MADRID-BOSTON PROJECT

FINAL ENVIRONMENTAL IMPACT STATEMENT

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Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

Alluvial	Pertaining to the loose, unconsolidated sediments that have been eroded, deposited, and reshaped by water in some form in a non-marine setting. Generally, not applied to deposits when the particular mode of deposition via water is identifiable.
Attribute	Any feature of a vegetation association that is not represented by the site series/vegetation association, site modifier or structural stage. Attributes may either be recorded from fieldwork or inferred by extrapolating features from similar vegetation associations.
CCME	Canadian Council of Ministers of the Environment. CCME is comprised of the environment ministers from the federal, provincial, and territorial governments. These 14 ministers normally meet at least once a year to discuss national environmental priorities and determine work to be carried out under the auspices of CCME. The CCME seeks to achieve positive environmental results, focusing on issues that are national in scope and that require collective attention by a number of governments.
COSEWIC (Committee on the Status of Endangered Wildlife in Canada)	A committee of experts that assesses and designates which species are in some danger of disappearing from Canada.
EA	Environmental Assessment
Ecological amplitude	The limits of environmental conditions within which an organism can live and function.
Ecosystem (terrestrial)	A volume of earth-space that is composed of non-living parts (climate, geologic materials, groundwater, and soils) and living or biotic parts, which are all constantly in a state of motion, transformation, and development. No size or scale is inferred.
Edaphic	Pertaining to soil characteristics, and specifically how these affect living organisms.
EIS	Environmental Impact Statement
ELC	Ecosystem Land Classification
FCIR	False-Colour Infrared
Floodplain	Area of unconsolidated, river-borne sediment in a river valley; subject to periodic flooding.
Fen	Peatlands where groundwater inflow maintains relatively high mineral content within the rooting zone. They are dominated by non-ericaceous shrubs, sedges, grasses, reeds, and brown mosses.

Fibric	Poorly decomposed peat with large amounts of well-preserved fiber readily identifiable as to botanical origin.
Forb	Non-graminoid herbaceous plants.
Habitat	Land and water surface used by wildlife. This may include biotic and abiotic aspects such as vegetation, exposed bedrock, water and topography.
HBML	Hope Bay Mining Limited
Hectare	10,000 m^2 or 0.01 km^2 or 2.47 acres.
Herb	A plant - annual, biennial or perennial - with stems that die back to the ground at the end of the growing season.
Hydric	A qualitative measure of soil moisture that indicates water being removed so slowly that a water table is at or above soil surface during the entire growing season. Organic and gleyed mineral soils are present.
Hydrophilic	Substances that have an affinity for water often because of the formation of hydrogen bonds.
Hygric	A qualitative measure of soil moisture regime that indicates wetter than mesic conditions. Saturation of the soil is limited so that anaerobic soil conditions are transient in the rooting zone.
Hydrodynamic index	And index measuring the magnitude of water vertical fluctuation and lateral flow.
ISSG	Invasive Species Specialist Group
LSA	Local Study Area
Marsh	A shallowly flooded mineral wetland dominated by emergent grass-like vegetation.
Mesic	1. Organic material in an intermediate stage of decomposition where some fibers can be identified as to botanical origin. 2. Medium soil moisture regime where a site has neither excess soil moisture nor a moisture deficit.
Moisture regime	Indicates the available moisture for plant growth in terms of the soil's ability to hold, lose, or receive water. Described as moisture classes from Very Xeric (0) to Hydric (8) (BC Ministry of Environment Lands and Parks and BC Ministry of Forests Research Branch 1998).
NGSWG	National General Status Working Group
NIRB	Nunavut Impact Review Board
NTDB	National Topographic Database

Nutrient regime	Indicates the available nutrient supply for plant growth. Nutrient regime is based on a number of environmental and biotic factors, and is described as classes from Oligotrophic (A) to Hypereutrophic (F) (BC Ministry of Environment Lands and Parks and BC Ministry of Forests Research Branch 1998).
NWT GSRP	Northwest Territories General Status Ranking Program. The program that integrates knowledge from relevant agencies regarding statue of species within the NWT.
Palsa	Palsas are low, often oval, frost heaves occurring in polar and subpolar climates, which contain permanently frozen ice lenses.
PDA	Project Development Area
Peatland	Organic wetlands containing at least 40 cm of peat accumulation on which organic soils (excluding folisols) develop (Warner and Rubec 1997).
Periglacial process	Freezing and thawing processes that drastically modify the ground surface.
Physiognomy	General appearance of an object without reference to its implied characteristics.
Polygon	Delineations that represent discrete areas on a map, bounded by a line on all sides.
Presence/absence surveys	Surveys which rely on visual observations to confirm the presence of the target. These cannot be used in isolation from other statistical techniques to determine the size or absence of a population. They can only be used to confirm the presence of a target species.
Rescan	Rescan Environmental Services Ltd.
Riparian ecosystem	Ecosystems whose structure and species composition is strongly influenced by regular flooding.
RSA	Regional Study Area
SARA	*Species at Risk Act*
Structural stage	Describes the existing dominant stand appearance or physiognomy for a land area. Structural stages range from non-vegetated to old forest.
Submesic	A qualitative measure of soil moisture regime that indicates soil conditions drier than mesic. Water is removed from the soil at a faster rate than supply.
TK	Traditional Knowledge
TK report	Banci, V. and R. Spicker. 2015. Inuit Traditional Knowledge for TMAC Resources Inc. Proposed Hope Bay Project, Naonaiyaotit Traditional Knowledge Project (NTKP). Prepared for TMAC Resources Inc. Kitikmeot Inuit Association: Kugluktuk, NU.

Topography The configuration of a surface, including its relief and the position of its natural and man-made features.

TRIM Terrain Resource Information Management

Tundra An area with permafrost soils which causes trees to be excluded from the landscape due to the edaphic conditions of the rooting zone within the soil.

UTM Universal Transverse Mercator

VEC Valued Ecosystem Component. Those aspects of the environment considered to be of vital importance to a particular region or community, including:

a) resources that are either legally, politically, publically, or professionally recognized as important, such as parks, land selections, and historical sites;
b) resources that have ecological importance; and
c) resources that have social importance.

VSEC Valued Socio-Economic Component. Those aspects of the socio-economic environment considered to be of vital importance to a particular region or community, including components relating to the local economy, health, demographics, traditional way of life, cultural well-being, social life, archaeological resources, existing services and infrastructure, and community and local government organizations.

Vegetation association Defines all sites capable of supporting similar plant communities.

Westroad Westroad Resource Consultants Ltd.

Wetland Land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrotrophic vegetation and various kinds of biological activity which are adapted to a wetland environment (National Wetlands Working Group 1988).

WHIF Wetland Habitat Inspection Form

WKSS West Kitikmeot/Slave Study

8. Vegetation and Special Landscape Features

This chapter presents the existing conditions of terrestrial ecosystems and vegetation for the proposed Madrid-Boston Project (the Project) and identifies and evaluates the potential Project-related effects and cumulative effects on terrestrial ecosystems, landforms, and vegetation within a local and regional context. The assessment is based on information provided in the *Inuit Traditional Knowledge for TMAC Resources Inc. Proposed Hope Bay Project, Naonaiyaotit Traditional Knowledge Project (NTKP)* (Banci and Spicker 2016) and the *Hope Bay Belt Project: 2010 Ecosystems and Vegetation Baseline Report* (Appendix V4-8A).

Terrestrial ecosystems, landforms, and vegetation are included in the application because of their key role in Inuit cultural heritage, as well as the habitat and forage they provide for many Arctic wildlife species and at-risk plant and lichens.

8.1 INCORPORATION OF TRADITIONAL KNOWLEDGE

This section discusses how traditional knowledge (TK) was incorporated in baseline data collection, impact prediction, significance assessment, and the development of mitigation and monitoring programs. It also explores any discrepancies between traditional knowledge and knowledge derived from baseline information collected during scientific studies.

8.1.1 Incorporation of Traditional Knowledge for Existing Environment and Baseline Information

Inuit Traditional Knowledge for TMAC Resources Inc. Proposed Hope Bay Project, Naonaiyaotit Traditional Knowledge Project (NTKP) (Banci and Spicker 2016) (TK report) was reviewed to identify traditional knowledge related to terrestrial ecosystems. The report compiled information from multiple sources including interviews, studies, and workshops dating back to the 1970s with the most recent workshop in 2013. Overall, the report highlights the holistic nature of Inuit knowledge and land use and makes reference to the importance of the land, wildlife, fish, and plants in the vicinity of the Project and regionally.

The report provides a description of traditionally harvested terrestrial plant species and valued ecological resources within the Project area including a reference to locations where resources are harvested as well as cultural and other uses of plant species within the area surrounding the Project. The Socio-economic and Land Use Baseline (Appendix V6-3A) also provide guidance on TK including information on the harvesting of terrestrial plants. Plant harvesting and species that are harvested was identified through a number of focus group meetings with hunters from the Kitikmeot study communities. Plant species reported as consumed for food include cloudberries (*Rubus chamaemorus)*, blueberries (*Vaccinium uliginosum*), crowberries (*Empetrum nigrum*), and bearberries (*Arctostaphylos* spp.), while mountain sorrel (*Oxyria digyna)*, or sweet leaves, were eaten raw or as fresh greens. Plants identified as having medicinal or other cultural value included Labrador tea (*Rhododenron groenlandicum*) and willows (*Salix* spp.). This information informed the collection of plant and lichen species in the area surrounding the Project and assisted in determining the potential effects on harvestable plant resources. The results of the metals assays on vegetation supported the *Human Health and Environmental Risk Assessment* (also discussed in Volume 6, Chapter 5, Human Health and Environmental Risk Assessment; Volume 2, Chapter 2, Traditional Knowledge; and Volume 2, Chapter 3, Public Consultation and Engagement).

The plant species and ecosystems identified in the TK report have been compared to the baseline mapping and field survey data to identify the presence and distribution of these valued resources throughout the study areas (defined in Section 8.2.4.6).

8.1.2 Incorporation of Traditional Knowledge for Valued Environmental Component Selection

The *TK* report (Banci and Spicker 2016) provides information on traditional land use activities in the Kitikmeot region, where the Project is located. This report describes important environmental components and conditions, presents maps showing sacred burial sites, locations of valuable resources, and annual patterns of behaviour of valued animal species.

The Nunavut Impact Review Board (NIRB) EIS Guidelines (NIRB 2012) for the Project included Valued Socio-economic Components (VSECs) such as land use, food security, and cultural and commercial harvesting, which are all directly associated with the quality and health of terrestrial ecosystems. Due to the dependence of social VSECs on functioning ecosystems, NIRB identified terrestrial ecology as a Valued Ecosystem Component (VEC).

Information on traditional land use and value by local peoples was used for scoping and refining the potential VEC list and to determine if the VEC could interact with the Project. This, along with information from consultation from the public and regulatory agencies, was used to determine the final VEC list.

8.1.3 Incorporation of Traditional Knowledge for Spatial and Temporal Boundaries

The information on traditional use of lands by Inuit provides insight on the value people place on the land and environment. The spatial boundaries include areas in which the Madrid-Boston Project may have an effect on vegetation and ecosystems of importance to Inuit.

No specific traditional knowledge regarding the temporal aspects of the environmental effects on VECs were presented in the TK. However, TMAC recognizes the enduring relationship between the Inuit and the land, and considers this in all temporal boundaries of the Project activities and components.

8.1.4 Incorporation of Traditional Knowledge for Project Effects Assessment

The selection of VECs that are of importance to Inuit is the principal method to ensure the Project-related effects assessment addresses traditional knowledge and potential effects to Inuit use of the land and resources.

8.1.5 Incorporation of Traditional Knowledge for Mitigation and Adaptive Management

Terrestrial ecosystems and vegetation are included in the application because of their key role in Inuit cultural heritage, habitat, and forage they provide for many Arctic wildlife species, and at-risk plants and lichens.

Outlined within the socio-economic and land use baseline (Appendix V6-3A), concerns regarding the potential for the Project to directly affect wildlife or degrade their forage and habitat quality were raised during focus group sessions and interviews with hunters from the Kitikmeot communities.

Mitigation measures largely pertain to reducing the potential for adverse effects on the habitat of wildlife species, particularly those used by Inuit, as well rare plants, and unique or special landscape features (Table 8.1-1). Avoidance of Project interactions with VECs is the most effective method of reducing Project effects.

Table 8.1-1. Features included in Environmental Sensitivity Mapping to Inform Project Design

Feature Type	Rationale for Inclusion
Riparian ecosystems and floodplains	Deciduous shrubs are an important food source for ungulates; provide nesting and cover habitat for various wildlife species (e.g., breeding birds); and are used by Inuit for tools, fuel, and hunting.
Ecosystems that can contain esker complexes	Esker-related ecosystems provide important denning habitat for mammals such as foxes, wolves, wolverine, and ground squirrels, and travel corridors for many wildlife species; used as travel routes by Inuit peoples.
Sensitive or rare wetlands	These ecosystems provide important habitat to grizzly bears and caribou in the spring. Shallow open water provides habitat for water bird species. Furthermore, the ecosystems provide food and other materials for Inuit traditional uses.
Bedrock cliff	Steep, exposed bedrock cliffs provide important bird nesting habitat and hunting for Inuit as well as habitat for rare plant species.
Bedrock-lichen veneer ecosystems	Dry, windswept areas support a continuous mat of lichens, an important food source for caribou.
Beaches, marine backshores and intertidal areas	These marine associated areas provide habitat for rare plant species and are travel and foraging areas for Inuit and a variety of wildlife.
Rare plants and lichens known locations	Rare plant species are important to biodiversity and may be federally protected.

To avoid interactions with special features, plants or habitat, baseline information was used to develop environmental sensitivity maps to inform the Project design and reduce potential effects to ecosystem and vegetation VECs. Terrestrial ecosystem surveys and mapping, vegetation surveys, terrain and soil mapping, and rare plant surveys were used to identify ecosystems and vegetation that are often considered important, due to their scarcity on the landscape, sensitivity, special habitat features they provide, and/or cultural importance (Table 8.1-1). Baseline ecosystem and vegetation information is included in Appendix V4-8A.

Reducing potential effects by avoidance is, where practicable, the most effective mitigation measure to reduce the potential for serious damage or harm. Hence, the locations of these features were identified and the Project infrastructure was relocated, where feasible, to avoid effects to these features.

8.2 EXISTING ENVIRONMENT AND BASELINE INFORMATION

This section describes the existing environment and baseline information for the terrestrial ecosystems, wetlands, plant species observed, rare plants, and plant metals content in the vicinity of the Project.

Ecosystems occur as a result of complex interactions between living and non-living components across the landscape. These interactions result in unique species composition, structure and functions. This summary focuses on groups of site-specific plant communities (ecosystems), which are typically characterized by unique assemblages of plant species with a consistent and developing vegetation structure.

8.2.1 Regulatory Framework

The assessment of Madrid-Boston Project-related effects on ecosystems and vegetation is guided by the relevant regulatory framework and requirements within Nunavut and Canada. A summary of the applicable regulatory and policy framework is provided in Table 8.2-1.

Table 8.2-1. Summary of Applicable Regulatory and Policy Framework for Terrestrial Ecology and Vegetation

Name	Jurisdiction	Description
Canada Species at Risk Act (SARA) (2002)	Federal	• Protects plant species at risk and critical habitat of those species listed on the "List of Wildlife Species at Risk". • Section 137 amends the *Canadian Environmental Assessment Act* (1992) to clarify, for greater certainty, that environmental assessments must always consider effects to listed species, their critical habitat, or the residences of individuals of that species. • Section 79(2) states "the person must identify the adverse effects of the project on the listed species and its critical habitat and, if the project is carried out, must ensure that measures are taken to avoid or lessen those effects and to monitor them. The measures must be taken in a way that is consistent with any applicable recovery strategy and action plans."
Federal Policy on Wetland Conservation (2014)	Federal	• The Federal Policy on Wetland Conservation (Environment Canada 2014) provides a coordinated federal approach to wetland conservation. This policy provides direction on wetland management, legislation, and related policies and programs which support wetland conservation on federal lands and waters.
Nunavut Scientists Act (2011)	Nunavut	• Requires a licence to conduct environmental research (except for wildlife).
Nunavut Wildlife Act (2003)	Nunavut	• Provides guidelines on wildlife harvesting, habitat protection, respectful conduct toward wildlife, and designation and protection of species at risk and their habitat • Pertinent Regulations are: Wildlife General Regulations (1999), and Wildlife Licenses and Permits Regulations (1999).
Nunavut Land Claims Agreement (1993)	Nunavut	• Provides guidelines for NIRB on the review of potential environmental and social effects of development projects.

8.2.2 Data Sources

This section details existing information and the results of studies completed to characterize baseline vegetation conditions. The description of data sources of information in the baseline includes:

- information from scientific field studies, supplemented by Inuit traditional and community knowledge, where available;
- references to supporting documents, including annual baseline data reports, engineering, and technical reports (included as appendices to the Application); and
- desktop research such as other EA reports and regional studies.

8.2.2.1 Ecosystem Classification

The West Kitikmeot/Slave Study (WKSS) region has a broad level vegetation classification system (RWED 2000; Matthews et al. 2001), which encompasses the Project area (Golder 2009). Golder (2009) created a preliminary regional Ecosystem Land Classification (ELC) for the area around the Project by collating multiple local ecosystem classification projects previously completed for the Project area (Rescan 1997; Burt 2003). The resulting ELC compares local ecosystems with the broad level WKSS classification system to enable the assessment of environmental impacts at both local and regional levels (Golder 2009). In 2010, Rescan modified the ELC to account for the new, larger study area and additional sample plot data (Appendix V4-8A).

8.2.2.2 Ecosystem Mapping and Field Surveys

Project baseline studies for terrestrial ecosystems, wetlands, and vegetation were conducted between 1997 and 2014. The baseline data collected in 2010 and 2014 builds on the existing work conducted in 1996 and 1997 by Westroad Resource Consultants Ltd. (Westroad) (Rescan 1997). Westroad conducted preliminary terrestrial ecosystem mapping of the Project area in 1997 (Rescan 1997). In 2010, Rescan (Appendix V4-8A) expanded the existing ELC mapping to include the potential Project infrastructure. Existing data collected to augment the baseline studies includes the following sources:

- West Kitikmeot/Slave Study (WKSS) land cover classification (Matthews et al. 2001);
- *Flora of the Canadian Arctic Archipelago* (Aiken et al. 2007);
- NWT Department of Environmental and Natural Resources;
- Northwest Territories GSRP;
- Quickbird natural color and false-colour infrared satellite imagery;
- 1:15,000 aerial photos digitized via mono-restitution; and
- Inuit Traditional Knowledge for TMAC Resources Inc. Proposed Hope Bay Project, Naonaiyaotit Traditional Knowledge Project (NTKP) (Banci and Spicker 2016).

8.2.2.3 Field Guide and Reference Data

The following guidebooks and reference data were used for field inventories and ecosystem descriptions:

- Burt, P. 2000. *Barren Land Beauties: Showy Plants of the Canadian Arctic*. Outcrop Ltd. Yellowknife, NWT;
- MacKinnon, A., J. Pojar, R. Coupe (eds.). 1992. *Plants of Northern British Columbia*. B.C. Ministry of Forests and Lone Pine Publishing. Canada;
- Mallory, C. and S. Aiken. 2004. *Common Plants of Nunavut.* Department of Education, Iqaluit, Nunavut; and
- Porslid, A. E. and W. J. Cody. 1980. *Vascular Plants of Continental Northwest Territories*. National Museums of Canada. Ottawa, ON, Canada.

Previous studies were used to generate lists of plant species known to occur in the Project area, and for general ecological information.

8.2.3 Methods

This section summarizes the methods and rationale used for the characterization of terrestrial ecosystems, wetlands, and vegetation including the study objectives, study areas, ecosystem classification, mapping, field surveys and analysis, rare plant and lichen survey design, and vegetation metals characterization.

8.2.3.1 Study Objectives

The main objectives of the baseline programs were to:

- map and characterize the terrestrial and wetland ecosystems within a local and regional context;
- document plant and lichen species listed by NatureServe, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), SARA, or otherwise considered rare or of conservation interest;
- document the occurrence and location of invasive plants tracked by the Working Group on General Status of NWT Species; and
- describe baseline metal concentrations in plant collections from the Project area.

8.2.3.2 Study Areas

In order to guide the scope of baseline studies, regional and local study areas (RSA and LSA, respectively) were developed (Figure 8.2-1). These are described further in Section 8.4. The RSA encompasses the area of influence of the Project, beyond which effects are not predicted to occur. It also contains the extent of home ranges for key wildlife species known to inhabit the region. The exceptions to these are widely migrating species such as birds that migrate to the southern hemisphere. The LSA surrounds the proposed Project infrastructure and the area in which direct effects from the Project may occur (Figure 8.2-1).

