlands, exposed bedrock, cliffs etc., which often provide high-value habitat to wildlife and may support sensitive vegetation communities and growth forms.	Minimizing vegetation clearing will reduce the effects on the VCs	Construction, Operation, Closure and Reclamation	Moderate (Proposed measures will minimize effect over the short, medium, and long term; however, losses will still occur)	Moderate (Setting realistic reclamation goals that take into consideration the ecology of the area will improve the likelihood of reinstating ecosystem function over time)	Yes
		The design of the Access Road optimizes the utilization of the existing forestry road to avoid and minimize new disturbance.					
		The area of landscape disturbance will be minimized and ecosystem-based revegetation and progressive reclamation will occur promptly to minimize erosion potential, introduction of invasive plants, and to facilitate initiation of successional ecological processes.					

VC/IC	Potential Effects	Mitigation Measures	Rationale	Applicable Phase(s)	Effectiveness[1]	Uncertainty[2]	Residual Effect
Alpine and Parkland Ecosystems; Old Growth and Mature Forested Ecosystems; Floodplains and Wetlands Ecosystems; BC CDC Listed Ecosystems	Loss of ecosystem function, abundance and/or distribution through surface clearing	Revegetation will be undertaken with seeds (and/or plants) suitable for the local ecosystem and during the appropriate growing season and conditions to: 1) ensure maximum survival rate; 2) avoid establishment of invasive species; and 3) facilitate the establishment of ecological functions and their associated attributes (e.g. species diversity and productivity).	Development of ecosystem-specific measures will allow for focused effects reduction. This approach helps establishment of an ecological trajectory that is suitable for the area	Construction, Operation, Closure and Reclamation, Post-closure	High (implementation time will vary – implementation is rapid for revegetation to control soil erosion and exclude invasive species; the development of ecological functions occurs over decades	Moderate (Setting realistic reclamation goals that take into consideration the ecology of the area will improve the likelihood of reinstating ecosystem function over time)	No
		Objectives of closure plans for reclaimed areas will be developed to establish site conditions that allow for realistic and operationally feasible ecological trajectories and that take into consideration ecosystem function and wildlife habitat objectives.					
		Monitoring of reclaimed areas will be conducted periodically to ensure they are revegetated.	This allows for the measurement of vegetation establishment				
Alpine and Parkland Ecosystems		Ecosystem-specific soil handling procedures will be developed. High-quality soils will be identified and stockpiled when required.	Separating high quality soils allows for better use of these soils during reclamation	Construction, Closure and Reclamation	Moderate (Tailored handling procedures will minimize some of the key issues, such as a reduction in chemical, physical, and biological properties of soil; however due to the sensitive nature of alpine and parkland soils, some effects will remain).	Low	Yes
Old Growth and Mature Forested Ecosystems		Construction activities will be conducted in accordance with the guidelines outlined in the Wildlife Management Plan to ensure minimal risk to old growth and mature forest wildlife habitat, such adhering to sensitive periods, specific guidelines, and applicable legislation for wildlife species of concern that use old growth and mature forests.	Development of ecosystem-specific measures will allow for focused effects reduction	Construction, Closure and Reclamation	Moderate: the effectiveness of avoiding new disturbance to ecosystem abundance and extent through optimization measures is high; however, there is low confidence that reclamation efforts can restore the structure and function associated with old and mature forest ecosystems to a level similar to that of baseline condition in the long term.	Low	Yes
		Manage forests according to the *Forest and Range Practices Act* (FRPA) silviculture requirements and BMPs.	IDM is committed to lawful operation of the Project. Adhering to FRPA requirements will ensure compliance		High	Low	
Floodplain and Wetland Ecosystems		Reduce effects to terrestrial ecosystems that depend on hydrological connectivity and flow through management by ensuring free passage of water through fill materials (i.e., using free-span bridges or culverts).	Maintaining existing hydrological regimes is important for maintaining baseline ecosystems	Construction, Operation, Construction and Reclamation	High	Low	Yes (only to the BC CDC Listed floodplain ecosystems)
		Soil handling procedures will be developed specific to sensitive ecosystems. High-quality soils will be identified and stockpiled.	Separating high value soil from less valuable or unsuitable soil allows for more effective restoration				
		Retain roots and groundcover where possible to maintain slope stability and prevent surface erosion.	This allows for soil retention				

VC/IC	Potential Effects	Mitigation Measures	Rationale	Applicable Phase(s)	Effectiveness[1]	Uncertainty[2]	Residual Effect
Floodplain and Wetland Ecosystems	Loss of ecosystem function, abundance and/or distribution through surface clearing	Reduce erosion potential by conducting sensitive work during periods of low runoff to the extent possible.	This allows for soil retention	Construction, Operation, Construction and Reclamation	High	Low	Yes (only to the BC CDC Listed floodplain ecosystems)
		Riparian areas will be managed per the legislated reserve and/or management zone setbacks and work practices established under FRPA, where feasible.	IDM is committed to lawful operation of the Project. Adhering to FRPA requirements will ensure compliance				
BC CDC Listed Ecosystems		Soil handling procedures will be developed specific to sensitive ecosystems. High-quality soils will be identified and stockpiled.	Development of ecosystem-specific measures will allow for focused effects reduction.	Construction, Operation, Closure and Reclamation	Moderate (The effectiveness of avoiding BC CDC listed ecosystems through the communication and delineation of no-work zones around these ecosystems is high; however, BC CDC listed ecosystems will not be avoided altogether so the overall effectiveness is considered moderate).	Low	Yes
		Communicate the location of BC CDC listed ecosystems to ground crews.	Staff training and awareness are key components of many of IDM's management plans.				
		Conduct pre-construction surveys to delineate relevant boundaries of the BC CDC listed ecosystems.					
		Delineate "no work" zones and/or buffers around BC CDC listed ecosystems, where feasible.					
Alpine and Parkland Ecosystems; Old Growth and Mature Forested Ecosystems; Floodplains and Wetlands Ecosystems; BC CDC Listed Ecosystems	Alteration of ecosystem function, abundance, and/or distribution through dust effects, fragmentation, edge effects, and invasive plant introduction	The Vegetation and Ecosystems Management Plan will be implemented and will include the following measures where practicable: conduct pre-construction invasive plant surveys within the Project footprint to determine the presence/absence of invasive plants; remove existing invasive plant populations to prevent the spread to adjacent areas; and establish an early detection, inventory, control, and monitoring and follow up program in accordance with Provincial guidance (i.e., FLNRO 2017) and expert recommendations.	Development of ecosystem-specific measures will allow for focused effects reduction. Addressing invasive plants through survey and removal limits effects to sensitive ecosystems	Construction, Operation, Closure and Reclamation	Moderate (Preventive measures and early detection systems are effective in terms of avoiding introduction and spread of invasive plants in most cases; however, an efficient early detection plan needs trained personnel with clear accountabilities and a sustained long-term commitment to preventing invasive plant introduction and spread)	Low	No
		Appropriate setback and buffer distances from surface water bodies and riparian features will be implemented and maintained.					
Alpine and Parkland Ecosystems	Alteration of ecosystem function, abundance, and/or distribution through dust effects, fragmentation, edge effects, and invasive plant introduction	Minimize deposition of fugitive dust in alpine ecosystems through adherence to the Air Quality and Dust Management Plan	Reducing the source of the potential effect minimizes the potential effect. Minimizing dust limits potential negative effects to alpine and parkland ecosystems.	Operation	High	Low	No

VC/IC	Potential Effects	Mitigation Measures	Rationale	Applicable Phase(s)	Effectiveness[1]	Uncertainty[2]	Residual Effect
Ecologically Valuable Soil	Alteration of ecosystem function, abundance, and/or distribution through dust effects, fragmentation, edge effects, and invasive plant introduction	Implement ecosystem-based revegetation and progressive reclamation promptly to minimize introduction of invasive plants and to facilitate initiation of successional ecological processes.	Development of ecosystem-specific measures will allow for focused effects reduction. Revegetation with suitable vegetation limits the negative effects of invasive plants.	Construction, Operation, Closure and Reclamation	Moderate (Any time soil is moved and disturbed there will be some loss to soil quality. This loss of soil quality is dependent on inherent soil characteristics as well as moisture levels at the time of salvage/disturbance. If salvage occurs under ideal moisture conditions and the soil has a high sand content, degradation is minimal. If fine textured soils are moved when wet, degradation can be substantial). The re-establishment of ecological functions associates with alpine ecosystems in areas that have been disturbed will occur over several decades.	Low	Yes
		Strip and stockpile soil for future reclamation.	Proactive treatment and handling is more effective than post-hoc reclamation.				
		Minimize the number of times soil is moved.					
		Salvage and store organic soils separately from mineral soils, where possible.					
Old Growth and Mature Forested Ecosystems		Construction activities will be conducted in accordance with the guidelines outlined in the Wildlife Maagement Plan to ensure minimal risk to old growth and mature forest wildlife habitat, such as adhering to sensitive periods, specific guidelines, and applicable legislation for wildlife species of concern that use old growth and mature forest.	Development of ecosystem-specific measures will allow for focused effects reduction. Minimizing disturbance limits negative effects.	Construction, Operation, Closure and Reclamation	Moderate: the effectiveness of avoiding new disturbance to ecosystem abundance and extent through optimization measures is high; however, there is low confidence that reclamation efforts can restore the structure and function associated with old growth and mature forest ecosystems to a level similar to that of baseline condition in the long term.	Low	Yes
		Manage forests according to the *Forest and Range Practices Act* (FRPA) silviculture requirements and BMPs	IDM is committed to lawful operation of the Project.		High	Low	
Floodplain and Wetland Ecosystems		Appropriate setback and buffer distances from surface water bodies and riparian features will be implemented and maintained.	Development of ecosystem-specific measures will allow for focused effects reduction. Appropriate buffers reduces negative effects.	Construction, Closure and Reclamation	Moderate to High (The effectiveness of mitigation is moderate to high as most effects to wetland ecosystems will be avoided and minimized through adherence to the established protection measures outlined in the Project management plans. The effectiveness of avoiding effects to wetland ecosystems that depend on hydrological connectivity and flow is moderate as hydrological connectivity can be difficult to determine depending on the site characteristics.)	Low	Yes (only to the BC CDC Listed floodplain ecosystems)
		Riparian areas will be managed per the legislated reserve and/or management zone setbacks and work practices established under FRPA, where feasible.	IDM is committed to lawful operation of the Project.				
		All vehicles and machinery travel will be restricted to designated road surfaces.	Reducing the source of the potential effect minimizes the potential effect. Traffic confined to designated roadways limits soil degradation.				
BC CDC Listed Ecosystems		Manage riparian areas per the legislated reserve and/or management zone setbacks and work practices established under the FRPA.	IDM is committed to lawful operation of the Project.	Construction, Closure and Reclamation	High	Low	Yes