8.2.3.3 Ecosystem Classification and Mapping

There are two types of ecosystem classification and mapping that were used to describe Project ecology:

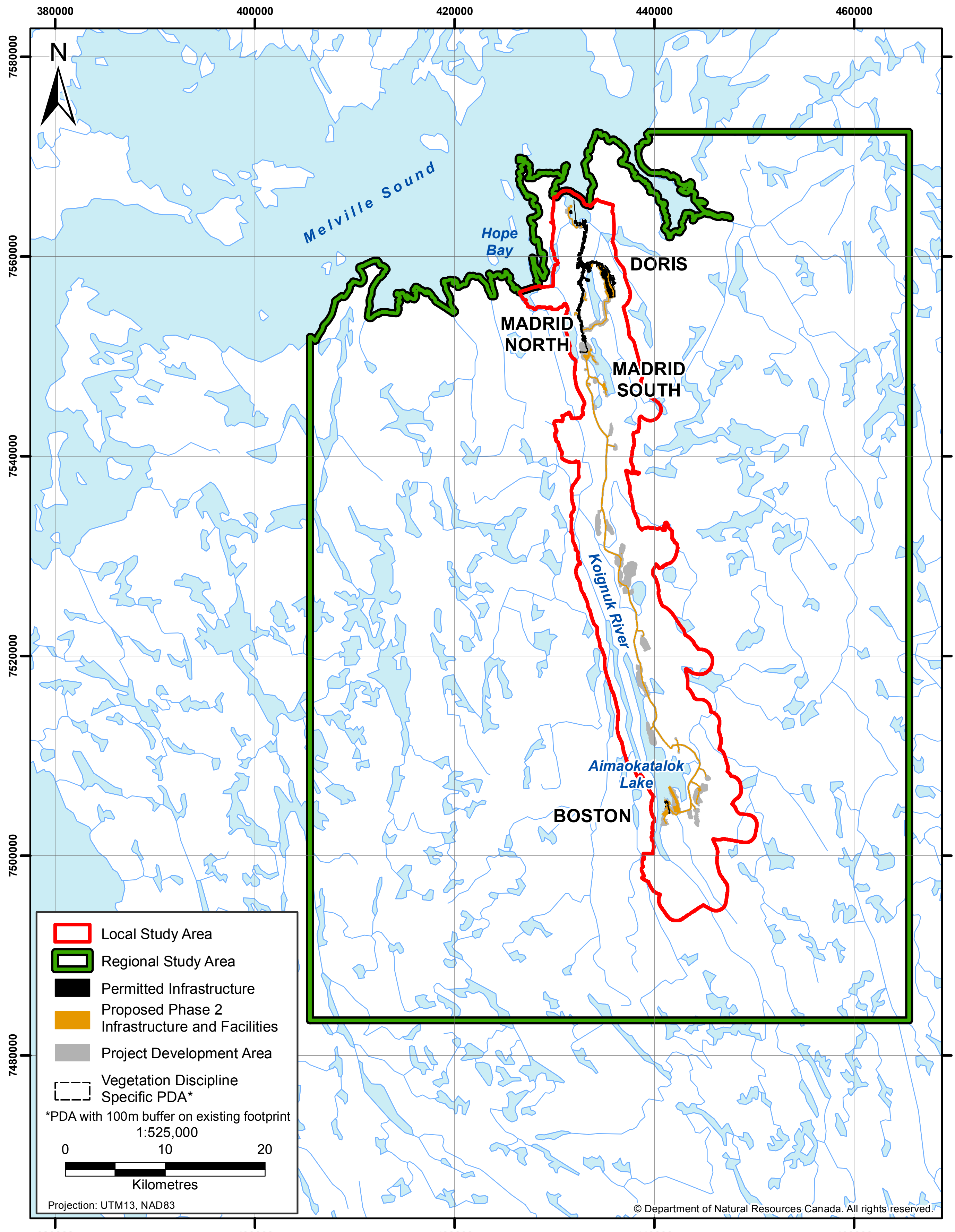
- WKSS (Matthews et al. 2001) classification and mapping which is a relatively coarse scale mapping product used for regional assessments such as cumulative effects; and
- The ELC classification used for Terrestrial Ecosystem Mapping (TEM; Appendix V4-8A) to map local ecosystems that may be affected by Project activities.

<u>Ecosystem Classification</u>

A comprehensive site level ecological classification system has not been developed for Nunavut or north of the treeline in the Northwest Territories. However, a coarse level vegetation classification system was developed for the WKSS region (Matthews et al. 2001). The WKSS mapping was used to characterize the regional study area.

Local ecosystem classification projects have been completed for the Project area. Over a period of two years (1996 and 1997), Rescan created a preliminary local ecosystem classification system for the Project area based on the existing classification projects and field data. Multivariate statistical analysis of 424 field plots identified 13 unique ecosystem units. A distinct assemblage of plant species and unique environmental considerations (soil moisture and nutrients, parent material, drainage, etc.) defines each unit (Rescan 1997). In addition to mapped ecosystem types, 11 non-vegetated map codes were developed to describe other features such as lakes, rivers, and rock outcrops. The TEM methods used to map the LSA are described below.

Figure 8.2-1
Hope Bay Project Ecosystem Study Area Boundaries



Terrestrial Ecosystem Mapping

Ecosystem mapping is effective in stratifying the landscape into meaningful units that reflect a combination of attributes, such as climate, surficial material, soil, and vegetation community (RIC 1998). Terrestrial Ecosystem Mapping requires specialists to interpret ecosystem boundaries and attributes from aerial photographs or digital stereo images. The first step involves the identification of permanent terrain units based on surficial material, geomorphology, and slope. There can be multiple polygons of a terrain unit (terrain polygon). A second step requires the identification of ecosystems mapped within each of the terrain polygons.

Preliminary mapping of 16,115 ha of the Project area was completed in 1997 (Rescan 1997) using 1:15,000 aerial photographs. An additional 40,023 ha were mapped in 2010 using 2008 Quickbird satellite imagery to characterize the ecosystems within the LSA. The total area mapped was 56,340 ha.

Field Surveys

Field surveys identified and recorded the type and distribution of ecosystems and vegetation types within the Project area. Timing of field surveys optimized the likelihood of accurate plant identification (e.g. during flowering and/or fruiting). Characteristics assessed at each site included landform type, soil texture, soil drainage, species composition, structure, and physiognomy. This information was used to confirm and refine the TEM.

Wetland ecosystems were classified to the class and form level according to the *Canadian Wetland Classification System* (Warner and Rubec 1997). Wetland class is based on general site characteristics such as soil type and the extent and quality of predominant vegetation cover. Wetland classes were further subdivided into forms based on surface morphology, surface pattern, water type, and characteristics of the soil (Warner and Rubec 1997). Sampling sites were based on the National Topographic Database (NTDB) mapping and proximity to proposed infrastructure features. Survey plots measured 400 m^2 in large wetlands and to the outer edge of the wetland vegetation in smaller wetlands. A Wetland Habitat Inspection Form (WHIF) was used to collect information relevant to wetland characterization.

8.2.3.4 Rare Plants

Rare plant surveys for plant and lichen species listed by NatureServe, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), SARA, or otherwise considered rare or of conservation interest were conducted in 2014. A qualified botanist applying an "Intuitive Controlled Survey Method" and conducted surveys from July 19 to 24 and August 6 to 17 of 2014. The Intuitive Controlled Survey Method established transects through habitats where target species are more likely to occur. Surveys focussed on areas where infrastructure footprints were identified. All rare taxa encountered were identified to the genus level or lower. The geographic position was recorded and a photograph taken of the rare plant or lichen. The habitat characteristics of the population were recorded, and a general group size was estimated. Where appropriate, at least one example of each rare species encountered in the rare plant and lichen surveys was documented with a voucher specimen by a qualified botanist. Voucher specimens were not taken of individual plants, from small groups, or very rare or listed species.

8.2.3.5 Soil and Vegetation Metal Analysis

Reclamation planning and identification of potential Project effects to human health and wildlife requires tracking metal concentrations in soils and plant tissues. The metals analyses determined existing levels of metals near the Project and at control sites outside of the predicted area of Project effects. The control sites can be used to identify if any changes in the level of metals in soil and plants are due to the Project. Samples were collected and analyzed from soil, lichens, and berries. In 2010, 18 plant tissue samples were collected from 18 sites within the LSA during field surveys. In 2014, an additional 33 plant, soil, and lichen samples were co-collected from 30 sites (21 within the LSA and 9 from reference areas outside the LSA). Samples collected in 2010 and 2014 were analyzed for metals and percent moisture. The berry, soil, and lichen samples collected in 2014 were analysed for 34 metals. This data is used to develop site-specific biotransfer factors (i.e., the relationship between soil metals and vegetation tissue metals) to predict future changes to vegetation metal concentrations that may occur as a result of the Project. Results from the baseline metals analysis were used for Human and Environmental Health Risk (Volume 6, Chapter 5).

8.2.3.6 Information Caveats and Limitations

Ecosystem mapping is a well-established method for documenting rare and unique ecosystems and assessing potential effects to them; however, ecosystem types that are less than 2 ha may not be mapped at a 1:20,000 mapping scale. Rare plant survey detection is limited to surveyed areas and complete surveys are not possible. For this reason, surveys focussed on areas where Project Footprints were identified. As a result, rare plant species locations are all located in or near Project Footprints and do not represent rare plant distribution throughout the LSA.

8.2.4 Characterization of Baseline Conditions

This section provides:

- a description of the existing conditions;
- the scientific importance of the baseline results;
- discussion of any exceptional existing conditions such as an elevated baseline conditions above an expected environmental or regulatory threshold; and
- data gaps or uncertainties that could potentially affect the confidence in the effects assessment.

8.2.4.1 Regional Setting

The National Ecological Framework is a hierarchal system of ecological classification that provides a way of describing the distribution of ecological patterns across Canada. At its broadest level, this system recognizes two ecozones within Nunavut: the Northern Arctic Ecozone and the Southern Arctic Ecozone (Natural Resources Canada 2003). The Project lies entirely within the Southern Arctic Ecozone (Figure 8.2-2) which extends across central Nunavut. Summers are typically cool and short with a mean temperature of 5˚C. Winters are long and cold with an average temperature ranging from -28ºC near the Mackenzie Delta to -18˚C in Northern Quebec. Precipitation is limited to approximately 200 mm per year. The climatic conditions of the Project area are further detailed in Climate and Meteorology (Volume 4, Chapter 1). On the south, the Southern Arctic Ecozone is bordered by the Taiga Shield Ecozone, which is demarcated by the northern extent of tree line, and on the North by the Northern Arctic Ecozone.

8.2.4.2 Protected or Conservation Areas

The proposed Project footprint does not overlap with any protected or conservation areas; a Territorial Park and a bird sanctuary are located outside the RSA.

Ovayok Territorial Park is situated 15 km east of Cambridge Bay, (Figure 8.2-2). The park is relatively small and covers an area of approximately 16 km². The central feature of the park is the mountain called Ovayok (Mount Pelly).

Figure 8.2-2
Proximity of Roberts Bay to Designated Environmental Areas

The Queen Maud Gulf Migratory Bird Sanctuary is Canada's largest federal protected area, encompassing 61,765 km^2 (Figure 8.2-2). The sanctuary is dominated by wetlands, streams, ponds, and shallow lakes and it was designated as a wetland of international importance in 1982.

8.2.4.3 Regional Ecology

The terrain within the region is comprised largely of flat and rolling bedrock covered by thin veneers of morainal, lacustrine, and fluvial deposits. Exposed bedrock is common, as repeated glacial advance and recession has removed much of the surficial material. Much of the exposed bedrock still bears striation from rocks entrained in glaciers (Natural Resources Canada 2003). Permafrost is found throughout the region and, although annual precipitation is low, many low-lying areas (as well as low-gradient hillsides) remain permanently saturated. This is due to very low rates of evaporation and transpiration as well as a continual supply of moisture from within the soil profile due to seasonal melting of permafrost.

The occurrence and development of Arctic wetlands, common throughout the region, is closely connected to the freezing and thawing of soil. The freeze-thaw action results in a number of distinct wetland types depending on the amount of dynamism in the active layer (the layer of soil above the permafrost, which is subject to periodic thawing), the depth of the surficial organic material, landscape position, and the properties of the subsurface mineral parent material. Many Arctic wetlands are located in depressions, caused by glacial scour, that have filled with water from snowmelt. Kettle and kame topography also promotes wetland development (Gracz 2007).

A lack of full-size trees along its southern edge defines the southern border of the Southern Arctic Ecozone. Stunted forms of common tree species, such as dwarf birch (*Betula nana*), green alder (*Alnus viridis* spp*. crispa*), willow species (*Salix* spp.) and less commonly, white and black spruce (*Picea glauca* and *mariana*) grow throughout the ecozone. Sedge meadows, tussock tundra, and heath tundra dominate the ground layers. Sparsely vegetated areas, such as the wind-swept crests of eskers, are also common.

Table 8.2-2 summarizes the results of the WKSS ecological classification within the RSA. Of the 22 potential land and water classification units, 18 units occur in the RSA. The Heath Tundra (< 30% rock) and Heath/Bedrock (30-80% bedrock) comprise more than 40% of the total area. Shallow water, is the next most prevalently mapped ecosystem unit (19%). Table 8.2-2 presents the areas for WKSS ecological classification units and the ecologically equivalent Local Ecosystem units (Rescan 1997) within the RSA. Figure 8.2-3 shows the WKSS ecological classifications in the RSA.

Table 8.2-2. Correlation of Regional ELC Units with the WKSS Classification

ELC Code	WKSS ELC Unit	Local Ecosystem Unit(s)	Area (ha)	% of RSA
0	Unclassified	NA	4,811	1.0%
1	Lichen Veneer	Carex-Lichen (CL)	3,357	0.7%
2	Deep Water	Lakes (LA) and Salt Water (SW)	22,133	4.5%
3	Esker Complex	Carex-Lichen (CL) and Dwarf Shrub-Heath (SH)	1,235	0.3%
4	Wetland (Sedge Meadow)	Wet Meadow (WM), Polygonal Ground (PG) and Emergent Marsh (EM)	27,572	5.6%
5	Shallow Water	Ponds (PD) and Shallow Open Water (OW)	94,990	19.4%
6	Tussock/Hummock	Eriophorum Tussock Meadow (TM)	46,523	9.5%
7	Heath Tundra	Dryas Herb Mat (DH) and Betula-Ledum-Lichen (BL)	98,430	20.1%
10	Bedrock Association	Rock Outcrop (RO) and Carex-Lichen (CL)	21,937	4.5%

ELC Code	WKSS ELC Unit	Local Ecosystem Unit(s)	Area (ha)	% of RSA
11	Riparian Tall Shrub	Riparian Willow (RW)	14,241	2.9%
13	Heath/Boulder	Carex-Lichen (CL) and Dwarf Shrub-Heath (SH)	6,013	1.2%
14	Heath/Bedrock	Dryas Herb Mat (DH) and Carex-Lichen (CL)	98,023	20.0%
15	Boulder Association	Blockfield (BI)	3,501	0.7%
16	Bare Ground	Barren (BA) and Exposed Soil (ES)	2,114	0.4%
17	Low Shrub	Dry Willow (DW) and Betula-Moss (BM	34,018	6.9%
18	Gravel Deposit	Barren (BA) and Exposed Soil (ES)	11,505	2.3%
TOTAL			**490,404**	**100**

8.2.4.4 Local Ecology

Local ecosystem units were grouped into Marine, Upland and Lowland community category (Table 8.2-3). Marine ecosystem units are strictly limited to the edge of the active marine environment along the shore of Roberts Bay. Upland ecosystem units are generally associated with bedrock outcrops and till or colluvial deposits found on the lower slopes of the outcrops. Lowland ecosystem units dominate the LSA and encompass the extensive lower slopes and plains and generally occur on lacustrine, marine, and fluvial deposits. The lowland ecosystems are mapped as single ecosystem unit discernible on satellite imagery, however, most of these wet ecosystems (including the EM, WM, OW and PG) are more accurately described as wetland complexes. These complexes are assemblages of fens, bogs, marshes, open water and other terrestrial ecosystem types which comprise much of the lowland regions of the LSA.

A summary of the LSA ecosystem mapping from 1997 and 2010 and the area of each ecosystem unit mapped (excluding the more detailed wetland classifications) is presented in Table 8.2-4 and shown on Figure 8.2-4. See Rescan (1997) for additional ecosystem unit descriptions and the detailed methodology used to develop the classifications. The most common and widespread ecosystem within the LSA is the Eriophorum Tussock Meadow. This ecosystem unit occurs in a variety of lowland landscape positions on gentle slopes. It is characterized by distinct well-formed cotton-grass (*Eriophorum vaginatum*) tussocks (Plates 8.2-1 and 8.2-2). The Betula-Ledum-Lichen (BL) unit occurs extensively across the level-to-gentle hillslopes across the LSA (Plate 8.2-3). This ecosystem typifies the drier tundra ecosystems present in the Project vicinity and often occurs in association with boulders. A distinct arctic wetland ecosystem is the Polygonal Ground (PG). Periglacial processes define these ecosystems rather than dominant vegetation or environmental conditions. They can occur as high-centre polygons with palsas surrounded by WM depressions (Plate 8.2-4) or as low-centre polygons with linear ridges underlain by ice-wedges. Complete descriptions of each ecosystem unit are provided in Appendix V4-8A, which also contains plot data and vegetation cover estimates for each species by plot.

Wetlands within the LSA are widely distributed and comprise approximately 17% of the mapped area. Some wetlands occur at too fine of a scale to be mapped (e.g. bogs), and thus the total distribution of wetlands in the LSA is likely underestimated. Common wetlands in the north of the LSA are fens and bogs, and large, shallow water bodies that are thought to have formed from the heaving and melting of ground ice under periglacial conditions (Rescan 1997). In the east of the LSA, many shallow ponds are formed in troughs behind what were once offshore sandbars now exposed above sea level due to isostatic rebound (Rescan 1997).