VC/IC	Potential Effects	Mitigation Measures	Rationale	Applicable Phase(s)	Effectiveness[1]	Uncertainty[2]	Residual Effect
Rare Plants, Lichens, and Associated Habitats	Loss of known occurrences of rare plants or lichens and/or habitat through surface clearing.	Apply adaptive Project design changes that avoid harm to rare plant and lichen populations, where practicable.	Reducing the source of the potential effect minimizes the potential effect.	Construction, Operation, Closure and Reclamation, Post-closure	High	Moderate (Potential alteration through surface clearing of adjacent areas and dust deposition may have effects on rare plants and lichens beyond our current understanding. Many rare plant and lichens and their specific abiotic and biotic requirements are not well understood)	Yes
		Conduct pre-construction rare plant surveys to delineate the rare plant/lichen habitat.	Improving quality of baseline data allows for better mitigation by excluding rare plant populations from development activity.				
		Avoid surface disturbance in areas with known rare plant and lichen populations.	Reducing the source of the potential effect minimizes the potential effect.				
		Avoid use of all herbicide sprays within 200 m of rare plant and lichen populations and limit such use to direct application rather than broadcast sprays.					
		Create exclusion zones around rare plant and lichen habitats to minimize effects related to surface clearing, fugitive dust, and invasive plant introduction.					
		Erect temporary fencing or other barriers around the nearby rare plant and lichen populations to avoid further disturbance to the site where avoidance is not feasible and development is permitted within buffer areas around plant populations.					
		Minimize deposition of fugitive dust on rare plant and lichen populations through adherence to the Air Quality and Dust Management Plan.					
		Ensure that a qualified environmental monitor, capable of identifying rare plants and lichens, is on site (at the clearing location) during vegetation-clearing activities in known rare plant habitat.	Regular monitoring allows for proactive solutions.				

VC/IC	Potential Effects	Mitigation Measures	Rationale	Applicable Phase(s)	Effectiveness[1]	Uncertainty[2]	Residual Effect
Rare Plants, Lichens, and Associated Habitats	Alteration of known occurrences of rare plants or lichens or habitat through edge effects, dust deposition and introduction and spread of invasive plants	Avoid use of all herbicide sprays within 200 m of rare plant and lichen populations and limit such use to direct application rather than broadcast sprays.	Reducing the source of the potential effect minimizes the potential effect. These collective mitigation measures reduce direct negative effects to rare plants and lichens, and associated habitat	Closure, Operation, Closure and Reclamation	High	Moderate (Effectiveness will vary among species)	Yes
		Apply dust suppression measures (i.e., wetting work areas, roads, and storage piles, installing equipment covers, and using dust hoods and shields).					
		Apply water to roads to minimize dust from ore and waste rock haulage and grading.					
		Install windbreaks or fences around known problem areas or stockpiles to limit the dispersion of dust emissions from equipment and stockpiles.					
		Design and manage stockpiles and storage areas to minimize dust emissions.					

[1]Effectiveness: Low = measure unlikely to result in effect reduction; Moderate = measure has a proven track record of partially reducing effects; High = measure has documented success (e.g., industry standard; use in similar projects) in substantial effect reduction

[2]Uncertainty: Low = proposed measure has been successfully applied in similar situations; Moderate = proposed measure has been successfully implemented, but perhaps not in a directly comparable situation; High = proposed measure is experimental, or has not been applied in similar circumstances.

15.7 Residual Effects Characterization

15.7.1 Summary of Residual Effects

Management and mitigation measures will help avoid and minimize adverse effects to Vegetation and Ecosystems VCs; however, direct and indirect effects cannot be fully mitigated and thus loss and/or alteration of Ecologically Valuable Soils, Alpine and Parkland Ecosystems, Old Growth and Mature Forested Ecosystems, Floodplain and Wetland Ecosystems, BC CDC Listed Ecosystems, and Rare Plants, Lichens, and Associated Habitat are expected.

15.7.2 Methods

The characterization of residual adverse effects on Vegetation and Ecosystems VCs were informed by changes to the ICs of soil quality and soil quantity and evaluated in relation to the measurement indicators of ecosystems abundance, distribution, and function.

15.7.2.1 Residual Effects Criteria

Residual effects were characterized in terms of magnitude, geographical extent, duration, frequency, reversibility, and context according to the definitions provided in Table 15.7-1.

Table 15.7-1: Characterization of Residual Effect on Vegetation and Ecosystems VCs

Criteria	Characterization with VC
Magnitude	• **Negligible (N)**: no detectable change from baseline conditions. • **Low (L)**: differs from the average value for baseline conditions but remains within the range of natural variation and below a guideline or threshold value. • **Moderate (M)**: differs substantially from the average value for baseline conditions and approaches the limits of natural variation but equal to or slightly above a guideline or threshold value. • **High (H)**: differs substantially from baseline conditions and is significantly beyond a guideline or threshold value, resulting in a detectable change beyond the range of natural variation.
Geographical Extent (Biophysical)	• **Discrete (D)**: effect is limited to the Project area. • **Local (L)**: effect is limited to the LSA. • **Regional (R):** effect extends beyond the LSA but within the RSA. • **Beyond regional (BR):** effect extends beyond the RSA.
Duration	• **Short-term (ST):** effect lasts less than 18 months (during the Construction Phase of the Project). • **Long-term (LT):** effect extends beyond the life of the Project (encompassing Operation, Closure and Reclamation, and Post-Closure Phases). • **Permanent (P)**: effect will continue in perpetuity.

Criteria	Characterization with VC
Frequency	• **One time (O):** effect is confined to one discrete event. • **Sporadic (S):** effect occurs rarely and at sporadic intervals. • **Regular (R):** effect occurs on a regular basis. • **Continuous (C):** effect occurs constantly.
Reversibility	• **Reversible (R):** effect can be reversed. • **Partially reversible (PR):** effect can be partially reversed. • **Irreversible (I):** effect cannot be reversed, is of permanent duration.
Context	• **High (H):** the receiving environment or population has a high natural resilience to imposed stresses and can respond and adapt to the effect. • **Neutral (N):** the receiving environment or population has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect. • **Low (L):** the receiving environment or population has a low resilience to imposed stresses and will not easily adapt to the effect.

15.7.2.2 Assessment of Likelihood

Likelihood refers to the probability of the predicted residual effect occurring (Table 15.7-2). The likelihood of residual effects occurring was assessed prior to the determination of significance following EAO guidance (EAO 2013). Likelihood has not been considered in the determination of significance as per the Canadian Environmental Assessment Agency guidance (1994; discussed in Volume 3, Chapter 6); that is, the likelihood of an effect has not been considered in determining its significance.

Table 15.7-2: Attributes of Likelihood

Likelihood Rating	Quantitative Threshold
High	> P80 (effect has > 80% chance of effect occurring)
Moderate	P40 - P80 (effect has 40-80% chance of effect occurring)
Low	< P40 (effect has < 40% chance of effect occurring)

15.7.2.3 Significance Determination

The evaluation of significance was completed by comparing predicted residual effects against thresholds, standards, trends, or objectives relevant to Vegetation and Ecosystems VCs, as defined below.

- Not significant (NS): Residual effects have low or moderate magnitude; local to regional geographic extent; short- or medium-term duration; could occur at any frequency; and are reversible or partially reversible within the life of the Project. The receiving environment or population has a neutral to high natural resilience to imposed stresses and is expected to respond and adapt to the effect. The effects on the VC are either indistinguishable from background conditions (i.e., occur within the range of natural variation as influenced by physical, chemical, and biological processes) or distinguishable at the individual level. Land and resource management plan objectives will likely be met, but some management objectives may be impaired.

- Significant (S): Residual effects have high magnitude; regional or beyond regional geographic extent; long-term or permanent duration; and can occur at all frequencies. Residual effects on VCs are consequential (i.e., structural and functional changes in populations, communities, and ecosystems are predicted) and are irreversible. The receiving environment has low resilience to imposed stress and is not expected to respond and adapt to the effect. The ability to meet land and resource management plan objectives is impaired.

15.7.2.4 Confidence and Risk

Confidence is the level of certainty associated with the evaluation and characterization of residual effects. Confidence is a measure of the reliability of data inputs, the analytical methods used to predict residual effects, the confidence regarding the effectiveness of mitigation measures, and the certainty of the predicted outcomes. Confidence ratings are based on the definitions described in Volume 3, Chapter 6 and shown in Table 15.7-3.

Table 15.7-3: Confidence Ratings and Definitions

Confidence Rating	Quantitative Threshold
High (H)	There is a good understanding of the cause-effect relationship between the Project and a VC, and all necessary data are available to support the assessment. The effectiveness of the selected mitigation measures is moderate to high. There is a low degree of uncertainty associated with data inputs and/or modelling techniques, and variation from the predicted effect is expected to be low. Given the above, there is high confidence in the conclusions of the assessment.
Moderate (M)	The cause-effect relationships between the Project and a VC are not fully understood (e.g., there are several unknown external variables or data for the Project area are incomplete). The effectiveness of mitigation measures may be moderate or high. Modelling predictions are relatively confident. Based on the above, there is a moderate confidence in the assessment conclusions

Confidence Rating	Quantitative Threshold
Low (L)	Cause-effect relationships between the Project and a VC are poorly understood. There may be several unknown external variables and/or data for the Project area is incomplete. The effectiveness of the mitigation measures may not yet be proven. Modelling results may vary considerably given the data inputs. There is a high degree of uncertainty in the conclusions of the assessment.

15.7.3 Potential Residual Effects Assessment

15.7.3.1 Ecologically Valuable Soils-Loss

15.7.3.1.1 Residual Effect Analysis

The maximum area of soil lost under the Project footprint before reclamation and other forms of mitigation will be equal to 209.3 ha, which represents 21.9 % of the PFSA and 2.2% of the LSA. This amount includes a buffer of 50 m around proposed Project components in order to account for potential changes in the Project footprint. It is estimated that 69.8 ha (one third of the lost soil) of this will be reclaimed. Reclamation is considered to be moderately successful at mitigating effects to soils that result in lost material. This material is expected to recover a significant portion of its original ecological function and fertility, as much of this material is in the early stages of pedogenesis and has not developed mature soil functions at the time of disturbance. The recovery period is expected to take several decades before the soils return to baseline biological functions. Given mitigation measures, it is expected that the Project will result in the permanent loss of 139.5 ha of soil.

15.7.3.1.2 Residual Effects Characterization

The permanent loss of soil on 139.5 ha is a detectable change beyond the baseline conditions, but is within the range of natural variation, and is characterized as a moderate magnitude (Table 15.7-4). This characterization is due to the environment within which the Project is situated, which is highly active with respect to soil loss due to recent deglaciation. While the geographic extent of this effect is discrete (limited to the immediate area of the Project surface facilities) it is expected that the duration of the land loss will be long-term (effects last more than 22 years). Loss of Ecologically Valuable Soils is expected to influence the measurement indicator of ecosystem function in areas where soils are stripped for construction and/or reclamation. The loss will occur sporadically, mostly occurring during Project Construction but also during the Closure and Reclamation Phase. The effect is considered irreversible, as the soils under the footprint of infrastructure remaining after closure (e.g. TMF footprint) will be permanently lost. The context is neutral, as the environment has the ability to adapt to the effect, and as many ecosystems within the PFSA and LSA are developing in areas with little to no soil. The estimated amount of soil lost will not affect the ability of the receiving environment to adapt and function; rather the areas subject to lost soils will develop pioneer seral ecosystems, which commonly occur within the PFSA and LSA.

Table 15.7-4: Characterization of Residual Effect of the Loss of Ecologically Valuable Soils

Criteria	Characterization for Soil Quantity
Magnitude	Moderate (M)
Geographical Extent	Discrete (D)
Duration	Long Term (LT)
Frequency	Sporadic (S)
Reversibility	Irreversible (I)
Context	Neutral (N)

15.7.3.1.3 Assessment of Likelihood

The likelihood of soil loss within the Project Footprint is high (more than 80%). There will be some additional soil loss within the areas immediately adjacent to infrastructure; however, it is unlikely the total estimated amount of soil loss will occur. The 150 m buffer was selected as the zone of potential influence in order to provide for small changes in the Project design.

15.7.3.1.4 Confidence

There is a good understanding of the relationship between the Project activities and the soil loss, and all necessary data, including mapping data, soil pit data, and lab data are available to support the assessment. The effectiveness of the selected mitigation measures are moderate as the proposed measures will minimize unnecessary effects to Ecologically Valuable Soils over the short-, medium-, and long-term; however, losses will still occur. Furthermore, setting realistic reclamation goals that take into consideration the ecology of the area will improve the likelihood of reinstating ecosystem function over time. There is a low degree of uncertainty associated with collected data and modelling. Thus, there is high confidence in the conclusions of the assessment.

15.7.3.2 Ecologically Valuable Soils-Alteration

15.7.3.2.1 Residual Effect Analysis

It is likely that, due to difficulty of monitoring of a wide range of soil characteristics, certain aspects of soil quality alteration will either remain undetected or will not be adequately mitigated within the Project life. Examples of residual effects include:

- Fugitive dust;
- Declining soil quality in stockpiles;
- Soil compaction;
- Degradation of soil structure due to handling; and
- Changes in soil moisture and nutrient regimes within reclaimed soils.

In total, there are 580.6 ha of Ecologically Valuable Soils that may be subject to some level of alteration. This represents 60.4% of the PFSA and 6.2% of the LSA. The vast majority of this is due to fugitive dust, as the fugitive dust zone of influence was set at 150 m. This is highly conservative, as dustfall did not exceed AAQA standards at any location within the PFSA. As well, the highest levels of dustfall were confined to sections of the Access Road.

15.7.3.2.2 Residual Effects Characterization

Project activities have the potential to alter 580.6 ha of Ecologically Valuable Soils. The alteration of 580.6 ha of soil is a detectable change beyond the baseline conditions, but the amount of alteration is very close to natural background levels (given that dust levels are approaching background levels during operations) thus the alteration is characterized as a low magnitude. While the geographic extent of this effect is discrete (limited to the immediate area adjacent to Project surface facilities) it is expected that the duration of the soil alteration will be long-term (effects last more than 22 years). The alteration is continuous, as the alteration is mostly due to vehicle traffic dust which will occur throughout the life of the Project. The effect is considered reversible as, due to natural process, soils will recover over time from alteration. The context is low as the environment has the ability to adapt to the effect (Table 15.7-5).

Table 15.7-5: Characterization of Residual Effect of the Alteration of Ecologically Valuable Soils

Criteria	Characterization for Soil Quality
Magnitude	Low (L)
Geographical Extent	Discrete (D)
Duration	Long Term (LT)
Frequency	Continuous (C)
Reversibility	Partially reversible (PR)
Context	Low (L)

15.7.3.2.3 Assessment of Likelihood

The likelihood of soil alteration is high (more than 80%). While it is likely that there will be some soil alteration due to Project activities, as the size of the Project footprint was enlarged in order to allow for design changes, it is not likely that the Project will expand fully into the buffer. Thus alteration effects will be lower than estimated.

15.7.3.2.4 Significance Determination

Potential Project residual effects on Ecologically Valuable Soils are considered not significant. The Project is not expected to result in significant changes to soil quality or quantity within the LSA. Project effects are limited in nature, occurring within and adjacent to proposed Project components, and are not expected to affect the assessment endpoint of ecological conditions that support Vegetation and Ecosystems relative to current conditions within the LSA. Project effects will not compromise vegetation-related land-use objectives identified within the NSSRMP.

15.7.3.2.5 Confidence

There is a good understanding of the relationship between the Project activities and soil alteration, and data are available to support the assessment. The effectiveness of the selected mitigation measures ranges from moderate to low. There is a low degree of uncertainty associated with collected data and modelling. Thus, there is high confidence in the conclusions of the assessment.

15.7.3.3 Alpine and Parkland Ecosystems

15.7.3.3.1 Residual Effect Analysis

Loss and alteration of Alpine and Parkland Ecosystems is expected to be a residual effect because of the time required to restore ecosystem function and extent to a level similar to that of baseline conditions (Frank and del Moral 1986; Forbes 1995; Forbes, Ebersole, and Strandberg 2001; BC Reg. 375/96).

15.7.3.3.2 Residual Effects Characterization

The magnitude of residual effects will range from negligible to high depending on the specific effect (e.g., dust deposition vs. surface clearing). Overall the magnitude will be moderate. Residual effects will be discrete in extent, occurring predominantly within the footprint of the Haul Road and Quarry and within the areas immediately adjacent to these components.

Residual effects are expected to occur over the long-term to permanent and be continuous in nature until the point at which the interactions between microbes, soils, and vegetation re-stabilize. Effects will be partially reversible through the progressive ecology-based reclamation (Table 15.7-6).

The context for Alpine Ecosystems is low. Cool temperatures and short growing seasons restrict growth to several months of the year, which limits the biological processes that facilitate pedogenesis. Thus, soil development is very slow, compared to lower elevations where soils are warmer for longer periods. Since many plant species are excluded from alpine areas due to the effects of freezing temperatures and high winds, organic input from litter-fall can be quite low. This impeded soil development and low organic matter inputs result in the slow mineralization of base cations from parent material, resulting in nutrient-poor and weakly buffered soils. Such conditions result in increased sensitivity to disturbance, such as compaction, salvage, and acidification due to combustion of fuel by diesel engines. Generally speaking, alpine soils take a long time to develop productive capacity; due to the nature of their development, they take a correspondingly long duration of time to recover to a productive state.