Figure 8.2-3
Regional Study Area WKSS Ecosystem Land Classification

TMAC RESOURCES

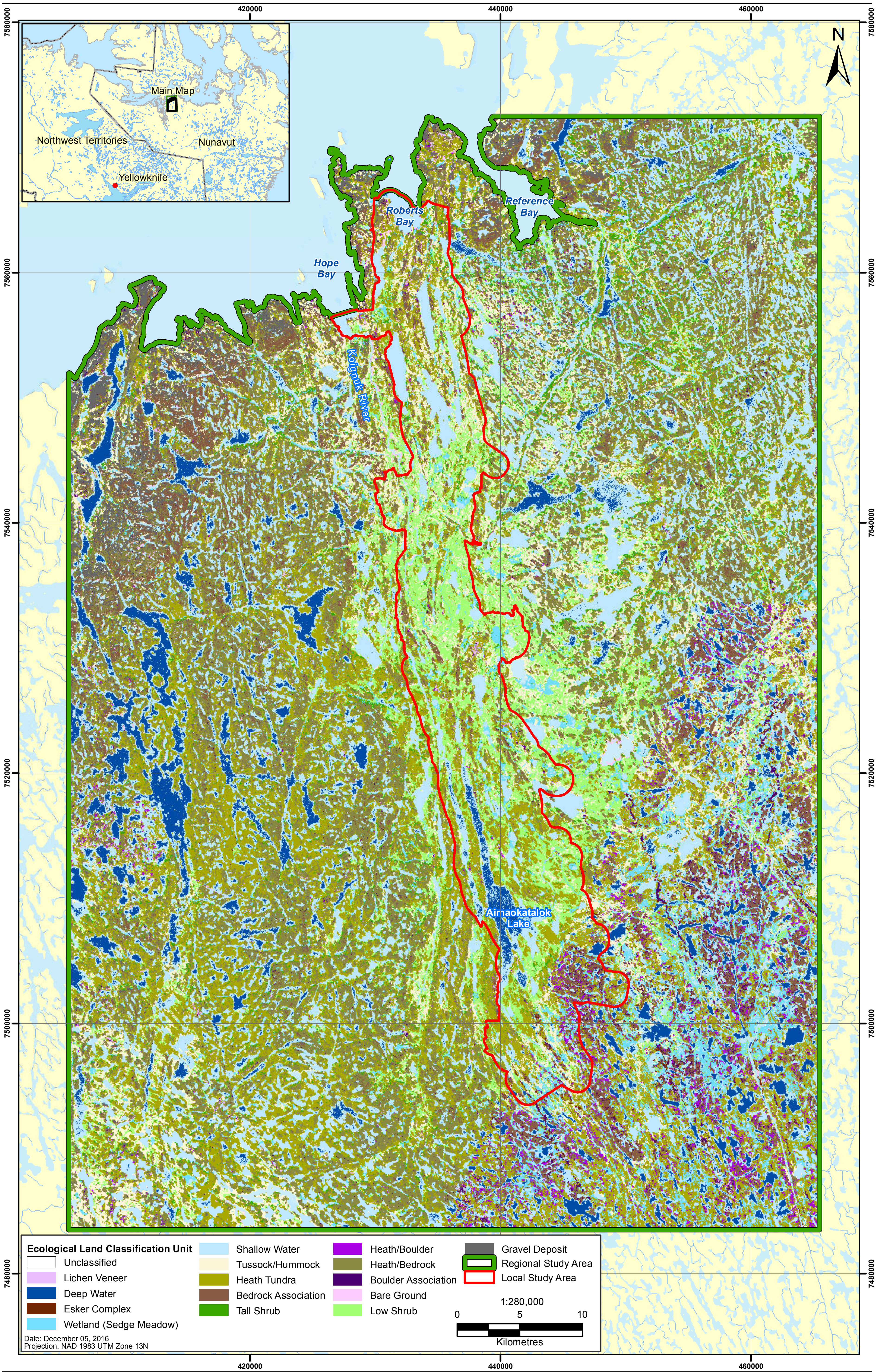


Figure 8.2-4
Distribution of Ecosystems in the Local Study Area

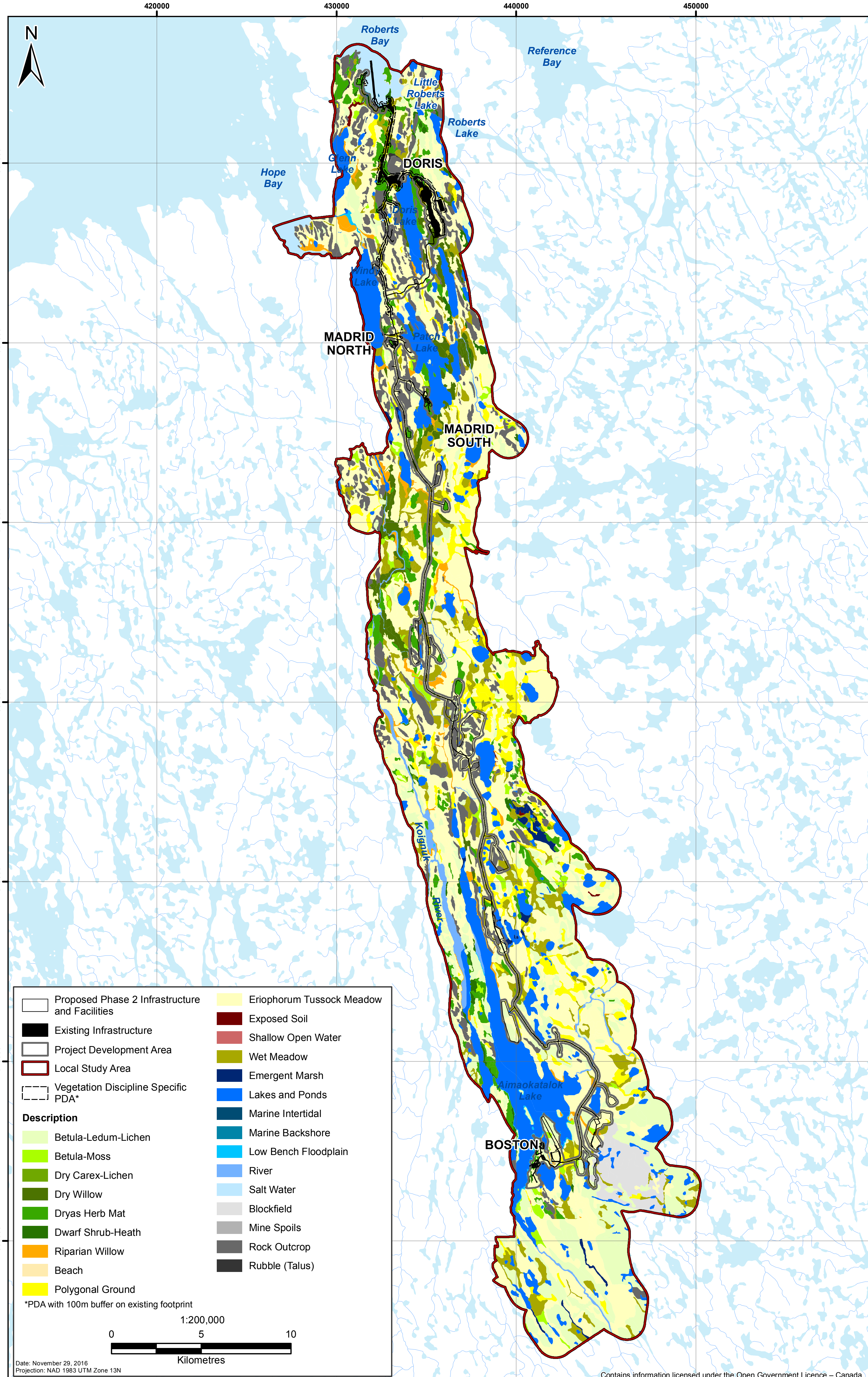


Table 8.2-3. Description of Ecosystem Units and Function

Category	General Ecosystem Unit	Description	Ecological function and/or importance to wildlife or humans
Marine	Marine Intertidal (MI)	Wet, medium nutrient marine community strictly limited to intertidal flats and shorelines containing low floral diversity of salt-tolerant herbs, with no shrubs, mosses or lichens. 50-90% cover. Vegetation height is generally very low to low.	Limited extent of ecosystems across the landscape which represent boundary between marine and terrestrial environment.
	Marine Backshore (MB)	Dry, nutrient poor community occurring directly upslope of marine backshore communities characterized by extensive deposits of washed marine sands with highly variable (but generally sparse) herb layer and few shrub, moss or lichen species. <50% cover. Vegetation height is generally very low to low.	
Upland Ecosystems	Dry Carex-Lichen (CL)	Dry, nutrient poor community restricted to exposed bedrock outcrops characterized by a variable but generally sparse cover of sedges, lichens and dwarf shrubs. Vegetation height is generally very low to low.	High lichen cover provides an important food source for muskox and caribou. Low vegetation cover provides denning habitat for fox, wolverine, and wolf.
	Dwarf Shrub-Heath (SH)	Mesic, poor to medium nutrient community restricted to moderate to steep slopes of glacial till over bedrock (often containing frost mounds) containing arctic heather and a highly variable assemblage of dwarf shrubs, herbs, moss and lichen in response to microtopography and aspect. Vegetation height in this community can vary from low to moderate.	When found as eskers, this unit can be a travel corridor for wildlife movement. Low vegetation cover provides denning habitat for fox, wolverine, and wolf.
	Dryas-Herb Mat (DH)	Dry to mesic, poor to medium nutrient community occurring on very thin, poorly developed soils on bedrock outcrops and morainal deposits dominated by Arctic avens and a high diversity of dwarf shrubs and herbs. Vegetation height is generally very low to low.	High shrub cover results in wildlife habitat opportunities and increases depth/duration of snow cover which remains longer and provides meltwater later in growing season and nutrients to downstream communities.
	Betula-Ledum-Lichen (BL)	Dry to mesic, poor to medium nutrient community occurring on hillslopes of glacial till containing thick covers of low dwarf birch, Labrador tea and a variety of dwarf shrubs, sedges, herbs and lichens. Vegetation height is generally very low to low.	
Lowland Ecosystems	Riparian Willow (RW)	Wet to very wet, medium to rich nutrient community restricted to active floodplains and seasonally fluctuating water tables with a thick cover of willow species and variable (often extensive) cover of sedges, cotton-grass, and moss species. Vegetation height is generally high, up to several metres.	Wood from willows and shrubs are harvested by Inuit for arrow shafts, sleds, drying racks, fires, and for smoking foods. The unit provides forage habitat for ungulates as well as nesting and habitat for numerous wildlife species.
	Dry Willow (DW)	Mesic, medium nutrient community occurring on steep slopes (typically fluvial, marine or lacustrine) with a thick cover of willow (occasionally dwarf birch) and few other species. Vegetation height is generally moderate.	

Category	General Ecosystem Unit	Description	Ecological function and/or importance to wildlife or humans
	Low Bench Floodplain (FP)	Permanently wet, medium to rich community restricted to active floodplains of rivers, streams and lake outlets lacking shrub and lichen cover and containing hydrophilic herbs and water tolerant mosses. Vegetation height is generally very low.	
	Betula-Moss (BM)	Mesic to moist, poor to medium nutrient community located in depressions or gently sloping fluvial and lacustrine plains typified by a high cover of dwarf birch (and often willow) and a thick moss layer, with few herbs or lichens present. Vegetation height is generally moderate.	
	Wet Meadow (WM)	Wet to very wet, medium to rich nutrient community occurring on plains and gentle lower slopes with constant water seepage dominated by thick covers of cotton-grass and sedges, few shrubs and lichens, and limited moss cover. Vegetation height is generally moderate.	The unit provides spring habitat for grizzly bears and caribou and can be habitat for other terrestrial and avian species, including small mammals which are prey for predators and raptors. Arctic wetlands play a role in carbon cycling and CO_2 accumulation in the atmosphere.
	Emergent Marsh (EM)	Permanently saturated rich to very rich communities which are rarely extensive and dominated by sedges, some hydrophilic herbs, and no shrubs of lichens, typically occurring along watercourses and ponds. Vegetation height is generally moderate.	
	Polygonal Ground (PG)	Mosaic of disjunct communities comprised of drier communities (raised palsa mounds with communities similar to birch-Ledum-lichen or birch-moss) and wet depressions (normally wet meadows) which typically occur in depressions and valley bottoms near lakes and ponds. Vegetation height is generally low to moderate.	
	Eriophorum Tussock Meadow (TM)	Moist to wet, medium to rich nutrient, widespread community type characterized by deep tussocks of sheathed cotton-grass and a variety of dwarf shrubs (on drier tussock tops), herbs, and mosses found in low lying plain of organic material overlying fine textures marine and lacustrine materials (permafrost almost always occurs at the organic – mineral transition). Vegetation height is generally low to moderate.	Arctic wetlands play a role in carbon cycling and CO_2 accumulation in the atmosphere.

8.2.4.5 Field Survey Plot Data

A total of 166 sample plots and 166 visual plots were surveyed within the LSA in 2010 to characterize the local ecosystem units. Consistent with the ecosystem mapping TM, BL, and DH were the most commonly sampled ecosystem units. Data from the terrestrial field plots were used to modify some of the Rescan 1997 ecosystem unit descriptions. The data were also used to confirm ecosystem mapping classification and polygon boundaries.

Table 8.2-4. Local Ecosystem Mapping Summary

Map Code	Description	Total LSA (ha)	Percent of LSA
BA	Barren	6	0.01%
BE	Beach	21	0.04%
BI	Blockfield	979	1.74%
BL	Betula-Ledum-Lichen	7,076	12.56%
BM	Betula-Moss	1,708	3.03%
CL	Dry Carex-Lichen	527	0.94%
DH	Dryas Herb Mat	4,345	7.71%
DW	Dry Willow	1,244	2.21%
EM	Emergent Marsh	751	1.33%
ES	Exposed Soil	78	0.14%
FP	Low Bench Floodplain	123	0.22%
LA & PD	Lakes and Ponds	8,215	14.58%
MB	Marine Backshore	18	0.03%
MI	Marine Intertidal	3	0.01%
MS	Mine Spoils	17	0.03%
OW	Shallow Open Water	11	0.02%
PG	Polygonal Ground	2569	4.56%
RI	River	798	1.42%
RO	Rock Outcrop	3280	5.82%
RU	Rubble	20	0.03%
RW	Riparian Willow	1,230	2.18%
SH	Dwarf Shrub-Heath	742	1.32%
SW	Salt Water	741	1.32%
TM	Eriophorum Tussock Meadow	15,630	27.74%
WM	Wet Meadow	6,210	11.02%
TOTAL		**56,340**	

A total of 52 ground surveys and 40 visual surveys were conducted within the LSA in 2010. The majority (75%) of the wetlands surveyed occur as complexes. Fens are over half (58%) of the wetlands surveyed (Table 8.2-5). Fens are nutrient-medium peatland ecosystems dominated by sedges and brown mosses. Bogs were the next most common wetland types surveyed, accounting for 23% of field plots. Bogs are acidic and nutrient-poor ecosystems dominated by *Sphagnum* or brown moss which are isolated from mineral-enriched groundwater. Bogs commonly comprised the polygonal ground ecosystems.

8.2.4.6 Ecosystems and Plants of Interest

<u>Plants and Ecosystems of Cultural Importance</u>

The TK report identifies numerous traditionally harvested food, medicinal, or culturally important plants (Banci and Spicker 2016). Harvested berries include cloudberries, blueberries, crowberries, and bearberries. Liquorice root (also called mahok) is also an important springtime food source. Leaves of the mountain sorrel and beach peas are also harvested and consumed. Other plants having medicinal or other cultural importance include white arctic heather, crowberries, and Labrador tea.

Plate 8.2-1. Typical Eriophorum Tussock Meadow (TM) ecosystem unit.

Plate 8.2-2. Close-up of typical Eriophorum vaginatum tussocks.

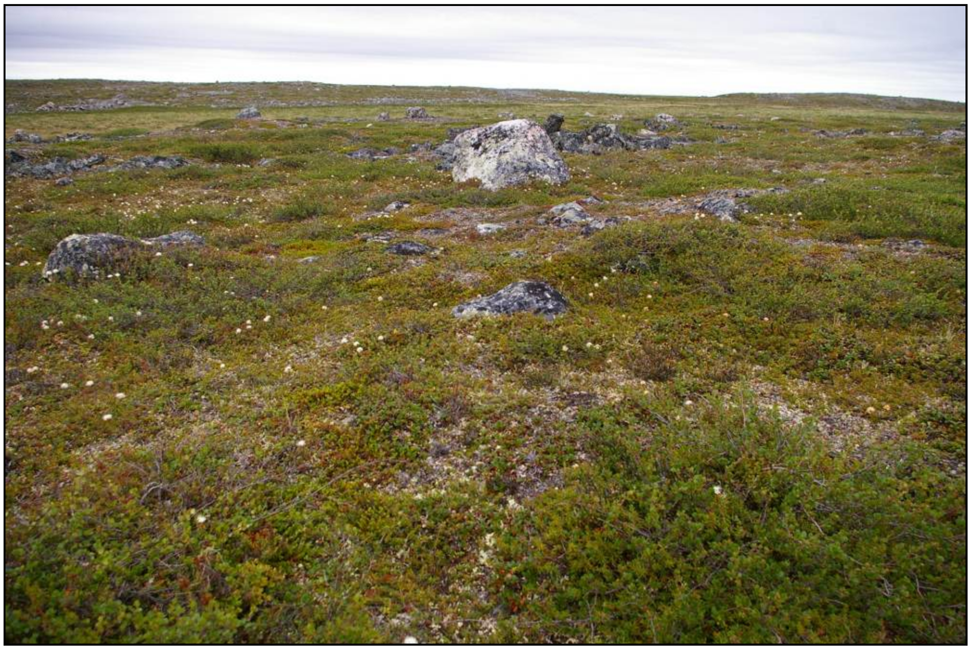


Plate 8.2-3. Bouldery Betula Ledum Lichen (BL) ecosystem unit typical of southern portions of the LSA.

Plate 8.2-4. Aerial view of a typical Polygonal Ground (PG) ecosystem unit.

Table 8.2-5. Distribution of Ground Wetland Plots by Class and Form Type

Class	Primary Wetland Form[1]	Number of Wetland Field Plots	Percent of Total Wetland Plots
Fen	horizontal fen	11	21.2
	lowland polygon fen	19	36.5
Bog	lowland polygon bog	8	15.4
	peat mound bog	3	5.8
	palsa bog	0[2]	0.0
Marsh	lacustrine marsh	4	7.7
	slope marsh	1	1.9
	basin marsh	1	1.9
Open Water	shallow open water	n/a[2]	0.0
Terrestrial sites		5	9.6
Total		**52**	**100**

[1] This field lists the primary wetland type identified at the field plot
[2] Present as sub-dominant community only. See Appendix 9 of the baseline study (Appendix V4-8A)

Consultation as part of the TK report also reveals a number of plants or ecosystems of importance for starting fires, providing food such as berries, or providing habitat. These include riparian areas which are important sources of wood and provide shelter for ptarmigan. Wetlands are also valuable as they provide habitat for cloudberries and act as a source of water for caribou during hot periods.

All plants of cultural importance, with the exception of mountain sorrel and beach pea, were recorded during the 2014 rare plant surveys (Appendix V4-8B). Species, such as Arctic heather, liquorice root, and bear berries were encountered throughout mesic to very-dry tundra ecosystems such as the Dryas Herb ecosystem unit. Willow shrubs and dwarf (scrub) birch were frequently noted within the riparian and shrub-dominated areas which include the low bench floodplain and riparian willow ecosystem units.

Sensitive or at Risk Ecosystems

Unique landscape features are often considered rare or sensitive, due to their scarcity on the landscape, special habitat features they provide, and/or cultural importance. Landscape features known to support, or suspected of supporting, rare plant species include cliff faces, eskers, pingos, and the margins of wetlands. Some of these features, such as cliff faces and pingos cannot be mapped at the baseline mapping scale, and thus remain as described features only. However, the locations of cliffs were identified as point sources during the assessment of raptor nesting habitat.

In some cases, the same feature may serve as both potential rare plant habitat, important wildlife habitat (i.e. nesting habitat for raptors), or have important traditional uses. From the list of map codes (Table 8.2-3), the following vegetation associations were identified as potentially sensitive on the basis of habitat use:

- riparian ecosystems (map code RW): Deciduous shrubs are an important food source for ungulates; provide nesting and cover habitat for various wildlife species (e.g. breeding birds); and are used by Inuit for tools, fuel, and hunting.
- esker complexes (map codes: CL and SH; Esker Complex Unit in WKSS mapping): Esker-related ecosystems provide important denning habitat for mammals such as foxes, wolves, wolverine,

and ground squirrels, and travel corridors for many wildlife species; used as travel routes by Inuit peoples;

- sedge-dominated wetland, shallow open water and marsh ecosystems (map codes: WM, PG, OW, and EM): These ecosystems provide important habitat to grizzly bears and caribou in the spring. Furthermore, the ecosystems provide food and other materials for Inuit traditional uses. They are sensitive to even minor disturbances;
- bedrock cliff (map code: RO): Steep, exposed bedrock cliffs provide important bird nesting habitat and habitat for rare plant species; and
- bedrock-lichen veneer (map code: CL): Dry, windswept areas support a continuous mat of lichens, an important food source for caribou.

Sensitive wetlands ecosystems include those that are rare or fragile, and whose formation and maintenance is dependent on factors that are uncommon or threatened. They can be dependent on unique environmental and geographic factors and/or complex ecological processes (Farmer 1993; McPhee et al. 2000). For rare wetland ecosystems, the following must be known in order to determine the level of risk, or rarity:

- the ecosystem must be definable by an accepted and tested method of classification; and
- there must be knowledge of the number of occurrences of the particular ecosystem, and the distribution thereof.

Nunavut does not have a defined site-level ecological classification system for wetlands, thus it is not possible to determine rarity. However, there are a number of wetland-related landscape features present within the Arctic that are considered uncommon or unique (NWT Department of Environment and Natural Resources 2012). However, none of these three wetland related landscape features was mapped during baseline mapping.

These include the following:

1. **Saline Sulphur Springs** — landscape features forming when saline water up wells due to artesian flow. The water becomes saline upon contact with the saline parent material. At the surface, salt precipitates out of solution, forming unique features.
2. **Pingos —** mounds or small hills composed of a thin layer of soil overtop of ice. The ice is forced up due to water pressure, causing the soil surface to rise. They are dynamic in that they are constantly in a state of rising or falling due to changes in soil temperature and hydrology.
3. **Karst Wetlands —** wetlands associated with karst landscapes. Karst landscapes form due to the dissolution of soluble bedrock by surface and subsurface water. Usually, the bedrock is carbonate-derived, such as limestone or dolomite. The resulting landscape is dominated by shallow basins and hollows.

Sensitive wetlands are those whose functional components are susceptible to even minor amounts of disturbance (McPhee et al. 2000). They are often considered fragile due to the transient and changing nature of the natural processes that lead to their creation. Natural disturbance is an important and constant feature of Arctic ecosystems. Mechanical disturbances such as freeze-thaw processes, thermokarst landscape formation, wind, slope processes, and flooding occur on a constant basis, significantly influencing wetland development, over various spatial and temporal scales (International Arctic Science Committee 2010).

Arctic wetland ecosystems are sensitive to anthropogenic disturbance. Even small, low intensity disturbances, such as vehicle use on Arctic tundra, often create immediate and persistent effects on vegetation and soils (Forbes, Ebersole, and Strandberg 2001). In general, lowland ecosystems are more likely to be susceptible to disturbance, as small changes to vegetation cover and/or soils may result in altered ecosystem values, particularly in wet areas. Disturbance in areas with saturated soil affect soil thaw characteristics that define many ecosystems. For instance, vehicle use may affect the depth of thaw resulting in increased melting of permafrost (Kevan et al. 1995). Changes in soil temperature, thaw depth, and vegetation disturbance commonly result and can persist for many years (Harper and Kershaw 1996; Kemper and MacDonald 2009). Disturbance often changes vegetation structure and composition, and may increase localized erosion by channelizing water flow (Kevan et al. 1995; Forbes, Ebersole, and Strandberg 2001).

Upland ecosystems are generally dryer and water shedding, so physical disturbances may have a limited effect on water movement relative to lowland ecosystems. However, the vegetation species growing in dryer areas are often slower to recover following disturbance (Kemper and Macdonald 2009; Jorgenson, Ver Hoef, and Jorgenson 2010). The marine ecosystem units are generally sparsely vegetated and characterized by unstable substrates that are constantly or erratically disturbed by tides, ice scouring and wave action. Vegetation that occurs in these ecosystem units should have a greater ability to re-colonize after disturbance, but literature reviews of Arctic marine foreshores indicate that knowledge in this area is limited.