Table 15.7-6: Characterization of Residual Effect on Alpine and Parkland Ecosystems

Criteria	Characterization for Alpine and Parkland Ecosystems
Magnitude	Overall Moderate (M), ranging from Negligible (N) to High (H)
Geographical Extent	Discrete (D)
Duration	Long Term (LT) to Permanent (P)
Frequency	Continuous (C)
Reversibility	Partially Reversible (PR)
Context	Low (L)

15.7.3.3.3 Assessment of Likelihood

There is a high likelihood that effects to Alpine and Parkland Ecosystems will occur. Clearing activities associated with the construction of the Haul Road and Quarry, in particular, will result in the loss or alteration of alpine ecosystem function at the site level.

15.7.3.3.4 Significance Determination

Potential Project residual effects on Alpine and Parkland Ecosystems are considered not significant. The Project is not expected to result in significant changes to the measurement indicators of distribution, abundance, or function of ecosystems or the assessment endpoint of the biological, physical, chemical, or ecological conditions that support Alpine and Parkland Ecosystems within the LSA. Project effects are limited in nature, occurring within and adjacent to proposed Project components, are not expected to affect the viability of the resource relative to baseline conditions within the LSA, and will not compromise vegetation-related land use objectives identified within the NSSRMP.

15.7.3.3.5 Confidence

There is a high to moderate level of confidence in the analysis of potential residual effects to Alpine and Parkland Ecosystems as the effects of surface clearing on Alpine and Parkland Ecosystems and soils are relatively well understood. Some uncertainty exists in relation to the specific effects of surface clearing on the recovery of soil bacterial diversity and structure, for example, which has implications for vegetation community development and overall success of progressive reclamation efforts (Li et. al. 2014).

Alpine areas within the PFSA were mapped at 1:5,000 scale, which provides further confidence in the accuracy of the mapping compared to mapping conducted at a larger scale.

15.7.3.4 Old Growth and Mature Forested Ecosystems

15.7.3.4.1 Residual Effect Analysis

Loss and alteration of Old Growth and Mature Forested Ecosystems is expected to be a residual effect because of the time required to restore ecosystem function to a level similar to that of baseline conditions.

The nature and rate of forest recovery may depend on several components, including the magnitude of disturbance, presence of biological legacies, and inherent productivity of the site (Johnson, 1996; Franklin et al., 2002; Chen et al., 2009; Ilisson and Chen, 2009a). Different disturbances contrast markedly in terms of biological legacies (Franklin et al., 2007), and forests faced with repeated perturbations tend to be less resilient (Payette and Delwaide, 2003). Rates of forest change following disturbances may ultimately depend on multiple interacting factors, such as disturbance history, pre-disturbance stand conditions, local site factors, regional species pool, and species life histories, among others (Foster et al., 1998; Harper et al., 2005; Mansuy et al., 2012; Girard et al., 2014).

It is widely acknowledged that disturbance severity determines the type of post-disturbance vegetation growing at a site (Johnstone and Kasischke, 2005; Ilisson and Chen, 2009a; Veilleux-Nolin and Payette, 2012), which may lead to different woody vegetation recovery patterns (Carleton and MacLellan, 1994). Frequency of disturbance is also important to forest vegetation recovery.

15.7.3.4.2 Residual Effects Characterization

The magnitude of the residual loss and alteration of ecosystem function, abundance, and distribution of Old Growth and Mature Forested Ecosystems ranges from negligible to moderate (Table 15.7-7). The magnitude varies based on the intensity of the effect (e.g., stand clearing versus invasive plant introduction) and the ability of the specific receiving environment to withstand or recover from the change. The Project will have a limited effect on the measurement indicators of overall abundance and distribution of old and mature ecosystems within the LSA.

The Project will affect 125 ha of the PFSA (25.7 ha loss and 99.3 ha of potential alteration) accounting for 7.6% (1.6% loss and up to 6.0% alteration) of the old growth and mature forests that occur in the LSA. The effects of loss will be limited to the Project area (i.e., discrete), but are considered permanent in nature due to the time required for disturbed areas to return to mature and old forest stages. The frequency of ecosystem loss and alteration will be continuous until the point at which the ecosystems reach an equilibrium where edge effect, for example, lessens due to emergence of additional vegetation. The loss of Old Growth and Mature Forested Ecosystems is considered irreversible. The alteration of Old Growth and Mature Forested Ecosystems through restoration and reclamation activities is considered partially reversible in the long-term. Old growth forests in particular have low resilience in terms of adapting to the effects of the Project based on the time required for disturbed forests to recover.

Table 15.7-7: Characterization of Residual Effect on Old Growth and Mature Forested Ecosystems

Criteria	Characterization for Old Growth and Mature Forested Ecosystems
Magnitude	Negligible (N) to Moderate (M)
Geographical Extent	Discrete (D)
Duration	Permanent (P)
Frequency	Continuous (C)
Reversibility	Partially Reversible (PR) to Irreversible (I)
Context	Low (L)

15.7.3.4.3 Assessment of Likelihood

There is a high likelihood that residual effects to Old Growth and Mature Forested Ecosystems will occur. Clearing activities associated with the construction of the TMF and Quarry, in particular, will result in the loss or alteration of Old Growth and Mature Forested Ecosystems at the site level.

15.7.3.4.4 Significance Determination

Potential Project residual effects on Old Growth and Mature Forested Ecosystems are considered not significant. Project effects are limited in nature and occur within and adjacent to proposed Project components. The Project is not expected to result in considerable changes to the measurement indicators of distribution, abundance, or function of ecosystems or the assessment endpoint of biological, physical, chemical, or ecological conditions that support Old Growth and Mature Forested Ecosystems within the LSA. The Project is also not expected to affect the viability of the resource relative to baseline conditions within the LSA.

15.7.3.4.5 Confidence

There is a high level of confidence clearing activities will result in loss of Old Growth and Mature Forested Ecosystems. Uncertainty exists with respect to the extent and degree of alteration due to edge effects, dust deposition, and invasive plants, as well as the resiliency of the ecosystem to withstand potential changes (Sturtevant et al. 2014).

Old Growth and Mature Forested Ecosystems within the PFSA were mapped at 1:5000 scale, which provides further confidence in the accuracy of the mapping compared to mapping conducted at a larger scale. Some uncertainty remains, as not all polygons within the PFSA were field-checked at survey intensity level 3.

15.7.3.5 BC CDC Listed Ecosystems

15.7.3.5.1 Residual Effect Analysis

Loss and alteration of BC CDC Listed Ecosystems is expected to be a residual effect due to clearing activities associated with construction. Potentially affected ecosystems include 06 - Act - Red-osier dogwood – mid-bench floodplain (CD) and the 05 - Ss - Salmonberry - high bench floodplain (SS). Effects to BC CDC Listed Ecosystems will be minimized through site-level Project design; it is unlikely that these ecosystems will be avoided altogether based on the current location of the existing forestry road and on the existing terrain.

15.7.3.5.2 Residual Effects Characterization

The Project is expected to decrease the measurement indicator of abundance of the vegetation community within the BC CDC Listed Ecosystems. Changes to the assessment endpoint of physical ecological conditions will occur due to surface clearing activities. The magnitude of residual effects will range from negligible to high depending on the specific effect (e.g., dust vs. surface clearing; Table 15.7-8). Residual effects will be discrete in extent, occurring predominantly within the footprint of the Quarry, Borrow, and Access Road and within the areas immediately adjacent to these components.

Residual effects are expected to be long-term to permanent, as it is unknown if future conditions will support the plant association that is Blue-listed by the CDC. The effect is expected to be continuous in nature until the point at which the site contains plant species endemic to mid- and high-bench floodplains. Depending on the severity of the effect and the specific attributes of the receiving environment, the effect is expected to be partially reversible to irreversible.

The receiving mid- and high-bench floodplain environment is expected to have a neutral context as these ecosystems are comprised largely of sandy substrates that are resilient to disturbance and are expected to adapt to the effect.

Table 15.7-8: Characterization of Residual Effects on BC CDC Listed Ecosystems

Criteria	Characterization for BC CDC Listed Ecosystems
Magnitude	Negligible (N) to High (H)
Geographical Extent	Discrete (D)
Duration	Long-term (LT) to Permanent (P)
Frequency	Continuous (C)
Reversibility	Partially Reversible (PR) to Irreversible (I)
Context	Neutral (N)

15.7.3.5.3 Assessment of Likelihood

There is a high likelihood that effects to BC CDC Listed Ecosystems will occur based on the location of these ecosystems in relation to the design and proposed activities of the Project.

15.7.3.5.4 Significance Determination

Project-related effects on BC CDC Listed Ecosystems are considered not significant due to the limited extent of the loss, the discrete nature of the effect, and the absence of guidelines or threshold values.

15.7.3.5.5 Confidence

There is a high level of confidence clearing activities will result in the loss of BC CDC Listed ecosystems. Uncertainty exists with respect to the magnitude of the effect due to the number of possible pathways and interactions involved and whether future conditions will support the plant association listed by the CDC.

15.7.3.6 Rare Plants, Lichens, and Associated Habitat

15.7.3.6.1 Residual Effect Analysis

Loss or alteration of known occurrences of rare plants and lichens could occur as a result to the clearing activities at the proposed Process Plant, Access Road, and Haul Road.

15.7.3.6.2 Residual Effects Characterization

The magnitude of the residual effects will range from negligible to high depending on the final design and activities of the Project and on the effectiveness of the prevention measures (Table 15.7-9). These species are often highly habitat-specific with low resiliency to habitat loss or alteration, invasive alien species, changes in ecological dynamics or natural processes, and disturbance (BC MOE 2013).

Rare plants and lichens represent at-risk components of regional, provincial, federal, or global biodiversity and thus the geographical extent is beyond regional.

The frequency of the effect will range from one-time to continuous. The duration of the effect will vary from short-term to permanent.

In an ecological context, rare plants and lichens have low resiliency to change in part because they can have limited dispersal ability, poor recruitment or reproduction, population fluctuations, inbreeding, and/or restricted ranges.

Table 15.7-9: Characterization of Residual Effect on Rare Plants, Lichens, and Associated Habitat

Criteria	Characterization for Rare Plants, Lichens, and Associated Habitat
Magnitude	Negligible (N) to High (H)
Geographical Extent	Beyond Regional (BR)
Duration	Short term (ST) to permanent (P)
Frequency	One time (OT) to Continuous (C)
Reversibility	Partially Reversible (PR) to Irreversible (I)
Context	Low (L)

15.7.3.6.3 Assessment of Likelihood

There is a moderate level of likelihood that residual effects to rare plants and lichens will occur based on the design of the Project. The current knowledge on the effects of disturbance on the species that may be lost or altered is sparse. Thus, uncertainty exists with respect to the likelihood that residual effects to rare plants and lichens will occur.

15.7.3.6.4 Significance Determination

Project effects on rare plants and lichens are considered not significant. The Project is not expected to result in the measurement indicators of a loss or alteration of rare plans and lichens and will not affect the assessment endpoint of biodiversity relative to current conditions due to the proposed mitigation measures namely the creation of exclusion zones around rare plant and lichen populations. Follow up monitoring will be conducted to verify the results of this assessment, to characterize the site conditions and existing plant and lichen populations, and to track potential Project related changes to these populations. This information will be used to inform management and monitoring and to improve upon the current understanding of plant and lichen response to anthropogenic disturbance.

15.7.3.6.5 Confidence

The overall confidence rating is moderate; the accuracy of the data collection is high based on the qualification of the botanists; however, uncertainty exists with respect to the final location of Project components and the response of each plant or lichen to the predicted disturbance.

15.7.4 Summary of Residual Effects on Vegetation and Ecosystems VCs

Table 15.7-10 presents a summary of the residual effects assessment.

Table 15.7-10: Summary of the Residual Effects Assessment for Vegetation and Ecosystems VCs

Residual Effect (Measurement Indicators)	Valued Component	Project Phase(s)	Mitigation Measures	Summary of Residual Effects Characterization *(context, magnitude, geographic extent, duration, frequency, reversibility)*	Likelihood *(High, Moderate, Low)*	Significance *(Significant, Not Significant)*	Confidence *(High, Moderate, Low)*
Loss of Ecologically Valuable Soils	Ecologically Valuable Soils	Construction Operation Closure and Reclamation	See Table 15.6-2	Context: Neutral Magnitude: Moderate Geographic Extent: Discrete Duration: Long-Term Frequency: Sporadic Reversibility: Irreversible	High	Not Significant	Moderate
Alteration of Ecologically Valuable Soils	Ecologically Valuable Soils	Construction Operation Closure and Reclamation	See Table 15.6-2	Context: Low Magnitude: Low Geographic Extent: Discrete Duration: Long-Term Frequency: Continuous Reversibility: Partially Reversible	High	Not Significant	High
Loss and alteration of ecosystem abundance, distribution, and/or function	Alpine and Parkland Ecosystems	Construction Operation Closure and Reclamation	See Table 15.6-2	Context: Low Magnitude: Moderate Geographic Extent: Discrete Duration: Long-Term to Permanent Frequency: Continuous Reversibility: Partially Reversible	High	Not Significant	Low to Moderate

Residual Effect (Measurement Indicators)	Valued Component	Project Phase(s)	Mitigation Measures	Summary of Residual Effects Characterization *(context, magnitude, geographic extent, duration, frequency, reversibility)*	Likelihood *(High, Moderate, Low)*	Significance *(Significant, Not Significant)*	Confidence *(High, Moderate, Low)*
Loss and alteration of ecosystem abundance, distribution, and/or function	Old Growth and Mature Forested Ecosystems	Construction Operation Closure and Reclamation	See Table 15.6-2	Context: Low Magnitude: Moderate Geographic Extent: Discrete Duration: Permanent Frequency: Continuous Reversibility: Partially Reversible to Irreversible	High	Not Significant	Moderate
Loss and alteration of ecosystem abundance, distribution, and/or function	BC CDC Listed Ecosystems	Construction Operation Closure and Reclamation	See Table 15.6-2	Context: Neutral Magnitude: Negligible to High Extent: Discrete Duration: Long-Term to Permanent Frequency: Continuous Reversibility: Partially Reversible to Irreversible	High	Not Significant	Moderate
Loss or alteration to known occurrences	Rare Plants, Lichens, and Associated Habitat	Construction Operation Closure and Reclamation	See Table 15.6-2	Context: Low Magnitude: Negligible to High Extent: Beyond Regional Duration: Short Term to Permanent Frequency: One time to Continuous Reversibility: Partially Reversible to Irreversible	Moderate to High	Not Significant	Moderate

15.8 Cumulative Effects Assessment

Cumulative effects are the result of a Project-related residual effect interacting with the effects of other projects or activities to produce a combined effect. Cumulative effects are assessed as required by EAO (2013).

The method for conducting a Cumulative Effects Assessment (CEA) generally follows the same steps as the Project-specific effects assessment; however, there is a greater reliance on qualitative methods due to the broader-scale nature of the assessment. The approach to assessing cumulative effects comprises the following steps:

1. Review the residual effects for each VC.
2. Identify potential cumulative effects.
3. Identify any additional mitigation measures, beyond those identified for each VC and IC.
4. Prepare a Project activity/residual effect interaction matrix.
5. Determine if the interaction will result in a cumulative effect in addition to the residual, Project-specific effect.
6. If a cumulative effect is determined:
    a. The effect is characterized by magnitude, geographic extent, duration, frequency, reversibility, and context.
    b. The significance of the cumulative effect is determined.
    c. The likelihood, confidence, and risk of the cumulative effect are identified.

15.8.1 Review of Residual Effects

Residual effects for Ecologically Valuable Soils, Alpine and Parkland Ecosystems, Old Growth and Mature Forest Ecosystems, and BC CDC Listed Ecosystems were carried forward from the Project-specific assessment to be considered in combination with the residual effects of past and future human actions, where some spatial and temporal overlap occurs.

The residual effects on Rare Plants, Lichens, and Associated Habitats were not carried forward into the CEA as there is no overlap between the relevant species and projects within the RSA.

Spatial and/or temporal overlap of residual effects of the Project coupled with the residual effects of past, present, and future infrastructure and human actions are termed cumulative effects and can occur in the following ways:

- Physical-chemical transport – A physical or chemical constituent is transported away from the action under review where it then interacts with another action.
- Nibbling loss – The gradual disturbance and loss of land and habitat.
- Spatial and temporal crowding – Cumulative effects can occur when too much is happening within too small an area and in too brief a period of time. A threshold may be exceeded and the environment may not be able to recover to pre-disturbance conditions.
- Synergistic – Combined effects along a pathway that collectively result in an increased effect that may not have existed if the effect occurred in isolation.
- Additive – Combined effects along a pathway that equal the sum of the individual effects.
- Growth-inducing – Each new action can induce further actions to occur.

15.8.2 Cumulative Effects Assessment Boundaries

15.8.2.1 Spatial Boundaries

The CEA boundary is the RSA delineated for the baseline studies. The RSA boundary provides context for the type, abundance, distribution, and extent of ecosystem VCs within the region. This boundary represents the area beyond which effects of the Project are expected to cumulatively interact with effects of other projects.

15.8.2.2 Temporal Boundaries

The temporal boundaries for the assessment of cumulative effects on wildlife encompass the periods during which the proposed Project-related residual effects are expected to interact with residual effects of other past, present, or reasonably foreseeable future projects and activities. The following temporal boundaries are evaluated as part of each CEA:

1. Past: 1988 to 2014 (includes projects that are active and ones that are inactive);
2. Present: 2014 to 2017, from the start of the Project's detailed baseline studies to the completion of the effects assessment; and
3. Foreseeable Future: The cut-off date for incorporating any new future developments in the CEA is 2029. This represents the final anticipated year of the mine life after the Closure and Reclamation Phase is complete.

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

The list of past, present and reasonably foreseeable projects and/or activities for consideration in the CEA was compiled from a variety of information sources, including municipal, regional, provincial and federal government agencies, and company websites (Volume 3, Chapter 6).