Plant Species Richness

A total of 6,067 plants were recorded during the field surveys within the Project area, accounting for 871 species (Table 8.2-6). The lichens represent the most species-rich category. The second richest category is the vascular plants, followed by mosses and algae.

Table 8.2-6. Total Species Richness by Taxonomic Category

Vascular Plants	Mosses	Liverworts	Lichens	Total
262	204	38	367	871

Rare Plant Species

Of the 871-species identified in the field, 23 are tracked by the National General Status Working Group (NGSWG) and NatureServe Canada (Table 8.2-7; Figure 8.2-5). Of these, eight lichen species are categorized to be at risk (S1 or S1S2) and two lichen species may be at risk (S1S3). Eleven species are considered sensitive, including three lichen species and eight vascular plant species. The rank of the remaining two tracked species of vascular plant rank is secure. An additional 29 species are either not ranked and documented from only a few known locations or were considered rare but were not ranked and previously undocumented in Nunavut. None of the rare plant species listed in Table 8.2-7 is in Schedule 1 of SARA (2002). Rare plant surveys locations and species information is contained in Appendices V4-8B, V4-8C, V4-8D and V4-8E.

Invasive Plant Species

There is limited information available for invasive plant species in Nunavut. Information regarding invasive plants was compiled from the NWT Department of Environment and Natural Resources 2010, the Invasive Species Specialist Group (ISSG) Global Invasive Species Database and the Evergreen Native Plant Database and compared with field data collected in 2010 (Appendix V4-8A).

Figure 8.2-5
Rare Plant Observations in the Hope Bay Local Study Area

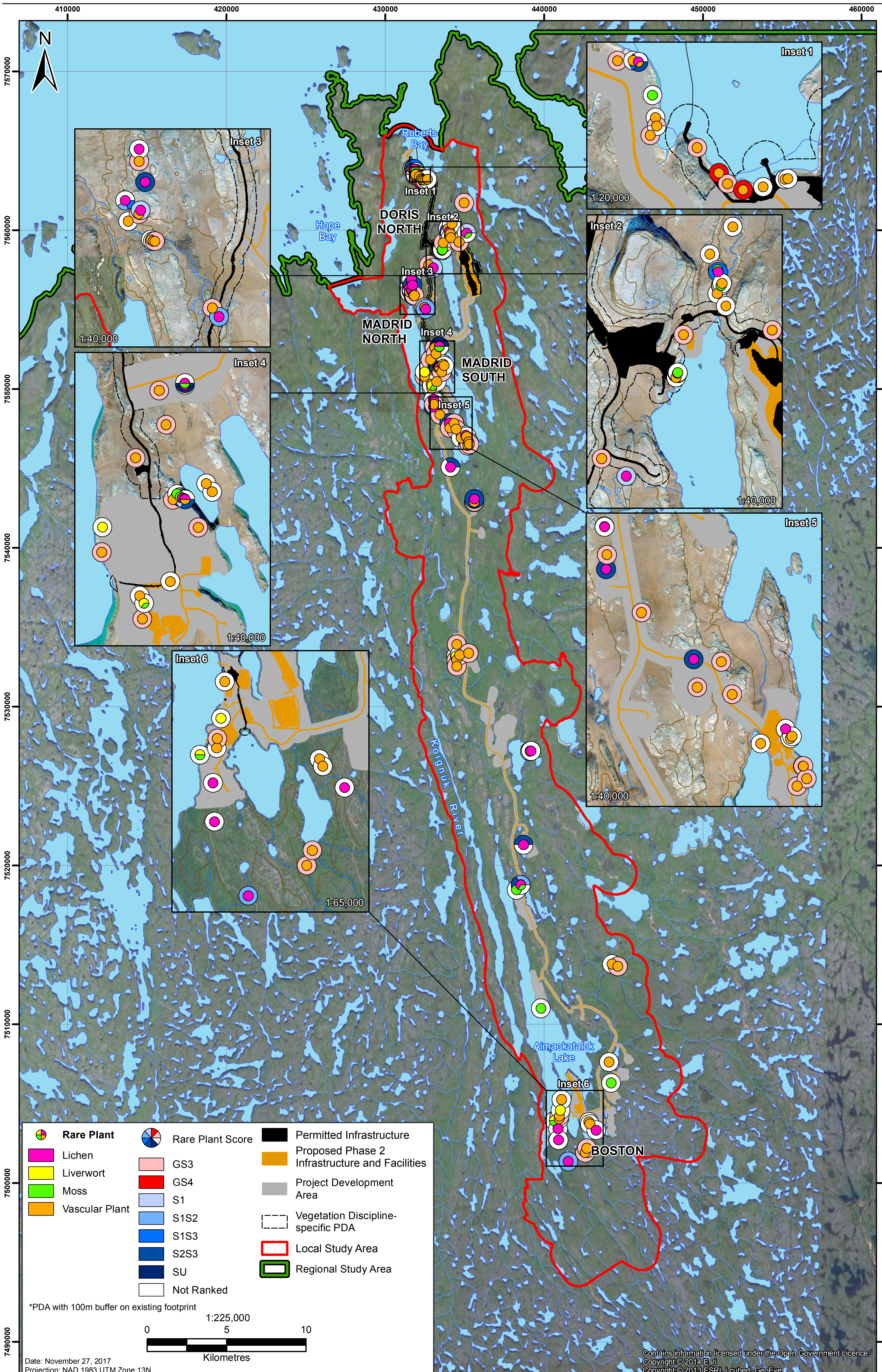


Table 8.2-7. Rare Lichen, Liverwort, Mosses, and Vascular Plants Identified in the Project Area

Species Category	Taxon	NatureServe Rank
Lichen	*Allocetraria madreporiformis*	S1S3 (May be at risk)
	Anaptychia crinalis	S1 (At risk)
	Collema auriforme s. lat.	Not ranked, previously undocumented in Nunavut
	Collema ceraniscum	S2S3 (Sensitive)
	Collema fuscovirens	S1S2 (At risk)
	Collema polycarpum	Not ranked, previously undocumented in Nunavut
	Collema tenax var. *expansum*	Not ranked, previously undocumented in Nunavut
	Endocarpon pulvinatum	S1S3 (May be at risk)
	Endocarpon pusillum	S1S2 (At risk)
	Evernia perfragilis	S2S3 (Sensitive)
	Hypogymnia imshaugii	Not ranked, first found in Nunavut in 2012, known in the Arctic only from the Hope Bay and Bathurst Inlet areas
	Leciophysma finmarkicum	S2S3 (Sensitive)
	Lemphlemma radiatum	S1 (At risk)
	Leptogium schraderi	SU (Not ranked due to lack of supporting specimens; the record from this project is the first documented from Nunavut)
	Leptogium turgidum	Not ranked, previously undocumented in Nunavut
	Lichinella nigritella	Not ranked, first discovered for Nunavut in 2012 and now known only from two localities in Nunavut
	Lobaria linita	S1S2 (At risk)
	Lobaria scrobiculata	S1 (At risk)
	Ramalina almquistii	S1S2 (At risk)
	Tuckermanopsis americana	S1S2 (At risk)
Liverwort	*Apometzgeria pubescens*	Not ranked, previously undocumented in Nunavut
	Frullania brittoniae	Not ranked, previously known in Nunavut from a single site
	Radula holtii	Not ranked, previously undocumented in Nunavut
Moss	*Aloina rigida*	Not ranked, previously documented in Nunavut from very few records.
	Brachythecium udum	Not ranked, previously undocumented in Nunavut, previously known definitively in North America in only one locality.
	Bryum blindii	Not ranked but known from few localities throughout its range
	Campylium laxifolium	Not ranked, previously undocumented in Nunavut, known previously in North America from three records
	Campylophyllum sommerfeltii	Not ranked, previously undocumented in Nunavut
	Encalypta vittiana	Not ranked, previously undocumented in Nunavut
	Hedwigia ciliata	Not ranked, previously known in Nunavut from a single locality
	Seligeria subimmersa	Not ranked, previously undocumented in Nunavut
	Sphagnum platyphyllum	Not ranked, previously undocumented in Nunavut
	Tortula cuneifolia	Not ranked, previously known in Nunavut from a single locality
Vascular Plant	*Astragalus australis* var. *lepagei*	GS3 (Sensitive)
	Braya glabella ssp. *glabella*	Not ranked but rare
	Calamagrostis deschampsioides	GS3 (Sensitive)

Species Category	Taxon	NatureServe Rank
	Carex microglochin	GS4 (Secure)
	Chrysosplenium rosendahlii	Not ranked, known from few localities worldwide
	Coptidium pallasii	GS3 (Sensitive)
	Draba arabisans	Not ranked, first found in Nunavut in 2012
	Festuca richardsonii	Not ranked in NatureServe's General Status Ranks
	Gentianella tenella	GS4 (Secure), but this appears to be in error; known from very few localities in Nunavut
	Halerpestes cymbalaria	Not ranked in NatureServe's General Status Ranks
	Kobresia sibirica	GS3 (Sensitive)
	Oxytropis deflexa var. *foliolosa*	GS3 (Sensitive)
	Oxytropis nigrescens var. *uniflora*	Not ranked in NatureServe's General Status Ranks
	Petasites sagittatus	Not ranked in NatureServe's General Status Ranks,
	Plantago canescens	GS3 (Sensitive)
	Potentilla uschakovii	Not ranked in NatureServe's General Status Ranks
	Puccinellia arctica	GS3 (Sensitive)
	Salix ovalifolia var. *ovalifolia*	Not ranked in NatureServe's General Status Ranks, first found in Nunavut in 2012
	Salix sp. 1 (eskers)	Not ranked in the NatureServe's General Status Ranks, a species discovered new for science in 2012
	Utricularia intermedia	GS3 (Sensitive)

Field surveys found one potentially invasive plant, common dandelion (*Taraxacum officiniale*). There are two subspecies of common dandelion (*Taraxacum officinale*) one of which is native (formerly known as *Taraxacum lacerum)* and the other is invasive (*T. officinale* ssp. *officinale*). Plant species were generally not identified to the subspecies level and thus field personnel were unable to determine the invasive status. Based on the location of occurrence and lack of human disturbance, it is believed that this species was likely native.

8.2.4.7 Metal Concentrations in Plant Tissues

Vegetation and soils sampling was conducted in July and August 2010 in August 2014 to characterize metal concentrations. Fifty-eight berry samples were collected and included *Empetrum nigrum, Arctostaphylos alpina*, and *Vaccinium sp.* Sampling for vegetation included 67 lichen samples of either *Flavocetraria cucullata or F. nivalis*. Samples were collected both at sites adjacent to proposed infrastructure and at nine reference sites where Project effects are not anticipated (Figure 8.2-6).

Assays detected twelve metals of interest during baseline studies. Most of the tissue samples had concentrations below detection limits (Rescan 2011). The un-summarized analytical results for all the metals analyzed in the lichen tissue samples (in both wet and dry weights) is presented Appendix 10 of the baseline report (Appendix V4-8A) and in Appendix V4-8F. There are no territorial or federal guidelines for metal limits in vegetation.

Table 8.2-8 presents metal concentrations for *Empetrum nigrum, Arctostaphylos alpina*, and *Vaccinium* sp. Table 8.2-9 presents metal concentrations for *Flavocetraria cucullata or F. nivalis*.

Figure 8.2-6
Vegetation Metal Sampling Locations

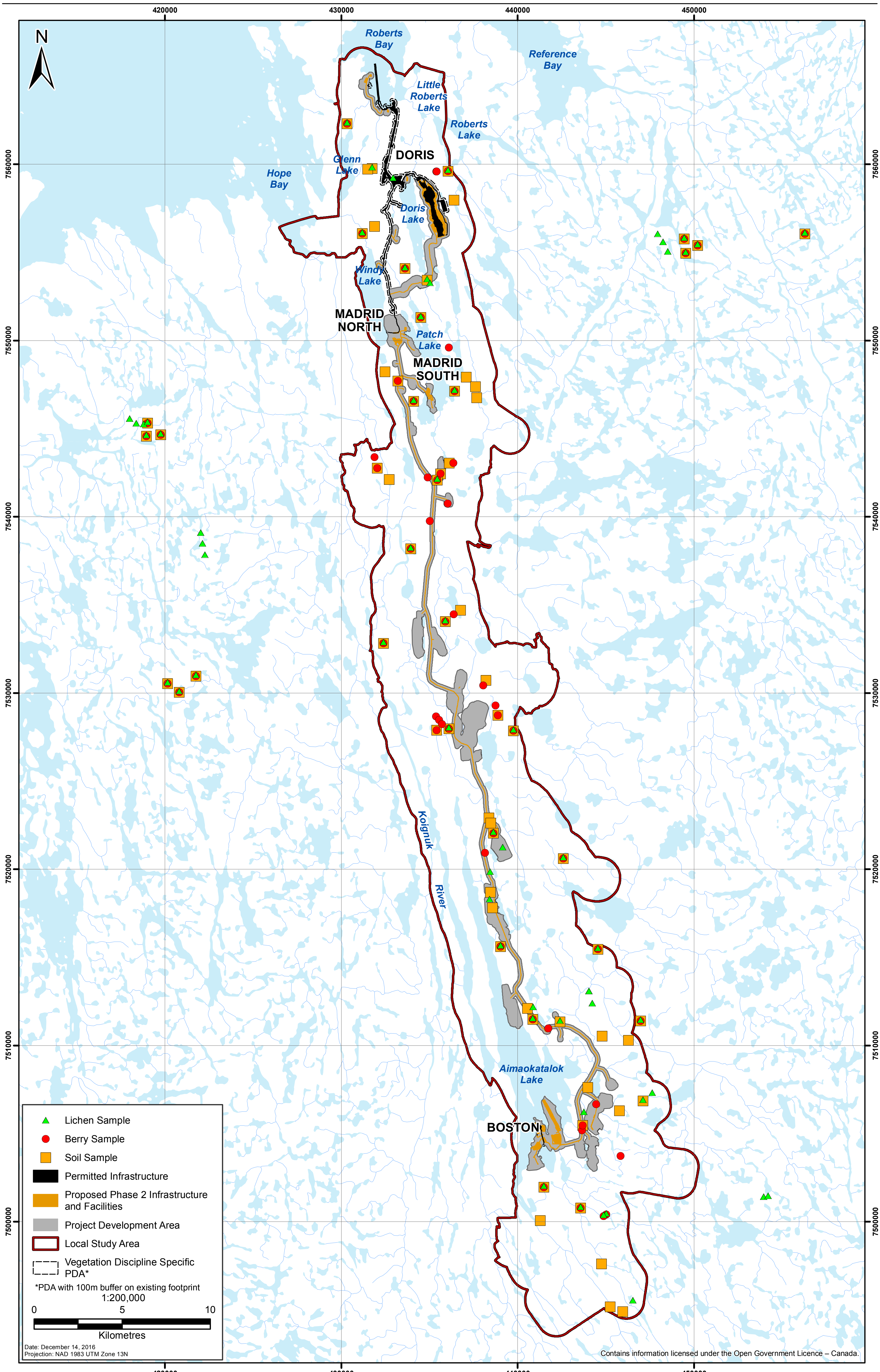


Table 8.2-8. Summary Statistics of Baseline Metal Concentrations in Berries (*Empetrum nigrum, Arctostaphylos alpina,* and *Vaccinium* sp.)

Parameter	Detection Limit	N	Standard Deviation	Minimum	Mean	Median	95th Percentile	Maximum
% Moisture	0.1	59	2.62	77.4	84.0	83.7	87.6	89.2
Metal (mg/kg, wet weight)								
Aluminum	0.4	59	5.74	0.200	2.00	0.670	5.48	37.3
Antimony	0.002	59	0	0.00100	0.00100	0.00100	0.00100	0.00100
Arsenic	0.004	59	0.00353	0.00200	0.00256	0.00200	0.00362	0.0290
Barium	0.01	59	0.510	0.263	1.00	0.928	1.93	2.83
Beryllium	0.002	59	0	0.00100	0.00100	0.00100	0.00100	0.00100
Bismuth	0.002	59	0	0.00100	0.00100	0.00100	0.00100	0.00100
Boron	0.2	59	0.394	0.730	1.44	1.37	2.10	2.51
Cadmium	0.001 - 0.002	59	0.00202	0.000500	0.00137	0.000500	0.00380	0.0134
Calcium	0.5 - 5	59	38.0	60.4	135	132	198	232
Cesium	0.001	59	0.0135	0.000500	0.00660	0.00240	0.0183	0.0896
Chromium	0.01 - 0.04	59	3.18	0.00500	1.94	0.123	9.33	14.5
Cobalt	0.004	59	0.0325	0.00200	0.0258	0.00650	0.0859	0.150
Copper	0.02	59	0.392	0.349	0.907	0.843	1.33	3.04
Gallium	0.004	29	0.00143	0.00200	0.00227	0.00200	0.00200	0.00970
Iron	0.2 - 0.6	59	32.4	1.17	15.4	3.66	52.580	230
Lead	0.004	59	0.0109	0.00200	0.00451	0.00200	0.0133	0.0807
Lithium	0.02 - 0.1	59	0.0192	0.0100	0.0322	0.0500	0.0500	0.0500
Magnesium	0.4 - 10	59	15.1	52.3	81.4	77.2	110	123
Manganese	0.004 - 0.01	59	10.7	0.926	7.39	4.52	23.5	62.3
Mercury	0.001	59	0.00156	0.000500	0.000703	0.000500	0.000500	0.0125
Molybdenum	0.004	59	0.110	0.00200	0.0882	0.0282	0.314	0.426
Nickel	0.02 - 0.04	59	1.72	0.0520	1.16	0.131	5.25	7.59
Phosphorus	2 - 50	59	35.9	103	159	155	219	261
Potassium	4 - 200	59	191	793	1215	1210	1597	1640
Rhenium	0.002	29	0	0.00100	0.00100	0.00100	0.00100	0.00100
Rubidium	0.01	59	1.36	0.620	2.81	2.76	5.04	6.13
Selenium	0.01 - 0.02	59	0.00252	0.00500	0.00746	0.00500	0.0100	0.0100
Silver	0.001	29	0	0.000500	0.000500	0.000500	0.000500	0.000500
Sodium	4 - 200	59	13.3	4.70	11.4	10.0	13.2	100
Strontium	0.01	59	0.100	0.0870	0.232	0.203	0.416	0.527
Tellurium	0.004	59	0	0.00200	0.00200	0.00200	0.00200	0.00200
Thallium	0.0004	59	0.0000365	0.000200	0.000205	0.000200	0.000200	0.000480
Thorium	0.002	29	0.00219	0.00100	0.00141	0.00100	0.00100	0.0128
Tin	0.004 - 0.02	59	0.173	0.0100	0.172	0.0830	0.468	0.697
Titanium	0.01	29	0.138	0.00500	0.0557	0.0120	0.198	0.719
Uranium	0.0004	59	0.000721	0.000200	0.000306	0.000200	0.000200	0.00570
Vanadium	0.004 - 0.02	59	0.0206	0.00200	0.0182	0.0100	0.0503	0.121
Yttrium	0.002	29	0.00737	0.00100	0.00241	0.00100	0.00166	0.0407

Parameter	Detection Limit	N	Standard Deviation	Minimum	Mean	Median	95th Percentile	Maximum
Zinc	0.1	59	0.495	0.700	1.46	1.31	2.15	3.55
Zirconium	0.04	59	0	0.0200	0.0200	0.0200	0.0200	0.0200

Notes: For calculation purposes, values that were below the method detection limit were replaced with values that were half of the method detection limit.

Table 8.2-9. Summary Statistics of Baseline Metal Concentrations in Lichen (*Flavocetraria cucullata* and *F. nivalis*)

Parameter	Detection Limit	N	Standard Deviation	Minimum	Mean	Median	95th Percentile	Maximum
% Moisture	0.1 - 0.25	78	12.7	4.17	16.5	12.2	47.0	61.2
Metal (mg/kg, wet weight)								
Aluminum	0.4 - 2	78	185	21.3	137	87.1	354	1300
Antimony	0.002 - 0.01	78	0.00217	0.00100	0.00456	0.00475	0.00592	0.0157
Arsenic	0.004 - 0.01	78	0.124	0.0167	0.0781	0.0539	0.207	1.09
Barium	0.01	78	4.51	1.56	8.82	8.23	16.1	20.9
Beryllium	0.002 - 0.1	78	0.0222	0.00100	0.0222	0.00715	0.0500	0.0500
Bismuth	0.002 - 0.03	78	0.00607	0.00100	0.00761	0.00460	0.0150	0.0150
Boron	0.20	48	1.97	0.330	2.03	0.855	6.16	6.91
Cadmium	0.001 - 0.005	78	0.0401	0.0129	0.0737	0.0681	0.150	0.226
Calcium	2 - 22.5	78	4409	326	5203	3960	12260	27700
Cesium	0.001	48	0.0233	0.00500	0.0388	0.0344	0.0854	0.135
Chromium	0.01 - 0.1	78	2.55	0.0670	1.79	0.804	5.79	16.4
Cobalt	0.004 - 0.02	78	0.316	0.0283	0.240	0.170	0.477	2.58
Copper	0.01 - 0.02	78	0.786	0.353	1.27	0.950	2.75	5.06
Gallium	0.004	48	394	0.00660	224	134	593	2200
Iron	0.2 - 2	48	110	27.0	89.1	63.4	157	785
Lead	0.004 - 0.2	78	0.236	0.0729	0.375	0.307	0.797	1.19
Lithium	0.02 - 0.2	78	0.116	0.0100	0.103	0.0500	0.239	0.860
Magnesium	0.4 - 45	78	266	288	775	760	1163	1670
Manganese	0.004 - 0.01	78	29.8	6.05	64.2	56.9	113	145
Mercury	0.001	78	0.0259	0.000500	0.0440	0.0396	0.0897	0.142
Molybdenum	0.004 - 0.01	78	0.0142	0.0180	0.0375	0.0342	0.0612	0.0840
Nickel	0.02 - 0.1	78	1.07	0.127	0.966	0.573	2.72	6.84
Phosphorus	2 - 225	78	164	230	441	396	789	1020
Potassium	4 - 900	78	360	713	1367	1250	2025	2450
Rhenium	0.002	18	0	0.00100	0.00100	0.00100	0.00100	0.00100
Rubidium	0.01	48	1.37	0.468	3.20	3.02	5.25	7.76
Selenium	0.01 - 0.2	78	0.0280	0.0100	0.0778	0.0830	0.100	0.160
Silver	0.001 - 0.01	48	0.00283	0.00310	0.00686	0.00500	0.0120	0.0130
Sodium	4 - 900	78	186	200	443	394	835	1210
Strontium	0.01	78	5.57	1.76	9.71	9.30	19.5	28.1
Tellurium	0.004	48	0.000491	0.00200	0.00207	0.00200	0.00200	0.00540

Parameter	Detection Limit	N	Standard Deviation	Minimum	Mean	Median	95th Percentile	Maximum
Thallium	0.0004 - 0.01	78	0.00326	0.00109	0.00573	0.00500	0.0138	0.0200
Thorium	0.002	18	0.0165	0.00680	0.0206	0.0143	0.0478	0.0745
Tin	0.004 - 0.05	78	0.0116	0.0100	0.0204	0.0244	0.0317	0.0896
Titanium	0.01 - 1	48	4.03	1.42	4.74	3.78	8.09	28.3
Uranium	0.0004 - 0.002	78	0.0128	0.00100	0.0135	0.00950	0.0438	0.0610
Vanadium	0.004 - 0.1	78	0.728	0.0500	0.461	0.199	1.68	4.36
Yttrium	0.002	18	0.0854	0.0197	0.0869	0.0479	0.266	0.314
Zinc	0.1	78	5.13	9.78	20.1	19.8	28.4	34.8
Zirconium	0.04	48	0.112	0.0200	0.131	0.120	0.283	0.688

Notes: For calculation purposes, values that were below the method detection limit were replaced with values that were half of the method detection limit.

Mercury, selenium, and zinc had higher mean values in plant tissues from the South end of the belt than in the North end of the belt. No further conclusions about differences between species or metals can be made due to high variability among the samples.

8.3 VALUED COMPONENTS

VECs are natural and human environmental features that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (NIRB 2012). For consideration in the EIS, there must be a perceived likelihood that the VEC will be affected by the proposed Project. VECs are scoped into the environmental assessment based on issues raised during consultation for the EIS Guidelines (NIRB) with Aboriginal communities, government agencies, the public, and other stakeholders. VECs may also be a legislated requirement, or known to be a concern because of previous project experience. The EIS Guidelines (NIRB) define VECs as: "aspects of the environment considered to be of vital importance to a particular region or community, including:

- resources that are either legally, politically, publically, or professionally recognized as important, such as parks, land selections, and historical sites;
- resources that have ecological importance; and
- resources that have social importance."

The EIS Guidelines (NIRB, Section 7.6.1) identified broad VECs for consideration that include: terrestrial ecology and vegetation. NIRB guidance, consultation with the public, TK, and technical expert advice was used in a scoping process, described below, to identify potential VECs to assess Madrid-Boston Project and Hope Bay Project and cumulative effects to vegetation and terrestrial ecosystems.

8.3.1 Potential Valued Components and Scoping

8.3.1.1 The Scoping Process and Identification of VECs

The scoping process for vegetation follows the process outlined in the Assessment Methodology (Volume 2, Chapter 4). VECs considered for inclusion in the effects assessment relate to the subjects of terrestrial ecology and vegetation as defined by the EIS Guidelines (NIRB).

The EIS Guidelines (NIRB) proposed a number of VECs to be considered for inclusion in the effects assessments, including:

- Terrestrial environment, including:
  - Terrestrial ecology,
  - Landforms and soils,
  - Permafrost and ground stability; and
- Vegetation.

The selection of VECs began with those proposed in the EIS Guidelines and was further informed through consultation with communities, regulatory agencies, available TK, professional expertise, and other recent projects in Nunavut and the NIRB's final scoping report (Appendix B of the EIS Guidelines).

To inform the selection of important vegetation, ecosystems, and landform components that need to be considered, information from TK was used from focus group meetings with members of Kitikmeot communities. The *Inuit Traditional Knowledge for TMAC Resources Inc. Proposed Hope Bay Project, Naonaiyaotit Traditional Knowledge Project (NTKP)* (Banci and Spicker 2016; TK report) provides information on terrestrial plant species and valued ecological resources within the Project area. These are described in the Socio-economic and Land Use Baseline (Appendix V6-3A).

NIRB guidelines identified that the assessment of effects should include impacts to unique or valuable landforms, vegetation cover, and species composition as well as changes to abundance and diversity of vegetation.

To include NIRB guidance and consideration of TK in VEC selection for vegetation, a combination of indicators was identified that could provide metrics for the assessment of potential effects to the terrestrial environment and vegetation including: special landscape features, ecosystem types, vegetation species diversity, and vegetation productivity.

8.3.1.2 NIRB Scoping Sessions

Consultation by NIRB with the public and interested parties was completed to scope the VECs in the EIS Guidelines (NIRB, Appendix B). Information from the Public Scoping Meetings provided guidance on concerns about ecosystems and vegetation.

Specific assessments regarding potential Project effects to vegetation, ecosystems, and landforms were identified in the EIS Guidelines (NIRB) and include:

- *Potential impacts to specific vegetation coverage and species composition from construction, operation, and reclamation activities in the Project area;*
- *Assessment of the potential loss, disturbance, and/or changes to vegetation abundance, diversity, and forage quality as a result of Project components and activities, including potential effects from airborne fugitive dust fall, airborne contaminants from emission sources, and changes to water quality and quantity, permafrost, or snow accumulation;*
- *Potential impacts on vegetation abundance and diversity from the transfer/introduction of invasive or exotic species into the LSA via Project equipment and vehicles, including aircraft and marine vessels;*
- *Potential impacts on vegetation quality due to soil erosion, structural soil changes, soil contamination, and fugitive dust and gaseous air emissions from mining, milling and waste management activities* (addressed in this chapter and Landforms and Soils, Volume 4, Chapter 7)*;*

- *Discussion of proposed vegetation monitoring, specifically contaminant levels in species directly consumed by wildlife (e.g., lichen) and/or humans (e.g., Labrador tea, blueberries) and/or indirectly consumed through food consumption (i.e., caribou)* (assessed in Terrestrial Wildlife and Wildlife Habitat, Volume 4, Chapter 9 and Human Health and Environmental Risk Assessment Volume 6, Chapter 5)*;*
- *Discussion of the management measures for minimizing/mitigation of disturbances to plant associations, including progressive reclamation/re-vegetation plans for disturbed areas, and measures to reduce the potential for establishment of invasive species in the area* (addressed in this chapter and Closure and Reclamation, Volume 3, Chapter 5);
- *Potential impacts on contamination of traditional foods as a result of bioaccumulation, i.e. food chain uptake through air, water and soil* (assessed in Human Health and Environmental Risk Assessment, Volume 6, Chapter 5)*;*
- *Potential impact from the loss or alteration of habitat (i.e. vegetation) due to pollutants and noise and its effects on wildlife, wildlife calving grounds and marine habitat* (assessed in this chapter and Terrestrial Wildlife and Wildlife Habitat, Volume 4, Chapter 9)*;*
- *Discuss the potential of invasive vegetative species (weedy species) from sealift activities along the shore line and from transportation along the all-weather road.*
- *General impact on topography in the LSA as a result of Project development, borrow resource extraction, with a focus on sensitive landforms, and those serving as important vegetation and wildlife habitat; Potential impacts to abundance and diversity of vegetation due to Project activities (*addressed in this chapter and Landforms and Soils, Volume 4, Chapter 7*);* and
- *Potential impacts on the abundance and distribution of unique or valuable landforms (e.g., wetlands, eskers and fragile landscapes) from the Project.*

8.3.1.3 TMAC Consultation and Engagement Informing VEC Selection

Community meetings for the Madrid-Boston Project were conducted in each of the five Kitikmeot communities as described in Chapter 3 of Volume 2. The meetings are a central component of engagement with the public and an opportunity to share information and seek public feedback. Overall, the community meetings were well attended. Public feedback (questions, comments, and concerns) about the proposed Project was obtained through open dialogue during Project presentations, through discussions that arose during the presentation of Project materials, and comments provided in feedback forms. Information from these meetings was used to help scope VECs related to vegetation.

8.3.2 Valued Components Included in Assessment

The selected VECs for assessment include Vegetation and Special Landscape Features (landforms). Table 8.3-1 summarizes the VECs included in the assessment and indicates whether each proposed by the EIS Guidelines (NIRB) has either been included as indicated, included as part of another VEC, or otherwise addressed elsewhere in the EIS. The rationale for the inclusion of these VECs and indicators is provided in Sections 8.3.2.1 and 8.3.2.2.

Table 8.3-1. Valued Ecosystem Components Selected for Assessment

Valued Ecosystem Components	Indicators	Traditional Knowledge	NIRB Guidelines	Government	Rationale for Inclusion
Vegetation	• Vegetation community type (ecosystem type) • Productivity • Species Diversity	X	X	X	• Importance for traditional uses; • provides structure, habitat, and forage for Arctic wildlife species; and • vegetation cover and diversity were identified in the EIS guidelines (2012).
Special Landscape Features	• Riparian ecosystems • Rare or sensitive wetlands • Ecosystems that can contain eskers • Cliffs • Bedrock lichen and outcrop ecosystems • Beaches and marine intertidal areas	X	X	X	• Support unique habitat types that provide materials for tools, hunting opportunities, travel corridors; • provide habitat for rare plant species; • habitat for animals including bird species, denning places, forage habitat, and security habitat for wildlife such as wolverine; and • valuable and unique land forms were identified in the EIS Guidelines (NIRB).

8.3.2.1 Vegetation

Inuit culture is linked with wildlife and vegetation and the continuation of functional vegetation communities that support traditional use is integral to the survival of traditional culture and use. Vegetation communities also provide structure, habitat, and forage for Arctic wildlife species.

Based on community consultation and the importance of vegetation in providing food, material for tools, and other TK uses as well as providing important habitat for wildlife species, such as culturally significant species like caribou, vegetation was selected as a VEC. It is vital to understanding the processes of northern ecosystems, terrestrial primary productivity, and food chains (Aiken et al. 2007). To assess potential effects to vegetation, including TK uses, species composition, and changes to abundance and diversity of vegetation, three indicators were identified. These include ecosystem type (also commonly referred to as vegetation community), vegetation species diversity, and vegetation productivity (Table 8.3-2).

Table 8.3-2. Vegetation Features Considered in the Effects Assessment

Indicator	Rationale for Inclusion
Ecosystem Type	Provides a metric for the effects to ecosystem diversity and ecological functions. Ecosystem types are the most refined unit of ecosystem classification and represent effects to distinct vegetation communities.
Vegetation Species Diversity	Species diversity is a measure of community and regional diversity and is used to characterize biodiversity. Effects to ecosystems with high species diversity provide an indication of the effects to local biodiversity.
Vegetation Productivity	Vegetation productivity is metric of site productivity and can indicate habitat value. Highly productive ecosystems, such as riparian habitat, generally have higher biomass, which can provide more forage for animals

Ecosystem Types — Vegetation is mapped as community types, also described as ecosystem types, with similar floristic composition. There are 25 different communities mapped in the TEM for Hope Bay area that can be grouped into three broad categories: Marine vegetation that limited to the edge of the active marine environment; upland ecosystem units associated with bedrock outcrops and till or colluvial deposits found on the lower slopes of the outcrops; and lowland ecosystem units that occur on the extensive lower slopes and plains on lacustrine, marine, and fluvial deposits. Characterizing effects to ecosystem units measures the loss of ecosystem abundance for each unit and potential effects to the functions provided by each unit.

Vegetation Species Diversity — Plant species diversity is determined by climatic conditions, local microclimate, soil nutrient regime, soil moisture regime, soil type, and snow cover (Aiken et al. 2007). Species richness is a measure of community and regional diversity and is used to characterize biodiversity. At the scale of terrestrial ecosystem mapping, species rich ecosystems are those with high ecological variability. To assess effects to plant species diversity, the potential for each ecosystem unit to support diverse species assemblages was characterized.

Individual species of plant and lichen are not assessed directly as many of the species occur across a wide range of mapped ecosystems, with individual presence and cover determined a microsite scale based on site-specific parent material and soil properties. Appendix V4-8A provides a list of the dominant plant species occurring within each of the mapped ecosystems. A list of all flora, rare and common, that were identified during the rare plant surveys is provided in Appendices V4-8B, V4-8C, V4-8D, and V4-8E. Rare plant survey locations are shown in Appendix V4-8E.

Vegetation Productivity —Vegetation productivity is a product of edaphic conditions and local and regional climate. It is a measure of the annual net primary productivity (ANPP) of vegetation. The least productive communities are cryptogram communities that occur on bedrock or very shallow or rapidly drained soils. The greatest productivity rates are found in ecosystems such as riparian willow communities. Productivity can also provide an indication of forage value as high productivity generally results in high above ground biomass and greater availability of forage. For example, muskox overwintering habitat includes sites that are typically lower elevation riparian corridors (P. E. Reynolds, Wilson, and Klein 2002).

8.3.2.2 Special Landscape Features

To assess landforms as they relate to terrestrial ecology and vegetation, Special Landscape Features have been selected as a VEC and indicators have been identified based on their ability to support unique habitat types that provide materials for tools, hunting opportunities, travel corridors, habitat for rare plant species, habitat for animals including bird species, denning places, forage habitat, and security habitat for wildlife such as wolverine. Similar to the selection of these indicators, ecosystems of traditional and cultural importance due to their value as wildlife habitat, including eskers, sedge wetlands, marine shores, and riparian ecosystems were incorporated into habitat suitability models to assess wildlife habitat (Volume 4, Section 9.1.1). Rare plant and lichen species surveys were primarily located in or near proposed Footprints. As a result, assessing effects to rare plants based on known locations does not provide an indication of effects to potential habitat in the LSA. Therefore, ecosystems and landscape features that have greater potential to support rare plant habitat such as cliffs, marine beaches and shores, and certain wetlands are included in the assessment of Special Landscape Features.

The Special Landscape Feature indicators and the rationale behind their selection for this VEC are described below and summarized in Table 8.3-3.

Table 8.3-3. Special Landscape Feature Indicators Considered in the Effects Assessment

Indicator	TEM Map Code	Rationale for Inclusion
Riparian ecosystems and floodplains	RW, FP	Deciduous shrubs are an important food source for ungulates; provide nesting and cover habitat for various wildlife species (e.g. breeding birds); and are used by Inuit for tools, fuel, and hunting.
Sensitive or rare wetlands	WM, PG, OW, EM	These ecosystems provide important habitat to grizzly bears and caribou in the spring. Furthermore, the ecosystems provide food and other materials for Inuit traditional uses. They are sensitive to even minor disturbances.
Dwarf Shrub Heath (Can contain esker complexes)	SH	Dwarf Shrub Heath ecosystem include esker-complexes that provide important denning habitat for mammals such as foxes, wolves, wolverine, and ground squirrels, and travel corridors for many wildlife species; used as travel routes by Inuit peoples. They also may provide conditions for rare plant species.
Bedrock cliff	RO	Steep, exposed bedrock cliffs provide important bird nesting habitat, hunting opportunities for Inuit, and habitat for rare plant species.
Bedrock-lichen veneer ecosystems	CL, BI	Dry, windswept areas support a continuous mat of lichens, an important food source for caribou. These types provide conditions for rare plant species. CL ecosystems may contain eskers complexes.
Beaches, marine backshores and intertidal areas	BE, MB, MI	These marine associated areas provide habitat for rare plant species and are travel and foraging areas for a variety of wildlife species.

Riparian Ecosystems — Riparian ecosystems provide important forage for many species including caribou and grizzly bears, which spend up to 75% of their time in these areas (Volume 4, Section 9.2.8). Tall riparian shrubs are rare on the tundra, but their occurrence provides habitat for a diverse bird community. Deciduous shrubs in riparian areas also provide nesting and cover habitat for various wildlife species, and are used by Inuit for tools, fuel, and hunting areas.

Sensitive or Rare Wetlands — Inuit TK identified wetlands as important areas for calving, as wetlands provided flat areas with a source of water, and provided a source of high quality food for their calves (Banci and Spicker 2016). Wetlands are also important foraging areas throughout summer, predominately in sedge meadows, where caribou can graze up to 50% of the net primary productivity (Jefferies 1992). Fall caribou habitat includes sedge wetland and riparian tall shrub habitats that may also be used depending on the availability of green forage. Wetlands also provide nesting habitat for waterfowl and snowy owls.

Dwarf Shrub Heath (potential esker complexes) — Eskers were mapped as a component of Dwarf Shrub Heath ecosystems. Esker ecosystems provide dens and travel corridors for multiple wildlife species and humans. TK indicates that wolves make their dens where it is easier to dig, such as eskers (Banci and Spicker 2016). Other animals such as foxes and wolverine also often den on eskers. Caribou use eskers as travel routes and rest upon esker crests to avoid insects and heat (Banci and Spicker 2016). Some plant species of cultural value, such as crowberries or blackberries grow well on exposed esker soils.

Bedrock Cliffs — Cliffs and talus features are common locations for rare plant and lichen species. Cliffs provide nesting and perch sites and associated guano and often have calcareous deposits from precipitation of solutes both of which create unique microsite conditions that support rare plant establishment and growth. The temperature, shade, aspect, and snow duration vary from much of the surrounding tundra and that provide unique microsite conditions that support rare plant establishment and growth.

Cliffs provide nesting, denning, foraging, and security, habitat for many bird and mammal species and are important landscape features that provide relief from the heat or insects (Banci and Spicker 2016; Russell, Martell, and Nixon 1993; Skarin et al. 2008; R. R. Wilson et al. 2012; Witter et al. 2012). In the study area, numbers nests of cliff-nesting raptors have been identified (Volume 4, Section 9.2.10). Cliff habitat in the LSA was identified using aerial imagery, data from bird surveys, and identifying slopes in excess of 25%.

Bedrock-lichen Veneer — Bedrock lichen and outcrop ecosystems are typically sparsely-vegetated, occurring within a matrix of bedrock outcrops and shallow, dry soils. These ecosystems are limited in extent and occur on crest positions on bedrock outcrops with very thin morainal or organic veneers. Inuit TK includes observations of wintering caribou in areas where snow is relatively shallow, such as in rocky or elevated wind-swept areas where caribou could more easily crater for lichen (Banci and Spicker 2016).

Beaches, Marine Backshores and Intertidal areas — Beaches and marine intertidal areas provide habitat for rare plant species and are travel and foraging areas for a variety of wildlife. They are also some of the least common landforms in the Project area, comprising less than 1% of the baseline study area.

8.3.3 Valued Components Excluded from the Assessment

No VECs were excluded from assessment. Assessment of terrain features and soils are discussed in Volume 4, Chapter 7, and permafrost and ground stability are assessed in Volume 4, Chapter 6.

8.4 SPATIAL AND TEMPORAL BOUNDARIES

The spatial boundaries selected to shape this assessment were determined by the Project's potential impacts on the Vegetation or Special Landscape Features. The rationale for the selection of spatial boundaries is described below.

Temporal boundaries were selected that consider the different phases of the Project and their durations. The Project's temporal boundaries reflect those periods during which planned activities will occur and have potential to affect Vegetation or Special Landscape Features.

The determination of spatial and temporal boundaries also takes into account the development of the entire Hope Bay Greenstone Belt. The assessment considers both the incremental potential effects of the Project as well as the total potential effects of the additional Project activities in combination with the existing and approved Projects including the Doris Project and advanced exploration activities at Madrid and Boston. The spatial boundaries developed for the assessment of potential effects on Vegetation and Special Landscape Features are described in Section 8.4.2.

8.4.1 Project Overview

The Madrid-Boston Project consists of proposed mine operations at the Madrid North, Madrid South and Boston deposits. The Madrid-Boston Project is part of a staged approach to continuous development of the Hope Bay Project, comprised of existing operations at Doris and bulk samples followed by commercial mining at Madrid North, Madrid South, and Boston deposits. The Madrid-Boston Project would use and expand upon the existing Doris Project infrastructure.