The following development categories were considered in the Application:

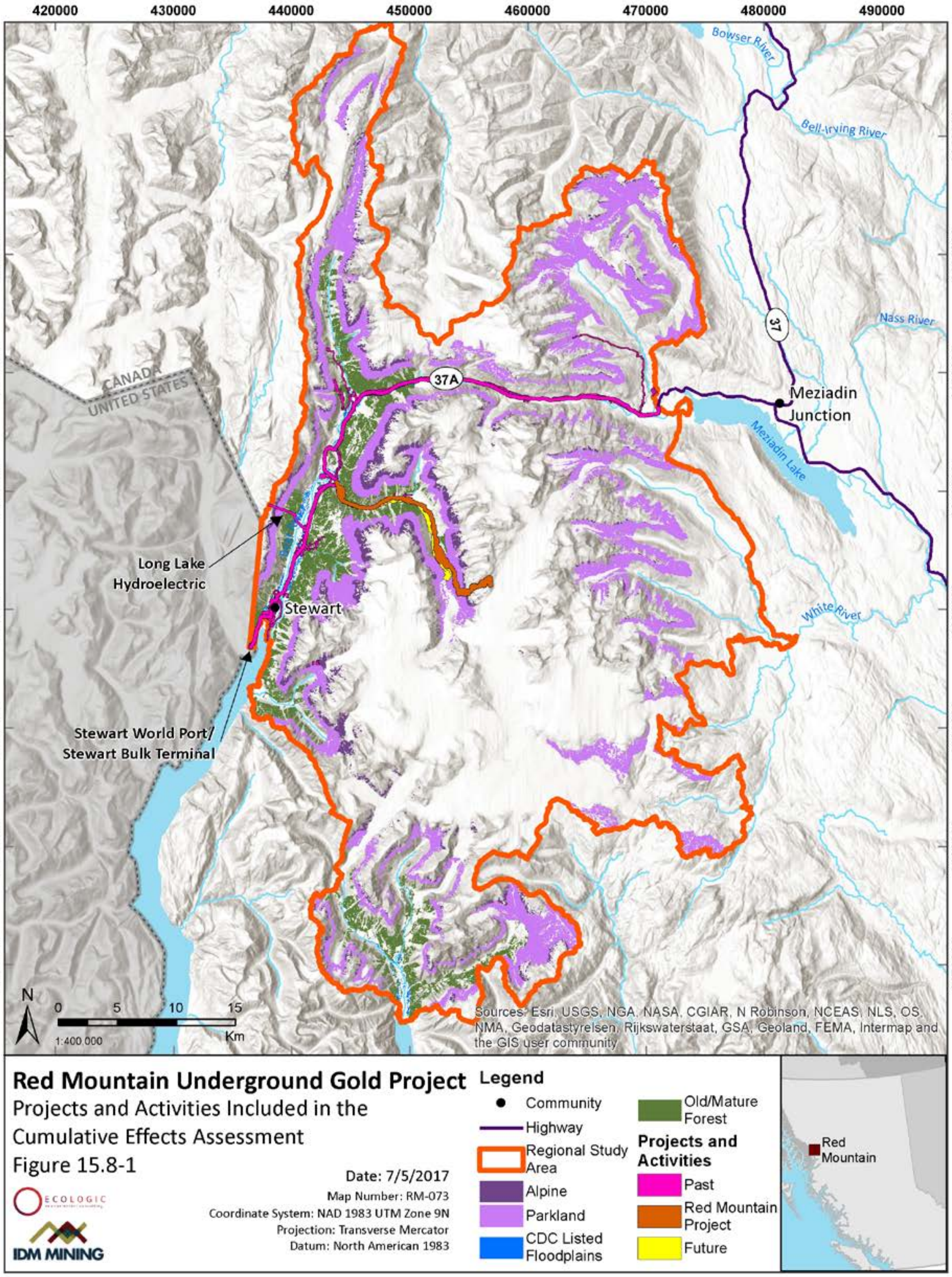
- Certain (past and present): Projects or activities that have already been built or conducted for which the environmental effects overlap with those of the proposed Project (i.e. certain); and
- Reasonably foreseeable: Projects that are either proposed (public disclosure) or have been approved to be built, but are not yet built, for which the environmental effects overlap the proposed Project.

Table 15.8-1: Past, Present and Reasonably Foreseeable Projects and Activities presents a summary of the projects and activities identified within the RSA for the cumulative effects analysis; Figure 15.8-1 illustrates the distribution and abundance of VCs relative to the Project and cumulative projects and activities. The complete disturbance footprint was not available for all identified projects and activities, particularly forestry.

Table 15.8-1: Past, Present and Reasonably Foreseeable Projects and Activities

Project/Activity	Project Life	Location	Proponent	Potential Cumulative Effect (Y/N)
Stewart Bulk Terminals	Currently Operating	Stewart	Stewart Bulk Terminals Ltd.	N
Stewart World Port	Currently Operating	Stewart	Stewart World Port	Y
Highway 37A	Ongoing	Stewart	MOTI	Y
Long Lake Hydroelectric Project	Currently Operating	25 km east of Stewart	Long Lake Hydro Inc.	Y
Bitter Creek Hydroelectric Project	Proposed	15 km northeast of Stewart	Bridge Power	Y
Forestry	Ongoing	Regional	Various	Y
Mineral Exploration	Historic	Regional	Various	N
Public Transmission Lines	Ongoing	Regional	BC Hydro	Y
Transportation (excluding Highway 37A)	Ongoing	Regional	Various	Y

Figure 15.8-1: Projects and Activities Included in the Cumulative Effects Assessment



15.8.4 Cumulative Project Interactions and Effects

Four cumulative effects were identified: 1) Nibbling loss, attributable to the incremental loss and alteration of ecosystems due to development infrastructure; 2) Physical-chemical transport, caused by the movement of invasive plants from one area to another; 3) Synergistic effects from clearing that result in edge effects, and 4) Growth-inducing, attributable to infrastructure development, primarily roads.

15.8.5 Cumulative Effects Interaction Matrix

A cumulative effects interaction matrix, summarizing potential cumulative interactions between the residual effect of the Project on VCs and each past, current, and foreseeable future projects is presented in Table 15.8-2: .

Table 15.8-2: Interaction with Effects of other Past, Present, or Reasonably Foreseeable Future Projects and Activities

Residual Effects of the Project on IC(s) or VC(s)	Past Projects and Activities							Future Projects and Activities
	Forestry	Transportation (excluding Hwy 37A)	Public Transmission Lines	Highway 37A	Long Lake Hydroelectric Project	Stewart Bulk Terminals	Stewart World Port	Bitter Creek Hydroelectric Project
Ecologically Valuable Soils	Y	Y	N	N	Y	N	N	Y
Alpine and Parkland Ecosystems	N	Y	N	N	Y	N	N	Y
Old Growth and Mature Forest Ecosystems	Y	Y	Y	Y	Y	N	N	Y
BC CDC-listed Ecosystems (floodplains)	Y	Y	Y	Y	Y	N	Y	Y

Notes:
Y = Yes, interaction exists between the residual effect of the Project and the other past, current, or future project/activity
N = No, interaction does not exist between the residual effect of the Project and the other past, current, or future project/activity

15.8.5.1 Residual Cumulative Effects Assessment

Past projects include Stewart Bulk Terminals, Stewart World Port, Long Lake Hydroelectric Project, Highway 37A, BC Hydro transmission line, and various old roads, cut blocks, and transportation quarries. The Bitter Creek Hydroelectric Project is the only known future project in the RSA. All historic mines present in the RSA finished operations before 1988 and were not included in the assessment. Highway 37A included a 150-m buffer to include potential effects (consistent with the approach used for the Project components). All other past and future projects were buffered by 50 m to account for past or present alterations. Where buffers overlapped, the Highway 37A buffer was given precedence, and then equal weights were given to the other buffered features to eliminate any overlaps. The buffered area was then overlain on the PEM to generate a list of predicted ecosystem units that have been or may be disturbed. From that, the area of each VC was calculated (Table 15.8-3) and used for the cumulative assessment process.

The PFSA was assessed independently; the future effects for Bitter Creek Hydroelectric and historic roads that fell within the PFSA were included in the Project effects and not for future or historic effects. For all evaluated VCs, the total hectares of cumulative effects were based on the same BEC subzone and ecosystem units as present in the PFSA to present comparable results. The analysis used the PEM mapping, in conjunction with Vegetation Resource Inventory (VRI) data, to determine the VC distribution and abundance in the RSA. The cumulative effects footprint (excluding the Project) was created using all available information regarding past, current, and future projects, as well as provincial TRIM data (roads, etc.). Additional known features were digitized in ArcGIS using a variety of orthomosaic and satellite imagery.

Table 15.8-3: Summary of Cumulative Effects for Vegetation and Ecosystems VCs in relation to Past, Present, and Future Activities

VC		Past (ha)	Project Loss and Alteration (ha)	Future (ha)	Total Loss and Degradation/Alteration (ha)	RSA Total (ha)[1]	Cumulative RSA Change (%)	Prov. (ha)[2]	Prov. (%)
Ecologically Valuable Soils		2,414	720	0	3134	115,352	2.7	-	-
Alpine Ecosystems		14	45	0	59	5,517	1.1	-	-
Parkland Ecosystems		19	163	59	240	31,621	0.8	-	-
Old and Mature Forest Ecosystems		219	125	13	357	9,764	3.7	-	-
BC CDC-Listed Ecosystems (Floodplains)	**CD**	57	23	0.4	80	166	48.2	4,158	1.9
	SS	135	44	1	180	464	38.9	-	-

[1] This area represents the vegetated ecosystems within the RSA.
[2] Provincial data only available for the CD ecosystem.