The Madrid-Boston Project is the focus of this application. Because the infrastructure of existing and approved projects will be utilized by the Madrid-Boston Project, and because the existing and approved projects have the potential to interact cumulatively with the Madrid-Boston Project, existing and approved project are described below.

8.4.1.1 Existing and Approved Projects

Existing and approved projects include:

- the Doris Project (NIRB Project Certificate 003, NWB Type A Water Licence 2AM-DOH1323);
- the Hope Bay Regional Exploration Project (NWB Type B Water Licence 2BE-HOP1222);
- the Madrid Advanced Exploration Program (NWB Type B Water Licence 2BB-MAE1727); and
- the Boston Advanced Exploration Project (NWB Type B Water Licence 2BB-BOS1727).

<u>The Doris Project</u>

The Doris Project was approved by NIRB in 2006 (NIRB Project Certificate 003) and licenced by NWB in 2007 (Type A Water Licence 2AM-DOH0713). The Type A Water Licence was amended in 2010, 2011 and 2012 and received modifications in 2009, 2010, and 2011.

Construction of the Doris Project began in early 2010. In early 2012, the Doris Project was placed into care and maintenance, suspending further Project-related construction and exploration activity along the Hope Bay Greenstone Belt. Following TMAC's acquisition of the Hope Bay Project in March of 2013, NWB renewed the Doris Project Type A Water Licence (Type A Water Licence 2AM-DOH1323), and TMAC advanced planning, permitting, exploration, and construction activities. In 2016, NIRB approved an amendment to Project Certificate 003 and NWB granted Amendment No. 1 to Type A Water Licence

2AM-DOH1323, extending operations from two to six years through mining two additional mineralized zones (Doris Connector and Doris Central zones) to be accessed via the existing Doris North portal. Amendment No. 1 to Type A Water Licence 2AM-DOH1323 authorizes a mining rate of approximately 2,000 tonnes per day of ore and a milling throughput of approximately 2,000 tonnes per day of ore. The Doris Project began production early in 2017.

The Doris Project includes the following components and facilities:

- The Roberts Bay offloading facility: marine jetty, barge landing area, beach laydown area, access roads, weather havens, fuel tank farm/transfer station, waste storage facilities and incinerator, and quarry;
- The Doris site: 280 person camp, laydown areas, service complex (e.g., workshop, wash bay, administration buildings, mine dry), two quarries (mill site platform and solid waste landfill), core storage areas, batch plant, brine mixing facilities, vent raise (3), air heating units, reagent storage, fuel tank farm/transfer station, potable water treatment, waste water treatment, incinerator, landfarm and handling/temporary hazardous waste storage, explosives magazine, and diesel power plant;
- Doris Mine works and processing: underground portal, overburden stockpile, temporary waste rock pile, ore stockpile, and ore processing plant (mill);
- Tailings Impoundment Area (TIA): Schedule 2 designation for Tail Lake with two dams (North and South dams), sub-aerial deposition of flotation tailings, emergency tailings dump catch basins, pump house, and quarry;
- All-season main road with transport trucks: Roberts Bay to Doris site (4.8 km, 150 to 200 tractor and 300 fuel tanker trucks/year);
- Access roads from Doris site used predominantly by light-duty trucks to: the TIA, the explosives magazine, Doris Lake float plane dock (previously in use), solid waste disposal site, and to the tailings decant pipe, from the Roberts Bay offloading facility to the location where the discharge pipe enters the ocean; and
- All-weather airstrip (914 m), winter airstrip (1,524 m), helicopter landing site and building, and Doris Lake float plane and boat dock.

Water is managed at the Doris Project through:

- freshwater input from Doris Lake for mining, milling, and associated activities and domestic purposes;
- freshwater input from Windy Lake for domestic purposes;
- process water input primarily from the TIA reclaim pond;
- surface mine contact water discharged to the TIA;
- underground mine contact water directed to the TIA or to Roberts Bay via the marine outfall mixing box (MOMB);
- treated waste water discharged to the TIA; and
- water from the TIA treated and discharged to Roberts Bay via a discharge pipeline, with use of a MOMB.

Hope Bay Regional Exploration Project

The Hope Bay Regional Exploration Project has been renewed several times since 1995. The current extension expires in June 2022. Much of the previous work for the program was based out of Windy Lake and Boston camps. These camps were closed in October 2008 with infrastructure either decommissioned or moved to the Doris site. All exploration activities are now based from the Doris site. Components and activities for the Hope Bay Regional Exploration Project include:

- operation of helicopters from Doris; and
- the use of exploration drills, which are periodically moved by roads and by helicopter as required.

Madrid Advanced Exploration

In 2017, the NWB issued a Type B Water Licence (2BB-MAE1727) for the Madrid Advanced Exploration Program to support continued exploration and a bulk sample program at the Madrid North and Madrid South sites, located approximately 4 km south of the Doris site. The program includes extraction of a bulk sample totaling 50 tonnes from each of the Madrid North and South locations, which will be trucked to the mill at the Doris site for processing and placement of tailings in the tailings impoundment area (TIA). All personnel will be housed in the Doris camp.

The Madrid Advanced Exploration Program includes the following components and activities.

- Use of existing infrastructure associated with the Doris Project:
  - camp facilities to support up to 70 personnel as required to undertake the advanced exploration activities;
  - mill to process ore;
  - TIA;
  - landfill and hazardous waste areas, particularly if closure and remediation becomes required for the Madrid Advanced Exploration Program infrastructure;
  - fuel tank farms; and
  - Doris airstrip and Roberts Bay facility for transport of personnel and supplies.
- Use of existing infrastructure at the Madrid and Boston areas:
  - borrow and rock quarry facilities: existing Quarries A, B, and D along the Doris-Windy all-weather road (AWR);
  - AWR between Doris and Windy Lake for transportation of personnel, ore, waste, fuel, and supplies; and
  - future mobilization of existing exploration site infrastructure, should it become necessary.
- Construction of additional facilities at Madrid North and South:
  - access portals and ramps for underground operations at Madrid North and at Madrid South;
  - 4.7 km extension of the existing AWR originating from the Doris to the Windy exploration area (Madrid North) to the Madrid South deposit, with branches to Madrid North, Madrid North vent raise, and the Madrid South portal;
  - development of a winter road route (WRR) from Madrid North to access Madrid South until AWR has been constructed;
  - borrow and rock quarry facilities; two quarries referenced as Quarries G and H;

    - waste rock and ore stockpiles;
    - water and waste management structures; and
    - additional site infrastructure, including compressor building, brine mixing facility, saline storage tank, air heating facility, four vent raises, workshop and office, laydown area, diesel generator, emergency shelter, fuel storage facility/transfer station.

- Undertaking of advanced exploration access to aforementioned deposits through:
    - continue field mapping and sampling, as well as airborne/ground/downhole geophysics;
    - diamond drilling from the surface and underground; and
    - bulk sampling through underground mining methods and mine development.

Boston Advanced Exploration

The Boston Advanced Exploration Project Type B Water Licence No. 2BB-BOS1217 was renewed as Water Licence No. 2BB-BOS1727 in July 2017 and includes:

- the Boston camp (65 person), maintenance shops, workshops, laydown areas, water pumphouse, vent raise, warehouse, site service roads, sewage and greywater treatment plant, fuel storage and transfer station, landfarm, solid waste landfill and a heli-pad;
- mine works, consisting of underground development for exploration drilling and bulk sampling, waste rock and ore stockpiles;
- potable water and industrial water from Aimaokatalok Lake; and
- treated sewage and greywater discharged to the tundra.

8.4.1.2 The Madrid-Boston Project

The Madrid-Boston Project includes: the Construction and Operation of commercial mining at the Madrid North, Madrid South, and Boston sites; the continued operation of Roberts Bay and the Doris site to support mining at Madrid and Boston; and the Reclamation and Closure and Post-closure phases of all sites. Excluded from the Madrid-Boston Project for the purposes of the assessment are the Reclamation and Closure and Post-closure components of the Doris Project as currently permitted and approved.

Construction

Madrid-Boston construction will use the infrastructure associated with Existing and Approved Projects. This may include:

- an all-weather airstrip at the Boston exploration area and helicopter pad;
- seasonal construction and/or operation of a winter ice strip on Aimaokatalok Lake;
- Boston camp with expected capacity for approximately 65 people during construction
- Quarry D Camp with capacity for up to 180 people;
- seasonal construction/operation of Doris to Boston WRR;
- three existing quarry sites along the Doris to Windy AWR;
- Doris camp with capacity for up to 280 people;
- Doris airstrip, winter ice strip, and helicopter pad;
- Roberts Bay offloading facility and road to Doris; and

- Madrid North and Madrid South sites and access roads.

Additional infrastructure to be constructed for the proposed Madrid-Boston Project includes:

- expansion of the Doris TIA (raising of the South Dam, construction of West Dam, development of a west road to facilitate access, and quarrying, crushing, and screening of aggregate for the construction);
- construction of a cargo dock at Roberts Bay (including a fuel pipeline, mooring points, beach landing and gravel pad, shore manifold);
- construction of an additional tank farm at Roberts Bay (consisting of two 10 ML tanks);
- expansion of Doris accommodation facility (from 280 to 400 person), mine dry and administrative building, water treatment at Doris site;
- expansion of the Doris mill to accommodate concentrate handling on the south end of the building facility and rearrangement of indoor crushing and processing within the mill building;
- complete development of the Madrid North and Madrid South mine workings;
- incremental expansion of infrastructure at Madrid North and Madrid South to accommodate production mining, including vent raise, access road, process plant buildings;
- construction of a 1,200 tpd concentrator, fuel storage, power plant, mill maintenance shop, warehouse/reagent storage at Madrid North;
- all weather access road and tailings line from Madrid North to the south end of the TIA;
- AWR linking Madrid to Boston (approximately 53 km long, nine quarries for permitting purposes, four of which will likely be used);
- all-weather airstrip, airstrip building, helipad and heliport building at Boston;
- construction of a 2,400 tpd process plant at Boston;
- all infrastructure necessary to support mining and processing activities at Boston including construction of a new 300-person accommodation facility, mine office and dry and administration buildings, additional fuel storage, laydown area, ore pad, waste rock pad, diesel power plant and dry-stack tailings management area (TMA);
- infrastructure necessary to support ongoing exploration activities at both Madrid and Boston; and
- wind turbines near the Doris (2), Madrid (2), and Boston (2) sites.

<u>Operation</u>

The Madrid-Boston Project Operation phase includes:

- mining of the Madrid North, Madrid South, and Boston deposits by way of underground portals and Crown Pillar Recovery;
- operation of a concentrator at Madrid North;
- transportation of ore from Madrid North, Madrid South, and Boston to the Doris process plant, and transporting the concentrate from the Madrid North concentrator to the Doris process plant;
- extending the operation at Roberts Bay and Doris;

- processing the ore and/or concentrate from Madrid North, Madrid South, and Boston at the Doris process plant with disposal of the detoxified tailings underground at Madrid North, flotation tailings from the Doris process plant pumped to the expanded Doris TIA, and discharge of the TIA effluent to the marine environment;
- operation of a concentrator at Madrid North and disposal of tailings at the Doris TIA;
- operation of a process plant and wastewater treatment plant at Boston with disposal of flotation tailings to the Boston TMA and a portion placed underground and the detoxified leached tailings placed in the underground mine at Boston;
- operation of two wind turbines for power generation; and
- ongoing maintenance of transportation infrastructure at all sites (cargo dock, jetty, roads, and quarries).

Reclamation and Closure

Areas which are no longer needed to carry out Madrid-Boston Project activities may be reclaimed during Construction and Operation.

At Reclamation and Closure, all sites will be deactivated and reclaimed in the following manner (see Volume 3, Chapter 5):

- Camps and associated infrastructure will be disassembled and/or disposed of in approved non-hazardous site landfills.
- Non-hazardous landfills will be progressively covered with quarry rock, as cells are completed. At final closure, the facility will receive a final quarry rock cover which will ensure physical and geotechnical stability.
- Rockfill pads occupied by construction camps and associated infrastructure and laydown areas will be re-graded to ensure physical and geotechnical stability and promote free-drainage, and any obstructed drainage patterns will be re-established.
- Quarries no longer required will be made physically and geotechnically stable by scaling high walls and constructing barrier berms upstream of the high walls.
- Landfarms will be closed by removing and disposing of the liner, and re-grading the berms to ensure the area is physically and geotechnically stable.
- Mine waste rock will be used as structural mine backfill.
- The Doris TIA surface will be covered waste rock. Once the water quality in the reclaim pond has reached the required discharge criteria, the North Dam will be breached and the flow returned to Doris Creek.
- The Madrid to Boston AWR and Boston Airstrip will remain in place after Reclamation and Closure. Peripheral equipment will be removed. Where rock drains, culverts or bridges have been installed, the roadway or airstrip will be breached and the element removed. The breached opening will be sloped and armoured with rock to ensure that natural drainage can pass without the need for long-term maintenance.
- A low permeability cover, including a geomembrane, will be placed over the Boston TMA. The contact water containment berms will be breached and the liner will be cut to prevent collecting any water. The balance of the berms will be left in place to prevent localized permafrost degradation.

8.4.2 Spatial Boundaries

8.4.2.1 Project Development Area

The Project Development Area (PDA) is shown in Figure 8.4-1 and is defined as the area which has the potential for infrastructure to be developed as part of the Madrid-Boston Project. The PDA includes engineering buffers around the footprints of structures. These buffers allow for refinement in the final placement of a structure through detailed design and necessary in-field modifications during Construction phase. Areas with buildings and other infrastructure in close proximity are defined as pads with buffers whereas roads are defined as linear corridors with buffers. The buffers for pads varied depending on the local physiography and other buffered features such as sensitive environments or riparian areas. The average engineering buffer for roads is 100 m on either side. All areas within the PDA are considered lost in the effects assessment.

Since the infrastructure for the Doris Project is in place, the PDA exactly follows the footprints of these features. In all cases, the PDA does not include the Madrid-Boston design buffers applied to potentially environmentally sensitive features. These are detailed in Volume 3, Chapter 2 (Project Description).

Since the infrastructure for the Doris Project is already in place, the Footprint of these features are well defined, and the Footprint for Madrid are also well defined due to the advanced state of engineering. A PDA, used only for the Vegetation and Special Landscape Features chapter, was created beyond the footprints of these features using a 100-m buffer. This was done to address any potential minor disturbances such as trampling by foot traffic that currently exist or may occur and affect vegetation. This PDA applies to the assessment of potential effects of the complete Hope Bay Project and includes the PDA areas for Madrid-Boston.

In all cases, the PDA does not include the Project design buffers applied to potentially environmentally sensitive features. These are detailed in Volume 3, Chapter 2 (Project Description).

8.4.2.2 Local Study Area

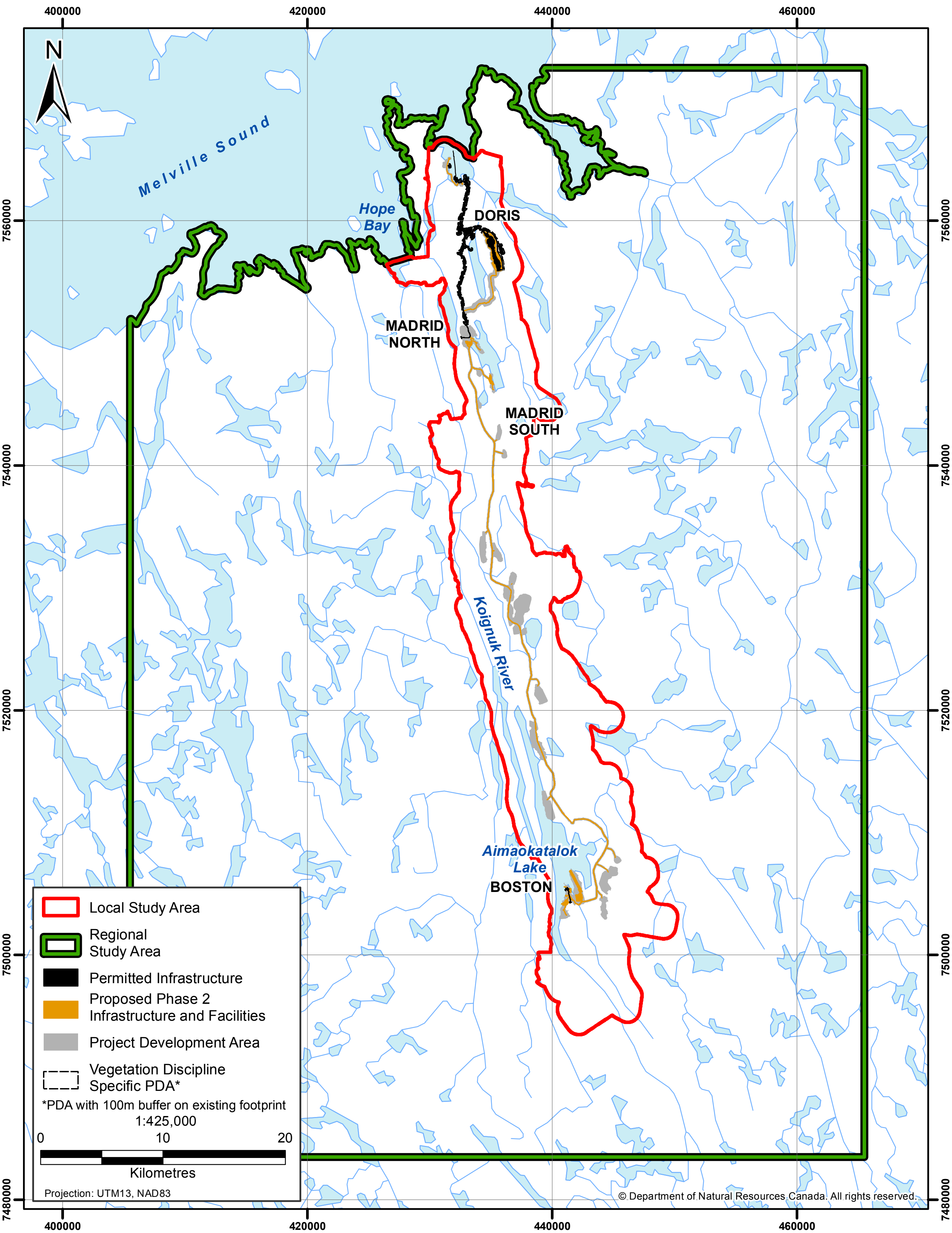
The Local Study Area (LSA), which includes the PDA, is the area within which there is a reasonable potential for immediate effects on a VECs due to an interaction with a Project component or physical activity (Figure 8.4-1). The Vegetation LSA does not include marine waters (Figure 8.4-1).

The LSA extends from approximately 1 km from Project infrastructure and up to 5 km in some areas. The LSA is the same as the Terrestrial Wildlife and Wildlife Habitat LSA and is defined by a combination of sub-watershed boundaries and buffers surrounding proposed Project components including use of Hope Bay Project infrastructure and roads. The LSA covers an area of approximately 56,340 ha. This boundary was selected based on empirical data and expert opinion regarding the scale at which immediate and localized disturbances typically occur.

8.4.2.3 Regional Study Area

The Regional Study Area (RSA) includes the LSA and an approximate 30 km buffer surrounding all proposed Project infrastructure and road corridors. It includes the broader spatial area representing the maximum limit where potential effects may occur (Figure 8.4-1). The RSA is the cumulative effects assessment study area for Vegetation and Special Landscape Features as per the EIS guidelines (NIRB). The RSA is the same as the Terrestrial Wildlife and Wildlife Habitat LSA and is 490,404 ha. The size of the RSA was designed to include habitat and ecosystems for wildlife with larger home range sizes that could potential come into contact with or be affected by activities in the PDA.

Figure 8.4-1
Project Development Area, Local Study Area, and Regional Study Area



8.4.3 Temporal Boundaries

The Project represents a significant development in the mining of the Hope Bay Greenstone Belt. Even though the Madrid-Boston Project spans the conventional Construction, Operation, Reclamation and Closure, and Post-closure phases of a mine project, Madrid-Boston is a continuation of development currently underway. Madrid-Boston has four separate operational sites: Roberts Bay, Doris, Madrid (North and South), and Boston. The development of these sites is planned to be sequential. As such, the temporal boundaries of this Project overlap with a number of Existing and Approved Authorizations (EAAs) for the Hope Bay Project and the extension of activities.

For the purposes of the EIS, distinct phases of the Project are defined (Table 8.4-1). It is understood that Construction, Operation and Closure activities will, in fact, overlap among sites; this is outlined in Table 8.4-1 and further described in Volume 3, Chapter 2 (Project Description).

The assessment also considers a Temporary Closure phase should there be a suspension of Project activities during periods when the Project becomes uneconomical due to market conditions. During this phase, the Project would be under care and maintenance. This could occur in any year of Construction or Operation with an indeterminate length (one- to two-year duration would be typical).