15.8.5.2 Potential Cumulative Mitigation Measures

Potential cumulative effects to Vegetation and Ecosystems can be minimized through strategic planning, data sharing, and coordinated planning with communities, government, and other proponents to ensure that current land use patterns, as well as historical and current cultural values are considered in a meaningful and effective way. Additional mitigation measures include:

- Utilization of existing infrastructure;
- Education and training opportunities that focus on identification and reporting of notable unforeseen Project effects;
- Submission of rare plant and ecosystem data to the BC CDC to inform the rank status of at risk plants and ecosystems at the regional level;
- Coordination of Project activities at the landscape level that takes into consideration other projects' activities and effects, where possible and relevant; and
- Effective data collection, storage, and reporting standards that follow standard protocols to increase the potential for useful data sharing opportunities and informed landscape level planning.

15.8.5.3 Cumulative Effects - Ecologically Valuable Soils

Loss and alteration of Ecologically Valuable Soils are expected result in a residual cumulative effect because reclamation activities associated with the various projects within the RSA were either limited, or unlikely to restore soils to baseline conditions. Unlike the residual effects characterization, the loss and alteration cumulative effects are assessed together as it is not feasible, given the resolution of information available, to separate effects to soil quantity and soil quality.

15.8.5.3.1 Characterization of Cumulative Residual Effects on Ecologically Valuable Soils

The total cumulative effect of past, present and future projects on Ecologically Valuable Soils is 3,134.1 ha. Regionally, this constitutes loss or alteration of 2.7% of soils within the RSA. For the purposes of this assessment, all areas within the RSA were considered to have functional soils, with the exception of bedrock, ice, and water features.

The Project will represent a loss/alteration of 720.1 ha loss of Ecologically Valuable Soils which represents 23.0% of the total contribution of 2.7%.

The magnitude of the cumulative residual effects on Ecologically Viable Soils is low. Cumulative residual effects are not expected to have a notable change on soil distribution or abundance. Effects to soils are expected to occur at the site level within the relevant Project footprints and adjacent areas and are expected to subside over time.

The changes to soils are considered long-term to permanent depending on the soil type and the level of effort invested in reclamation activities and follow up. Loss is considered a regional effect because each project contributes to the incremental loss of the resource at a regional scale, which may also influence the way in which these ecosystems are used. Frequency of effects is difficult to quantify, as this will vary between projects and is based on the proposed or historic activities and on the effect itself. Most effects are expected to occur continuously during Project development, after which they may occur sporadically. The majority of soils have low resiliency to disturbance, as they develop over the long-term. As a result, they have limited ability to adapt to changes that extend beyond typical edaphic conditions.

15.8.5.3.2 Likelihood of Cumulative Residual Effects on Ecologically Valuable Soils

There is a high likelihood of loss and alteration of Ecologically Valuable Soils within the RSA based on the spatial footprints and likely activities associated with historic, present, and proposed developments.

15.8.5.3.3 Significance of Cumulative Residual Effects on Ecologically Valuable Soils

The loss and alteration of Ecologically Valuable Soils due to the incremental reduction of the resource is considered not significant because CEA effects are not expected to influence the assessment endpoint of ecological conditions of other VCs, and are not expected to affect any of the vegetation-related objectives within the NSSRMP at any scale.

15.8.5.3.4 Confidence of Cumulative Residual Effects on Ecologically Valuable Soils

The confidence of the characterization of residual effects and the determination of significance is medium. There is high level of confidence that effects to Ecologically Valuable Soils have occurred and will continue to occur as resource development continues in the region. However, uncertainty exists regarding the type, extent, and severity of the changes to the function of Ecologically Valuable Soils due to the absence of spatial data and reported effects.

15.8.5.4 Cumulative Effects - Alpine and Parkland Ecosystems

Loss and alteration of Alpine and Parkland Ecosystems is expected to be a residual cumulative effect because reclamation activities associated with the various projects within the RSA were either limited, or unlikely to restore ecosystem function and extent comparable to baseline conditions. The restoration success of each alpine ecosystem is influenced by the magnitude and extent of the disturbance in relation to the local edaphic conditions (Chapin III and Shaver 1985; Forbes, Ebersole, and Strandberg 2001; Urbanska and Chambers 2002). In addition, the level of investment in reclamation varies depending, in part, on the regulatory standards and priorities at the time of development (Errington 2001, Ministry of Energy, Mines and Petroleum Resources 2007).

15.8.5.4.1 Characterization of Cumulative Residual Effects on Alpine and Parkland Ecosystems

The total cumulative effect of past, present and future projects on Alpine and Parkland Ecosystems is 59 ha and 240 ha, respectively. Regionally, this constitutes loss or alteration of 1.1% of alpine ecosystems and 0.8% of parkland ecosystems within the RSA.

The Project will represent a loss/alteration of 45.4 ha (loss [9.0 ha] and alteration [36.4 ha]) of alpine ecosystems and 163 ha (loss [33.4] and alteration [129.2]) parkland ecosystems, which represents 0.6% of the total contribution.

The magnitude of the cumulative residual effects on ecosystem abundance, distribution, and function is low. Cumulative residual effects are not expected to have a notable change on alpine and parkland distribution or abundance. Alpine and Parkland Ecosystems occur in high elevation areas throughout the RSA. Of this, CEA effects will remove a small portion of the available alpine and parkland ecosystems present within the region. Effects to ecosystem function are expected to occur at the site level within the relevant Project footprints and adjacent areas and are expected to subside over time.

The changes to ecosystem function are considered long-term to permanent depending on the ecosystem type and the level of effort invested in reclamation activities and follow-up. Loss is considered a regional effect because each project contributes to the incremental loss of the resource at a regional scale, which may also influence the way in which these ecosystems are used (see Volume 3, Chapter 16). Frequency of effects is difficult to quantify, as this will vary between projects and is based on the proposed or historic activities and on the effect itself. Most effects are expected to occur continuously until a new steady state is reached, at which time they may occur sporadically. The majority of alpine and many parkland ecosystems have low resiliency to disturbance. These ecosystems develop in response to harsh environmental conditions and to soils with low nutrients. As a result, they have limited ability to adapt to changes that extend beyond their natural range of variation.

15.8.5.4.2 Likelihood of Cumulative Residual Effects on Alpine and Parkland Ecosystems

There is a high likelihood of loss or alteration to Alpine and Parkland Ecosystems within the RSA based on the spatial footprints and likely activities associated with historic, present, and proposed developments.

15.8.5.4.3 Significance of Cumulative Residual Effects on Alpine and Parkland Ecosystems

The loss and alteration of Alpine and Parkland Ecosystems due to the incremental reduction of the resource is considered not significant because CEA effects are not expected to influence the measurement indicators of abundance, distribution, or function to an extent that would alter the ecological conditions that support alpine and parkland vegetation and are not expected to affect any of the vegetation-related objectives within the NSSRMP at any scale.

15.8.5.4.4 Confidence of Cumulative Residual Effects on Alpine and Parkland Ecosystems

The confidence of the characterization of residual effects and the determination of significance is medium. There is high level of confidence that effects to Alpine and Parkland Ecosystems have occurred and will continue to occur as resource development continues in the RSA. However, uncertainty exists regarding the type, extent, and severity of the changes to the function of Alpine and Parkland Ecosystems due to the absence of spatial data and reported effects.

15.8.5.5 Cumulative Effects - Old Growth and Mature Forested Ecosystems

15.8.5.5.1 Characterization of Cumulative Residual Effects on Old Growth and Mature Forested Ecosystems

Loss and alteration of Old Growth and Mature Forested Ecosystems due to clearing, fragmentation, and edge effects are considered a low magnitude effect because effects account for less than 4% of the Old Growth and Mature Forested Ecosystems mapped within the RSA. The effects are expected to occur at a regional level with the greatest extent of effects occurring as a result of historic development within the region. The effects are considered permanent for old-forest ecosystems and partially reversible for mature forest ecosystems. Effects are predicted to occur both sporadically (e.g., windthrow) and continuously (e.g., fragmentation and edge effects) until the point of site stabilization. Forested ecosystems have low to high resiliency to the aforementioned effects depending on the degree of the disturbance and the receiving environment.

The potential introduction and spread of invasive plants is considered a low-magnitude effect because the effect is limited in extent, occurring predominantly along roadsides within the RSA. However, the magnitude of the effect will vary depending on the invasive plant species and the resiliency of the specific ecosystems affected at the site level. The effect is expected to occur at a regional level, with higher frequency in the lower elevation areas (in comparison to the alpine areas) due to the amount of traffic associated with Hwy 37A, which acts as a mechanism for dispersion.

15.8.5.5.2 Likelihood of Cumulative Residual Effects on Old Growth and Mature Forested Ecosystems

There is a high likelihood of cumulative residual effects to Old Growth and Mature Forested Ecosystems within the RSA based on the historic and reasonably foreseeable future projects and activities due to clearing activities, which will result in alteration of the soil characteristics that support these ecosystems.

15.8.5.5.3 Significance of Cumulative Residual Effects on Old Growth and Mature Forested Ecosystems

The alteration of Old Growth and Mature Forested Ecosystems due to clearing, fragmentation, edge effects, alteration of hydrology, and the potential introduction and spread of invasive plants within the region is considered not significant because any effects to the abundance, distribution, or function of the ecosystems are limited and considered within a range of natural variation that could be remediated over time. Loss and alteration of Old Growth and Mature Forested Ecosystems will occur at the regional level but will not affect the viability of the ecological conditions that support Old Growth and Mature Forested Ecosystems within the RSA.

15.8.5.5.4 Confidence of Cumulative Residual Effects on Old Growth and Mature Forested Ecosystems

The confidence in the analysis is moderate as the old and mature structural stage information was obtained from old VRI data and PEM modelling. Although the precise abundance and extent of Old Growth and Mature Forested Ecosystems is not known, the combination of PEM and VRI is a reasonable estimate to determine cumulative effects.