Table 8.4-1. Temporal Boundaries for the Effects Assessment for Vegetation and Special Landscape Features

Phase	Project Year	Calendar Year	Length of Phase (Years)	Description of Activities
Construction	1 - 4	2019 - 2022	4	• **Roberts Bay:** construction of access road (Year 1), marine dock and additional fuel facilities (Year 2 – Year 3); • **Doris**: expansion of the Doris TIA and accommodation facility (Year 1); • **Madrid North:** construction of concentrator and road to Doris TIA (Year 1 – Year 2); • **All-weather Road**: construction (Year 1 – Year 3); • **Boston**: site preparation and installation of all infrastructures including process plant (Year 2 – Year 5).
Operation	5 - 14	2023 - 2032	10	• **Roberts Bay**: sealift operations (Year 1 – Year 14) • **Doris**: processing and infrastructure use (Year 1 – Year 14); • **Madrid North:** mining (Year 1 – 13); ore transport to Doris process plant (Year 1 -13); ore processing and concentrate transport to Doris process plant (Year 2 – Year 13); • **Madrid South:** mining (Year 11 – Year 14); ore transport to Doris process plant (Year 11 – Year 14); • **All-weather Road**: operational (Year 4 – Year 14); • **Boston**: winter access road operating (Year 1 – Year 3); mining (Year 4 – Year 11); ore transport to Doris process plant (Year 4 – Year 6); and processing ore (Year 5 – Year 11).

Phase	Project Year	Calendar Year	Length of Phase (Years)	Description of Activities
Reclamation and Closure	15 - 17	2033 - 2035	3	• **Roberts Bay**: facilities will be operational during closure (Year 15 – Year 17); • **Doris**: camp and facilities will be operational during closure (Year 15 – Year 17); mine, process plant, and TIA decommissioning (Year 15 – Year 17); • **Madrid North:** all components decommissioned (Year 15 – Year 17); • **Madrid South:** all components decommissioned (Year 15 – Year 17); • **All-weather Road**: road will be operational (Year 15 – Year 16); decommissioning (Year 17); • **Boston**: all components decommissioned (Year 15 – Year 17).
Post-Closure	18 - 22	2036 - 2040	5	• **All Sites:** Post-closure monitoring.
Temporary Closure	NA	NA	NA	• **All Sites:** Care and maintenance activities, generally consisting of closing down operations, securing infrastructure, removing surplus equipment and supplies, and implementing on-going monitoring and site maintenance activities.

8.5 PROJECT-RELATED EFFECTS ASSESSMENT

8.5.1 Methodology Overview

This assessment was informed by a methodology used to identify and assess the potential environmental effects of the Project and is consistent with the requirements of Section 12.5.2 of the Nunavut Agreement and the EIS Guidelines (NIRB). The effects assessment evaluates the potential direct and indirect effects of the Project on the environment and follows the general methodology provided in Volume 2, Chapter 4 (*Effects Assessment Methodology*), and comprises a number of steps that collectively assess the manner in which the Project will interact with VECs defined for the assessment (Section 8.3).

To provide a comprehensive understanding of the potential effects for the Project, the Project components and activities are assessed on their own as well as in the context of the Approved Projects (Doris and exploration) within the Hope Bay Greenstone Belt. The effects assessment process is summarized as follows:

1. Identify potential interactions between the Project and the VECs or VSECs;
2. Identify the resulting potential effects of those interactions;
3. Identify mitigation or management measures to eliminate or reduce the potential effects;
4. Identify residual effects (potential effects that would remain after mitigation and management measures have been applied) for Madrid-Boston in isolation;
5. Identify residual effects of Madrid-Boston in combination with the residual effects of Approved Projects; and
6. Determine the significance of combined residual effects.

To assess potential interaction between the Madrid-Boston Project and Hope Bay Project and VECs, the potential loss and alteration of the mapped area (in hectares) of Vegetation indicators and Special Landscape Feature indicators within the PDA was compared to baseline conditions. The total loss and alteration for each VEC were used in the assessment of potential Madrid-Boston and Hope Bay Project residual effects. The areas affected for each Vegetation indicator and Special Landscape Feature are reported as a percentage of the baseline area of the LSA.

8.5.2 Identification of Potential Effects

Potential effects of the Project on Vegetation and Special Landscape Features follow one of two pathways: 1) Madrid-Boston Project component interaction that causes loss due to clearing or grubbing; or 2) component interaction resulting in alteration to Vegetation and Special Landscape Features.

The EIS Guidelines (NIRB) identified concerns about potential effects that were raised during public consultation. They include:

- potential loss, disturbance, and/or changes to vegetation coverage and species composition, abundance, vegetation species diversity, and forage quality as a result of Project activities and components;
- potential effects from airborne fugitive dust fall, airborne contaminants from emission sources, and changes to water quality and quantity, permafrost, or snow accumulation;
- impacts on vegetation quality due to soil erosion, structural soil changes, soil contamination, sewage discharge, and fugitive dust and gaseous air emissions from mining, milling and waste management activities;
- impacts on vegetation abundance and species diversity from the transfer/introduction of invasive or exotic species;
- potential of invasive vegetative species (weedy species) from sealift activities along the shore line and from transportation along the all-weather road; and
- potential impacts on the abundance and distribution of unique or valuable landforms (e.g., wetlands, eskers and fragile landscapes).

8.5.2.1 Potential Effects due to Loss of Vegetation and Special Landscape Features

Potential loss of VECs within the footprint will occur primarily during Construction and Operation phases. Minor additional loss could occur during Reclamation and Closure or Post Closure. The amount of loss is calculated by overlaying the PDA with Vegetation and Special Landscape Feature indicators (Table 8.5-1). The use of a PDA versus Footprint losses was selected to account for site level differences in siting infrastructure and to provide flexibility that may be required during final engineering.

Table 8.5-1. Summary of Footprint and PDA Area for Madrid-Boston and Hope Bay Project

Project	PDA (ha)	Footprint Area (ha)	Percent Footprint of PDA
Madrid-Boston	4,188.9	1,463.5	35
Hope Bay Project	4,706.1	1,695.8	36

As the entire PDA is assessed as lost, the PDA overestimates the total area that will be altered or lost due to the Project. Despite this overestimate of affected area, the PDA is used to assess residual effects. To provide an indication of the difference between PDA losses and actual losses, the loss according to Footprint clearing is shown but not assessed. Clearing of vegetation and grubbing during site preparation for the various facilities will cause the greatest amount of loss in the early stages of construction.

The potential loss of Vegetation is characterized and reported based on the potential effects to Vegetation indicators, which include ecosystem types, vegetation species diversity and productivity. Assessment of loss is based on the areas lost in the PDA relative to total abundance in the LSA. The indicators were selected to represent ecosystem functions and characteristics identified in the EIS Guidelines (NIRB) such as vegetation cover, species composition abundance, and species diversity.

The loss of Vegetation and Special Landscape Features VECs in the PDA (which incorporates both loss and alteration effects) is assessed as a net change (in hectares) and expressed as a percentage of baseline distribution availability within the LSA.

8.5.2.2 Potential Effects due to Alteration of Vegetation and Special Landscape Features

For plants, ecosystems provide the biotic and abiotic conditions upon which they rely to obtain nutrients, water, and sunlight. Alteration of environmental conditions can cause changes in the functions of an ecosystem or the suitability of an area to support certain vegetation types or rare plants. The magnitude and direction (positive or negative) of the change depends on the type and scale of an effect and the ecosystem or species being considered.

Beyond the bounds of the PDA, potential edge effects may occur that can alter ecosystem functions or directly affect Vegetation or Special Landscape Feature indicators.

The potential effects that could alter Vegetation and Special Landscape VECs include: soil disturbance, invasive plant species, fugitive dust, changes in water quality or quantity, and changes in permafrost and snow accumulation. These are discussed below.

Vegetation alteration can be caused by activities that create bare soil, thus enabling the establishment of invasive plant propagules and increasing potential for soil erosion and alteration of soil structural characteristics. Ecosystem and vegetation recovery from disturbance in Arctic environments is slow (Miller 1989; Forbes, Ebersole, and Strandberg 2001). Disturbances that could result from the Project include trampling of vegetation, removal, or disturbance of the organic layers, and rutting of soil from vehicles and machinery.

Invasive species can negatively affect native plant and animal communities, especially where native biodiversity has been reduced by other impacts (Dukes 2002). The effects of invasive species on native diversity have been well documented, are growing in magnitude, and are the second greatest threat to listed species after habitat loss (Wilcove et al. 1998; Enserink 1999).

Introduction of invasive species due to sealift activities results in primarily marine invasive species such algae, crustaceans, and molluscs not terrestrial invasive plant species (Ruiz et al. 2000). Most terrestrial invasive plant species spread is associated with road corridors, not shipping routes. However, cargo on ships can provide a mechanism for the introduction of terrestrial invasive plant species once the cargo is transported to land, which is described below.

The introduction and spread of invasive or exotic plant species could occur as a result of equipment and vehicles, including from aircraft, marine vessels, sealift activities along the shore line, and from transportation along the all-weather roads. Invasive plants can alter the productivity, diversity, and abundance of native vegetation, as they can out-compete and displace native vegetation (Haber 1997).

Invasive species favour recently disturbed areas, such as road edges. One of the principle distribution mechanism for the dispersal of invasive species is mud on vehicles that contains seeds or vegetative matter. Ground disturbance during construction and operation activities may create conditions that favour the establishment and spread of invasive species (Invasive Species Council of British 2017). Weed seeds may be dispersed accidentally by machinery and establish in disturbed areas where native vegetation has been reduced or stripped. Once established, seeds from new populations may be carried by wildlife, wind, and water to new locations. Invasive species can often out-compete native vegetation, especially on disturbed sites. Depending on the species present and their abundance, invasive plant species can decrease vegetation species diversity and productivity and increase the difficulty of reclamation (Polster 2005).

Vegetation could be altered by airborne fugitive dustfall and contaminants, including increases in metal concentrations. Airborne contaminants from emission sources include transport, mining, milling, or waste management activities. Fugitive dustfall includes NO_x and SO_x, which can affect lichens and other sensitive plants, depending on the amount and frequency of dusting, the chemical properties of the dust, and the receptor plant species. In addition to blocking photosynthesis, respiration, and transpiration, dust can also cause physical injuries to plants (Farmer 1993).

Long-term cumulative effects of dust fall, sedimentation, or sewage can result in a shift in vegetative communities and change habitat functions. Dust impacts can be substantial in areas such as road sides where the traffic rate is high (Padgett et al. 2008). As the Arctic lacks tall vegetation, the spread of dust and can be greater than treed ecosystems. Discharge of sewage can alter the nutrient and soil moisture regimes, affecting vegetation community productivity and plant species abundance.

The chemical effects of deposited dust often have greater impacts than the quantity of dust (Farmer 1993). Chemical effects can result from direct deposition on foliage or other tissues or through uptake through fine roots from the soil. Plant growth may be affected by dust-induced changes in soil pH, nutrient availability, radiation absorption, and leaf temperature and chemistry (Eller 1977; McCune 1991; Walker and Everett 1991; Farmer 1993; CEPA/FPAC Working Group on Air Quality Objectives and Guidelines 1998; Anthony 2001). Evergreen shrubs may experience greater cumulative dusting than deciduous shrubs as they retain leaves from year to year (Auerbach, Walker, and Walker 1997). Chemically active dusts that are alkaline, acidic, or bio-available will have the largest effects on vegetation, ecosystem, and biochemical pathways (Grantz, Garner, and Johnson 2003).

Soil pH may be altered by dust inputs. The effects of pH changes on ecosystems such as wetlands can include the loss of listed species, and alterations to functional diversity and habitat functions. The effects of pH change are species dependent. Species tolerant of high or low pH conditions will respond positively within a range of acidity levels, outside of which they will generally decline (Farmer 1990). As acidity increases, there is a general decrease in species diversity in lacustrine wetlands and a presumed loss of functional diversity (Farmer 1990). The effects of pH changes are more pronounced on invertebrates, fish, and birds and include a general decrease in habitat quality associated with greater acidity (Sheldon 2005). Soil pH and soil sensitivity to eutrophication are discussed in greater detail in Soils and Landforms (Volume 5, Chapter 7).

A study of the impacts from dust adjacent to high-speed gravel highways in Arctic Alaska showed reduced albedo resulting in earlier snowmelt, which attracts raptors, waterfowl, ptarmigan, caribou, grizzly bears and other predators in early spring to the snow-free vegetation within 30 m to 100 m of the roads (Walker and Everett 1991). Other dust related changes noted roadside included thermokarst features, or irregular patterns of slumps and depressions. A maximum dustfall of 300 m along roads, with no dust effects beyond this zone has been reported (Auerbach, Walker, and Walker 1997). This is similar to dustfall estimates for the Madrid-Boston Project that indicate the majority of dustfall is predicted within 500 m of most infrastructure and 250 of roads (Volume 4, Chapter 2; Appendix V4-2I).

Other potential minor degradation effects to vegetation VECs related to the Project include: changes to water quality and quantity, permafrost, and snow accumulation. Localized degradation could result from development and use of the winter roads, including damage to tussock tundra ecosystems and short-term reductions in the active growth layer thickness (Gary Schultz, Alaska Department of Natural Resources, in Bailey 2012). While Project activities can affect water features, avoidance of these features was considered in the Project design (Volume 3, Chapter 2). Where avoidance was not possible, crossings have been designed to mitigate potential effects, including changes in water quantity or quality and the associated effects on terrestrial ecosystems. The crossing of water features was avoided as much as possible to minimize potential effect on terrestrial ecosystems. Potential effects to water quality and quantity are assessed in Volume 5, Chapter 4, and potential effects to permafrost and snow accumulations are discussed in Volume 4, Chapter 6. Where these effects may alter vegetation VECs, mitigation measures are presented in Section 8.5.3 and residual effects are considered in Section 8.5.4.

8.5.2.3 Predicted Project Component Interactions with Vegetation and Landscape Features

Table 8.5-2 summarizes the main Project activities and components that are expected to result in the loss or alteration of Vegetation and Special Landscape Features. Effects due to loss of Vegetation and Special Landscape Features are predominantly anticipated during Construction phase; however, most alteration will occur during the Operation phase.

Table 8.5-2. Project Interaction with Vegetation and Special Landscape Features

	Madrid-Boston Effect			
	Vegetation		Special Landscape Features	
Project Component / Activity	**Loss**	**Alteration**	**Loss**	**Alteration**
Construction				
Expansion of Roberts Bay facility	X	X	X	X
Expansion of the Doris Site	X	X	X	X
Construction of the Madrid – Boston All-weather Road	X	X	X	X
Construction of the Boston Site	X	X	X	X
Operations and Closure				
Operation of the Roberts Bay facility		X		X
Operation of Doris Site		X		X
Operation of the expanded TSF		X		X
Continued operation of Madrid North and South Sites		X		X
Operation the Madrid – Boston All-weather Road		X		X
Operation of the Boston Site		X		X

8.5.3 Mitigation and Adaptive Management

Mitigation and management measures were determined based on potential Project effects, professional judgement, and scientific literature. Mitigation measures were developed to address potential effects based on the concept of the mitigation hierarchy, which includes (in order of priority) avoidance, minimization of effects, and restoration on-site environmental values. The hierarchy identifies avoidance of impacts on environmental values as the highest priority mitigation measure because of effectiveness. Mitigation measures to address effects to Vegetation and Special Landscape Features are described below.

8.5.3.1 Mitigation by Project Design

To avoid potential Project effects, baseline information was used to develop environmental sensitivity maps to inform design and reduce potential effects to Vegetation and Special Landscape Features. Terrestrial ecosystem surveys and mapping, vegetation surveys, terrain and soil mapping, and rare plant surveys were used to identify ecosystems and vegetation that are often considered rare or sensitive, due to their scarcity on the landscape, special habitat features they provide, and/or cultural importance (Table 8.1-1).

Reducing potential effects by avoidance is, where practicable, the most effective mitigation measure to reduce the potential for serious damage or harm. Hence, the locations of these features were identified and the Project infrastructure was relocated, where feasible, to avoid effects to these features (Figure 8.5-1). As described above, the effectiveness of avoidance measures is very high. Additional setback used to inform Project design include:

- 31-m setbacks from riparian areas, streams and waterways, or a 51-m setback where possible;
- minimum 30-m buffer zone from known rare plants;
- minimize Project footprint to reduce habitat loss and alteration;
- maintain a buffer zone from important bird nesting areas;
- develop site-specific mitigations in cases where the minimum buffer cannot be achieved, such as working under the direction of an archaeologist for certain sites;
- reduced effects to riparian and wetland habitat by routing roads, far as is practical, from streams, channel crossings, and wet, boggy areas where fish habitat may be disturbed; and
- no allowance for disturbance of the tundra vegetation, permafrost, or soils is allowed outside of the airstrip and road footprints.

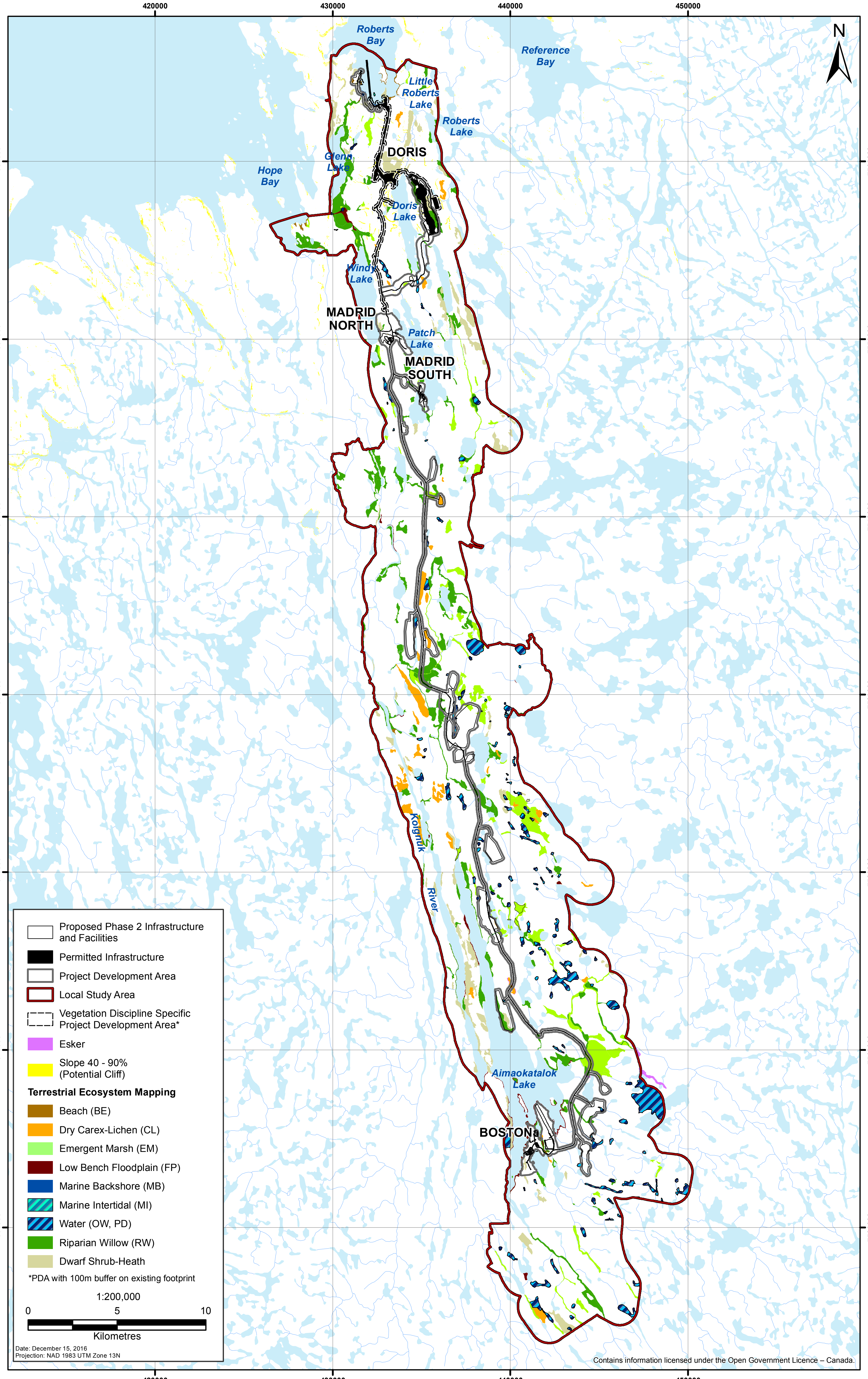
The Preliminary Mine Closure and Reclamation Plan (Volume 8, Chapter 4) identifies measures, including progressive reclamation for disturbed areas, that will help reclaim losses of Vegetation and Special Landscape Features.

8.5.3.2 Best Management Practices

Best management practices (BMPs) which address potential effects of vehicles and heavy mobile equipment on Vegetation and Special Landscape features include:

- a speed limit of no more than 50 km/hr will be set and enforced on all Phase Project roads to reduce dust generation;
- all equipment maintained to reduce potential spills;
- vehicles restricted to site roads and quarry footprints and ice roads; and
- dust control will be carried out, as needed, on all-season roads.