15.8.5.6 Cumulative Effects - BC CDC-Listed Ecosystems

15.8.5.6.1 Characterization of Cumulative Residual Effects on BC CDC-Listed Ecosystems

The Blue-listed CWHwm 06 mid-bench floodplain ecosystem (CD) has equivalent ecosystems described in 12 CWH subzones and one Coastal Douglas-Fir subzone (BC CDC 2017a). It occurs on river floodplains from Vancouver Island north along the coast of BC (BC CDC 2017a). The CD ecosystem has been mapped 32 times in the province (covering 3,992 ha), with no element occurrences (EOs) within the RSA and the closest mapped EO located southwest of Terrace (BC CDC 2017d). It likely occurs in numerous other areas along large- and medium-sized rivers throughout the coast of BC, as few other floodplain ecosystems are described in the area. The BC CDC indicates that it likely occurs on 100 to 500 km^2 of the province as of 2010 (CDC 2017b). In the RSA, it was predicted through the PEM to occur in less than 0.1% of the RSA, occupying approximately 166 ha. Combined with the BC CDC mapped EOs, there is at least 4,158 ha of CD ecosystems known to occur in the province.

The Blue-listed CWHwm 05 high-bench floodplain ecosystem (SS) is only known to occur on the north coast of BC in a single BEC subzone. The BC CDC does not currently have any EOs mapped in the province, nor do they provide any estimate of extent (BC CDC 2017c). Similar to the CD, it likely occurs on many of the medium and large rivers on the north coast, but has yet to be mapped by the BC CDC. In the RSA, it was predicted though the PEM to occur in 0.1% of the RSA, occupying approximately 464 ha.

The effects assessment found that the Project will result in a loss of 5.5 ha and alteration of 17.2 ha of the CD ecosystem and a loss of 9.6 ha and alteration of 34.8 ha of the SS ecosystem. Of that, 5.2 ha of loss and 14.1 ha of CD alteration, and 7.3 ha of loss and 21.6 ha of SS alteration will occur in shrub, pole sapling, or young forests, with the remainder mature and old growth forests. This indicates that the majority of the CD and SS ecosystems that will be affected by the Project are either in early stages of ecosystem establishment or in various stages of post-disturbance regeneration.

An analysis of past, present and future projects within the RSA indicates that 192 ha of the two listed ecosystems (57 ha of CD and 13 ha of SS) have been disturbed or are potentially influenced (within the 50- or 150-m buffers) by past and ongoing projects and activities. The majority of this area occurs within the Highway 37A corridor. An additional 0.4 ha of CD and 1.0 ha of SS may be affected by future projects other than the Project. The total cumulative effect (loss and alteration) on listed ecosystems in the RSA (including the Project) is estimated to be 260 ha or 41.3% of the total mapped area of the two listed ecosystems.

15.8.5.6.2 Likelihood of Cumulative Residual Effects on BC CDC-Listed Ecosystems

There is a high likelihood of cumulative residual effects to BC CDC-Listed Ecosystems within the RSA based on the historic and reasonably foreseeable future projects and activities.

15.8.5.6.3 Significance of Cumulative Residual Effects on BC CDC-Listed Ecosystems

The loss and alteration of the CD ecosystem is considered not significant as the vast majority of the predicted effect is due to a very conservative estimate of alteration (i.e., within a 150-m buffer). The CD ecosystem occurs in 13 BEC subzones across a large geographic area.

Regionally the Project, along with past, present, and future projects will affect up to 166 ha (48.2% of the CD mapped in the RSA); this represents 1.9% of the known provincial abundance of the CD ecosystem (4,158 hectares. In addition, as younger stages of the CD ecosystems are expected to have more effects than older structural stages, the natural recovery time of this ecosystem should result in a return to ecosystems with similar ecological conditions and values within 20 to 50 years (BC CDC 2017b).

The loss and alteration of the SS listed ecosystem is considered not significant. This ecosystem is known to occur in the CWHwm subzone (BC CDC 2017c); in total there is a total of 464 ha of SS mapped in the RSA, with no additional known mapped occurrences outside of the RSA. Although the Project assessment methodology for applying 150-m disturbance buffers resulted in the identification of 180 ha of loss and alteration from past, current, and future projects (representing a potential effect to 38.9% of the known abundance of this ecosystem type), the vast majority of this area is due to a very conservative estimate of alteration. Most of this occurs along HWY 37a, where alteration due to dust does not have the same level of impact as it does with forest roads. There is no information available to determine how the Project will affect the ecosystem province-wide.

15.8.5.6.4 Confidence of Cumulative Residual Effects on BC CDC-Listed Ecosystems

The confidence of the characterization of residual cumulative effects and the determination of not significant is medium. There is high level of confidence that effects to BC CDC-Listed Ecosystems have occurred and will continue to occur as resource development continues in the region. There is insufficient data to fully determine the amount of existing and disturbed BC CDC-Listed Ecosystems at the provincial level. BC CDC mapping is only available for one of the two listed ecosystems, and it does not appear to be comprehensive. As well, the full potential effect of current and past projects and activities on BC CDC-Listed Ecosystems is not fully understood.

15.8.6 Summary of Cumulative Effects Assessment

Table 15.8-4: summarizes the residual cumulative effects, characterization criteria, likelihood, significance determination, and confidence for each evaluated Vegetation and Ecosystem VC.

Table 15.8-4: Summary of Residual Cumulative Effects Assessment

Residual Effect (Measurement Indicators)	Valued Component	Project Phase(s)	Mitigation Measures	Summary of Effects Characterization *(context, magnitude, geographic extent, duration, frequency, reversibility)*	Likelihood *(High, Moderate, Low)*	Significance *(Significant, Not Significant)*	Confidence *(High, Moderate, Low)*
Loss and degradation of Ecologically Valuable Soils	Ecologically Valuable Soils	Construction Operation Closure and Reclamation	See Table 15.6-2	Context: Low Magnitude: Low Geographic Extent: Regional Duration: Long-Term Frequency: Continuous Reversibility: Partially Reversible	High	Not Significant	Moderate
Loss and alteration of ecosystem abundance, distribution, and/or function	Alpine and Parkland Ecosystems	Construction Operation Closure and Reclamation	See Table 15.6-2	Context: Low Magnitude: Low Geographic Extent: Regional Duration: Long-Term Frequency: Continuous Reversibility: Partially Reversible	High	Not Significant	Low to Medium
Loss and alteration of ecosystem abundance, distribution, and/or function	Old Growth and Mature Forested Ecosystems	Construction Operation Closure and Reclamation	See Table 15.6-2	Context: Low Magnitude: Low Geographic Extent: Regional Duration: Permanent Frequency: Continuous Reversibility: Partially Reversible	High	Not Significant	Moderate
Loss and alteration of ecosystem abundance, distribution, and/or function	BC CDC-Listed Ecosystems	Construction Operation Closure and Reclamation	See Table 15.6-2	Context: Low Magnitude: Moderate Extent: Beyond-Regional Duration: Long-Term - Permanent Frequency: Continuous Reversibility: Irreversible	High	Not Significant	Moderate

15.9 Follow-up Program

A follow-up program will be implemented to evaluate the effectiveness of mitigation measures on rare plants and lichens and to verify the accuracy of the predictions made during the Application/EIS. Field surveys will be conducted prior to Construction to characterize the rare plant and lichen population site conditions located within the proposed infrastructure footprint. This information will be used to identify, evaluate, and track Project-related changes to populations over time.

Mitigation and monitoring strategies for Vegetation and Ecosystem VCs will be updated to maintain consistency with best management practices, improved scientific methods, and regulatory changes that may become available during the life of the Project. Key stakeholders, Aboriginal Groups, and government agencies will be involved in developing strategies and additional mitigation as applicable.

15.10 Conclusion

In summary, the Project-related residual effects of loss and/or alteration of ecosystem abundance, distribution and/ or function will result in Not Significant effects on Vegetation and Ecosystem VCs.

A follow-up program will be implemented to evaluate the effectiveness of mitigation measures on Rare Plants, Lichens, and Associated Habitat and to verify the accuracy of the predictions made in this effects assessment.

The Project's residual effects, in combination with the residual effects of past, present, and future projects, will result in Not Significant cumulative effects on Ecologically Valuable Soils, Alpine and Parkland Ecosystems, Old Growth and Mature Forest Ecosystems, and BC CDC-Listed Ecosystems. The residual effects on Rare Plants, Lichens, and Associated Habitats were not carried forward into the CEA as there is no overlap between the relevant species and projects within the RSA.

This chapter is linked to the development of the Screening Level Ecological Risk Assessment (Volume 8, Appendix 22-B) and to the potential effects of other related pathways and VCs including those identified and evaluated in the following chapters:

- Landforms and Natural Landscapes Effects Assessment (Volume 3, Chapter 9);
- Wildlife and Wildlife Habitat Effects Assessment (Volume 3, Chapter 16);
- Fish and Fish Habitat (Volume 3, Chapter 18);
- Air Quality Effects Assessment (Volume 3, Chapter 7);
- Social Effects Assessment (Volume 3, Chapter 20, Section 20.10);
- Tsetsaut Skii km Lax Ha (Volume 4, Chapter 25), Métis Nation BC (Volume 4, Chapter 26), and Nisga'a Nation (Volume 4, Chapter 27).

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