Figure 8.5-1
Environmental Sensitivity Mapping used to Inform Project Design



Best management practices will also be used to manage fuels, hazardous materials to prevent spills and to contain and clean up any spills that may occur, including:

- The *Spill Contingency Plan* (Volume 1, Annex V1-7, Package P4-3) is designed to protect worker and public safety and minimize any effects of a spill of fuel, soluble solids, liquids like solvents or paint, flammable gases, and other hazardous substances on the environment.
- The *Oil Pollution Prevention Plan* (Volume 8, Annex V8-1) describes the responses to oil spill scenarios at the Roberts Bay facility and is a requirement of the *Canada Shipping Act* (2001).
- The *Hazardous Waste Management Plan* (P4-15) outlines the safe handling requirements, storage, transportation, disposal, and reporting of hazardous materials at Project sites.

8.5.3.3 Mitigation Measures for Specific Potential Effects or VECs

Rare Plant and Lichen Mitigation Measures

In addition to the avoidance measures identified for rare plants and lichens, management and mitigation measures for rare plants and lichens will include the following:

- include the location of known rare plants/lichens on Project maps to allow for incorporation into project planning;
- create exclusion zones (i.e., temporary fences) around priority rare plant and lichen habitats where these are close to proposed infrastructure to avoid disturbance; and
- make site-specific adjustments, where feasible, to avoid identified rare plants.

Invasive Plant Species Management

The management objective is to avoid the introduction and spread of invasive plant species that may affect native vegetation or wildlife. Due to the remote location of the Project, the focus of invasive plant species management will be on reducing the probability of the introduction and spread of invasive plant species.

There is no invasive plant species legislation in Nunavut and the Federal government does not regulate invasive plant species but have developed *An Invasive Alien Species Strategy for Canada*[1] that provides guidance. Guidance documents from BC have been identified that will help inform invasive plant species management. These include:

- Integrated Vegetation Management Plan: For Transmission Rights-of-way (BC Hydro 2010);
- Invasive Alien Plant Program: Reference Guide (BC MFLNRO 2010);
- Pest Management Plan for Invasive Alien Plants on Provincial Crown Lands in Central and Northern British Columbia (BC MOFR 2015); and
- Invasive Species Council of British Columbia (ISCBC 2017).

Invasive plant species management for the Project will be informed by the *Pest Management Plan for Invasive Alien Plants on Provincial Crown Lands in Central and Northern British Columbia* (BC MOFR 2015), which outlines an integrated pest management (IPM) approach for invasive plants.

Management recommendations address general management (regardless of ecosystem) to minimize risk from invasive plant material being brought into the Project area, management measures to ensure the early detection and eradication of invasive plants, and on-site education and training.

As preventing the introduction of invasive plant species is the most effective measure, vehicles (bulldozers, mine trucks, excavators, etc.) will be thoroughly inspected before transport to the site. Vehicles will be washed at an appropriate location to remove dirt or plant propagules. Vehicles and equipment will be inspected prior to being used on the Hope Bay Project site as a secondary measure. During security checks for personnel working or visiting the site, inspections will be conducted of boots and other items such as shovels that are likely to transport invasive species. All items with soil or plant material will be cleaned prior to transport to the site.

Invasive species thrive in recently disturbed areas where there is little shade or competition from other plant species; therefore, minimizing ground disturbance reduces the opportunity for invasive plant establishment (J. Clark 2003; Polster 2005).

General management actions recommended to address the target of minimizing suitable habitat and invasive plant establishment include the following:

- minimize all clearing dimensions during construction (regardless of clearing size);
- identify short-term disturbances or clearings and ensure that they are re-vegetated as soon as possible, preferably with native plant species, to avoid soil degradation;
- minimize soil erosion through adherence to the Erosion Control Plan;
- clean vehicles that have worked in known invasive plant locations prior to relocating them; and
- ensure all vehicles and equipment restrict their travel and operation to designated or approved (for their respective activities) roads and surfaces.

In the event that invasive plants are identified on site, the type of plant, the season of identification, and the degree of invasion will be determined. If control is required, appropriate treatment options and timing will be identified and implemented.

Potential treatment options include mechanical, biological, and chemical methods. Mechanical control adopts physical means of removal, such as pulling by hand. Biological control uses living organisms, such as insects, to control pest populations of invasive plants, and chemical control uses herbicides to reduce and eradicate plant populations.

Further detail regarding control methods, including legislation and site-specific use of herbicides (from storage and transport to application and disposal), is available within the following recent document:

- Pest Management Plan for Invasive Alien Plants on Provincial Crown Lands in Central and Northern British Columbia (BC MOFR 2015).

In the event herbicide use is deemed a recommended treatment, the *Integrated Vegetation Management Plan for Transmission Rights-of-Way* (BC Hydro 2010) will be used to inform treatment activities, including management measures (e.g., designation of pesticide-free and no-treatment zones) to protect environmentally sensitive areas such as riparian areas, fish and wildlife and their habitat, waterbodies, and areas supporting country food or medicinal plants. To the extent possible, approved herbicides will be applied using spot-control methods, rather than broad spraying techniques, to minimize adverse effects to the surrounding environment.

Appropriate education and training are essential to a successful management strategy. Prior to the construction phase, employees and contractors, including those responsible for moving equipment to the Project site, will be provided a brief orientation outlining what invasive plants are, associated adverse effects of invasive plants, and how to avoid the introduction and spread of invasive plants.

In the event that invasive plant species are observed on site, the Project's designated personnel will receive further training in invasive plant identification, available data entry tools, and reporting programs to be better equipped to identify invasive plants (with emphasis on the regionally significant species). Training will also include specific management methods to prevent the spread of invasive plants within the areas affected by the Project.

In the event that invasive plant species are observed on site, a monitoring program will be developed. Monitoring frequency and locations will be determined based on the abundance, location, and type of invasive species present. Monitoring will occur in spring before flowering and seed dispersal to identify any invasive species on site and assess the success of previous control measures during construction and operation. Invasive plant monitoring and control activities will be recorded in a database which will be maintained by the environment department.

Soil Mitigation Measures

The soils management and mitigation measures for site preparation and soil management for the Project include the following:

- ensure clearing activities are coordinated with other management plans including but not limited to the *Air Quality Management Plan* (Annex V8-2), the *Wildlife Mitigation and Monitoring Plan* (Annex V8-3), and the Water Management Plans (P4-7 and P4-8);
- limit the extent of vegetation clearing during Construction activities to the required minimum.
- minimize soil degradation (i.e., erosion) by establishing and implementing erosion control procedures early during construction;
- carry out dust suppression on roads to prevent fugitive dust from impacting plants and soils; and
- progressively reclaim disturbed areas to reduce soil erosion (P4-19 and P4-21).

Water Quality and Quantity

Water Quality and quantity will be monitored and potential effects mitigated according to the Site Water Management Plans (P4-7 and P4-8) which monitors non-compliance related to tundra discharges. Water quality will also be monitored and potential effects to aquatic life and water quality objectives will be mitigated through implementation of the *Aquatic Effects Monitoring Plan* (P4-18). Water quality discharges to tundra will also meet guidelines established under the water license as described in the *Domestic Wastewater Treatment Management Plan* (P4-4). One of the objectives of this plan is to mitigate effects to vegetation due to wastewater discharge to the tundra. Compliance with the regulatory requirements is expected to be highly effective at mitigating effects to Vegetation and Special Landscape Features.

Dust Mitigation Measures

The *Air Quality Management Plan* (Annex V8-2) outlines the various mitigation measures employed specifically to reduce dust and air emissions caused by the Project. These mitigation measures include water or chemical suppression and reduced aeolian exposure. Air quality effects from equipment exhausts and incinerator stack emissions are managed according to prescribed standards described in Annex V8-2. Additional dust mitigation measures include:

- maximum road design speed for any vehicle will be 50 km/hr, which will reduce dust adjacent to roadways;
- discharge heights from the crushers onto conveyers, and conveyors onto stockpiles are minimized. In addition, the discharge from crushers onto conveyors or into other equipment is enclosed where practicable;
- if dust suppression is required at the airport, a truck with a mounted tank will spray water to suppress dust on the runway. Water will be obtained from existing or planned fresh water supply systems; no chemical suppressants are planned for or thought necessary; and
- progressive reclaiming of disturbed areas to reduce dust generation (P4-19 and P4-21).

Dust mitigation measures for potential effects to vegetation consumed by humans or wildlife are described in the *Human Health and Environmental Risk Assessment* (Volume 6, Chapter 5) and in *Terrestrial Wildlife and Wildlife Habitat* (Volume 4, Chapter 9). An air quality monitoring, including is also being implemented for Doris North. This program includes dustfall monitoring at sample locations. Analysis and interpretation of the results will be used by the *Wildlife Mitigation and Monitoring Report* submitted to NIRB as part of Doris North Reporting. It will also inform adaptive management measures to ensure compliance with regulatory requirements.

To confirm conclusions regarding dustfall adjacent to roads, a dustfall monitoring program is proposed in the Air Quality Management Plan (Annex V8-2) to identify changes in dust deposition with distance from road edge. The information from this monitoring program will be used to evaluate the assessment of dust effects on vegetation and determine if additional monitoring or mitigation is required.

<u>Contaminant Mitigation</u>

The *Spill Contingency Plan* (P4-3) recognizes sensitive habitat. It describes the spill response procedures to ensure timely and appropriate spill cleanup on land, water and ice. Responsible authorities and potentially affected communities will receive reports for any spills of harmful substances near sensitive habitat.

The *Oil Pollution Prevention Plan/Oil Pollution Emergency Plan* (Annex V8-1) outlines the procedures associated with the sealift, transfer, handling, and storage of fuel at the oil handling facility at Roberts Bay.

<u>Permafrost Mitigation Measures</u>

Mitigation measures to reduce effects to permafrost are listed below. Any effects to permafrost and potential effects to Vegetation will be contained within the PDA. Mitigation for effects to permafrost include:

- thermal modelling (P-26) to determine fill requirements over tundra to ensure preservation of permafrost for infrastructure construction;
- thermal modelling of the Boston TMA (P-26);
- thermal modelling of the North, South and West Dams at the Doris TIA (P-16);
- no allowance for disturbance of the tundra vegetation, permafrost or soils is allowed outside of approved areas;
- wherever possible, the airstrip and roads will be constructed in the winter to ensure the integrity of the permafrost using sufficient cover material to insulate the permafrost; and

- pollution control ponds (PCPs) and contact water ponds (CWPs) will be designed to minimize effect to permafrost and ensure pond structural stability.

8.5.3.4 Proposed Monitoring Plans and Adaptive Management

Monitoring plans and adaptive management for Vegetation and Special Landscape Features VECs will be developed on a case-by-case basis. Triggers that could result in the development and implementation of monitoring and adaptive management plans would include programs to monitor air quality, water, and waste management, which will help eliminate or minimize effects to Vegetation and Special Landscape Features. These include:

- the *Air Quality Management Plan* (Annex V8-2) indicates exceedances of air quality requirements;
- the *Wildlife Mitigation and Monitoring Program* (Annex V8-3) describes planned monitoring of adverse effects on wildlife or wildlife habitat; and
- the *Water Management* Plans (P4-7 and P4-8) describes planned monitoring of non-compliance related to tundra discharges.

8.5.4 Characterization of Potential Effects

Management and mitigation measures will help avoid and minimize adverse effects to ecosystem functions and extent resulting from Madrid-Boston Project Construction, Operation, Reclamation and Closure, and Post-closure phases. However, direct and indirect effects cannot be fully mitigated, and potential effects are anticipated for Vegetation and Special Landscape Features (Table 8.5-3).

Table 8.5-3. Potential Residual Effects Predicted after Mitigation

VEC	Effect	Potential Residual Effect	Rationale / Mitigation
Vegetation	Loss	Yes – Loss of Vegetation indicators due to Project clearing and grubbing is expected after mitigation measures are applied and is carried through for assessment.	Despite the application of the mitigation hierarchy and the use of avoidance during Project design, effects to Vegetation are expected due to clearing and grubbing.
	Alteration	No – Alteration of Vegetation indicators outside of the PDA is not anticipated including: invasive plant species, soil compaction or disturbance, fugitive dust or other airborne contaminants, spills or other ground or water discharge, changes in water quality or quantity, permafrost or snow accumulation. No residual effects are anticipated.	The mitigation measures in place to reduce the potential for introduction and spread of invasive plant species are anticipated to be highly effective. Potential site level changes to soil characteristics, permafrost, or snow accumulation will be moderately effective but effects will be contained in the PDA. Spill and contamination mitigation measures are anticipated to be highly effective. Dust mitigation measures are well understood and are anticipated to be highly effective. All alteration effects are anticipated to occur with the PDA area and are accounted for as loss.
Special Landscape Features	Loss	Yes – Loss of Special Landscape Features due to Project clearing and grubbing is expected after mitigation measures are applied and is carried through for assessment.	Despite the application of the mitigation hierarchy and the use of avoidance during Project design, effects to Special Landscape Features are expected.

VEC	Effect	Potential Residual Effect	Rationale / Mitigation
	Alteration	No – Alteration of Special Landscape Features outside of the PDA is not anticipated including: invasive plant species, soil compaction or disturbance, fugitive dust or other airborne contaminants, spills or other ground or water discharge, changes in water quality or quantity, permafrost or snow accumulation. No residual effects are anticipated.	The mitigation measures in place to reduce the potential for introduction and spread of invasive plant species are anticipated to be highly effective. Potential site level changes to soil characteristics, permafrost, or snow accumulation will be moderately effective. Spill and contamination mitigation measures are anticipated to be highly effective. Dust mitigation measures are well understood and are anticipated to be highly effective. All alteration effects are anticipated to occur with the PDA area and are accounted for as loss.

Project effects to Vegetation and Special Landscape Features are indicated by area loss or alteration for each indicator. The assessment compares the pre-Madrid-Boston distribution of the indicators with post-Madrid-Boston conditions. As part of a precautionary approach to assessing potential effects to VECs, the entire area within the PDA is considered lost, including all effects that could be caused by alteration of VECs as indicated in Section 8.5.2.

8.5.4.1 Loss of Vegetation and Special Landscape Features

Loss of Vegetation and Special Landscape Feature VEC indicators were assessed based on spatial overlap of the PDA with the indicator. Within the PDA, all indicators were assumed to be lost. As the PDA includes a buffer around the currently planned Project Footprint, all effects that result in potential alteration of indicators in the buffered area are included and are conservatively assessed as lost. These include effects due to dust, sewage discharge to the tundra at Boston exploration camp, invasive plant species, soil characteristics, permafrost, snow accumulation, and possible contamination due to accidents or malfunctions.

Loss was assessed as the overlap between the PDA and each Vegetation indicator. Loss for each indicator is described by the total hectares and the percent of area lost relative to the abundance of the indicator in the LSA.

Loss of Special Landscape Features was assessed based on the overlap of the PDA with indicators. The loss of area for each indicator was summed to create a total loss for all indicators, which was then compared to the total area of Special Landscape Features in the LSA to identify the percent loss in the LSA.

The PDA was used to provide flexibility in siting Project infrastructure during final design and is an overestimate of the actual loss that will occur during Construction phase. The Footprint area as currently designed is presented to provide context and provides an indication of actual loss that will result based on final Project design.

For Madrid-Boston, loss was assessed for Construction of Roberts Bay, the expansion of Doris TIA and camp, Madrid North process plant and road to Doris, and construction of Boston, as detailed in Table 8.5-3. Madrid-Boston assessment also considers the effects that result during Operation for Madrid-Boston.

For the Hope Bay Project, loss was assessed for both Madrid-Boston and previously permitted activities and infrastructure. Previously permitted activities and infrastructure include: Doris Project, Hope Bay Regional Exploration Project, Madrid Advanced Exploration Project, and the Boston Advanced Exploration Project (as described in Section 8.4.1.1). A separate Vegetation PDA was included to identify loss associated with the Hope Bay Project that occurred outside the Madrid-Boston PDA. The

Hope Bay Project assessment represents all current and future disturbance currently planned for the Hope Bay area by TMAC.

Loss of Ecosystem Types

Madrid-Boston - Loss of Ecosystem Types

Loss of ecosystem types will occur during the Construction phase due to clearing and grubbing with very limited localized losses during Operation (assessed within the PDA). Table 8.5-4 shows the abundance of each ecosystems type in the LSA and the overlap of the Project Footprint and PDA (Figure 8.5-2). The largest proportional loss of mapped ecosystems in the LSA is Eriophorum Tussock Meadow (1,410 ha, 2.5%), which is the most abundant ecosystem type in the LSA (15,630 ha, 28%). Betula-Ledum-Lichen is next most abundance ecosystem in the LSA (7,076 ha) of which 594 ha (1.1%) will be lost due to Project activities. There is less than a 1% loss of area for each of the remaining ecosystems in the LSA. Total loss of all ecosystems due to Project development is 4,188.9 ha or 7.4% of ecosystems in the LSA.

Table 8.5-4. Madrid-Boston Ecosystem Loss within the PDA and Footprint

TEM Map Code	Ecosystem Type	LSA	Madrid-Boston Footprint loss		Madrid-Boston PDA loss	
		ha	ha	%	ha	%
BA	Barren	5.8	0.1	< 0.1%	0.5	< 0.1%
BE	Beach	20.9	0.0	< 0.1%	-	0.0%
BI	Blockfield	979.1	17.4	< 0.1%	30.1	0.1%
BL	Betula-Ledum-Lichen	7,075.8	250.8	0.4%	593.9	1.1%
BM	Betula-Moss	1,708.4	34.8	< 0.1%	147.4	0.3%
CL	Dry Carex-Lichen	527.1	58.7	0.1%	86.7	0.2%
DH	Dryas Herb Mat	4,344.8	209.8	0.4%	425.1	0.8%
DW	Dry Willow	1,243.8	19.2	< 0.1%	80.1	0.1%
EM	Emergent Marsh	751.1	5.2	< 0.1%	34.1	0.1%
ES	Exposed Soil	77.5	0.1	< 0.1%	1.6	< 0.1%
FP	Low Bench Floodplain	122.8	0.2	< 0.1%	3.1	< 0.1%
LA & PD	Lakes and Ponds	8,214.6	1.7	0.1%	74.5	0.1%
MB	Marine Backshore	17.7	0.2	< 0.1%	3.2	< 0.1%
MI	Marine Intertidal	3.3	0.0	< 0.1%	-	< 0.1%
MS	Mine Spoils	16.9	0.8	< 0.1%	5.8	< 0.1%
OW	Shallow Open Water	10.6	0.0	< 0.1%	5	< 0.1%
PG	Polygonal Ground	2,569.3	24.2	< 0.1%	161.6	0.3%
RI	River	797.6	0.7	< 0.1%	9.5	< 0.1%
RO	Rock Outcrop	3,280.4	215.2	0.4%	390.4	0.6%
RU	Rubble (Talus)	19.6	0.0	< 0.1%	-	< 0.1%
RW	Riparian Willow	1,229.5	28.4	0.1%	110.3	0.2%
SH	Dwarf Shrub-Heath	741.8	19.0	< 0.1%	46.6	0.1%
SW	Salt Water	741.1	0.8	< 0.1%	6.9	< 0.1%
TM	Eriophorum Tussock Meadow	15,630.1	402.1	0.7%	1410	2.5%
WM	Wet Meadow	6,210.4	174.1	0.3%	562.5	1.0%
Total		**56,340.0**	**1463.5**	**2.6%**	**4,188.9**	**7.4%**

Based on the assessment, residual effects due to Madrid-Boston are predicted for ecosystem types due to loss. Residual effects are carried forward to the next section for characterizations according to the defined criteria and significance determination.

Hope Bay Project - Loss of Ecosystem Types

Loss of ecosystem types for the Hope Bay Project will occur during Construction/Operation of Madrid-Boston and for previously permitted activities and infrastructure for the Hope Bay Project, which precedes Madrid-Boston. Loss assessed as part of the Hope Bay Project is due to clearing and grubbing associated with construction of Madrid-Boston and previously permitted activities and infrastructure. The area potentially affected by sewage discharged to the tundra during construction at the Boston exploration camp was included in the PDA and assessed as lost. During Operation, there will be very limited localized losses that are assessed within the PDA for the Hope Bay Project.

Table 8.5-5 shows the abundance of each ecosystems type in the LSA and the overlap of the Footprint and PDA (Figure 8.5-2). The two most affected ecosystem types by Hope Bay Project are the Eriophorum Tussock Meadow (1,539, 2.8%), Wet Meadow (673, 1.2%) and Betula-Ledum-Lichen (619, 1.1%). There is less than a 1% loss for each of the remaining ecosystems in the LSA. Total loss of all ecosystems due to the complete Hope Bay Project Development is 4,706 ha or 8.4% of ecosystems in the LSA.

Based on the assessment, residual effects due to the Hope Bay Project are predicted for ecosystem types due to loss. Residual effects are carried forward to the next section for characterizations according to the defined criteria and significance determination.

<u>Loss of Vegetation Species Diversity</u>

The potential for ecosystems to support diverse plant species communities was identified as indicator to assess effects to the Vegetation VEC (NIRB 2012). Species richness is a fundamental measurement of community and regional diversity and is used to characterize biodiversity (Gotelli and Colwell 2001: Magurran 1988; Gould and Walker 1999). At the scale of terrestrial ecosystem mapping, species rich ecosystems are those with high ecological variability (Grace and Pugesek 1996; Pollock et al. 1998: Gould and Walker 1997).

A rating system to assess Project effects to vegetation species diversity was developed using a multi-scale analysis of plant species richness in the arctic in the Hood River area, southwest of the Hope Bay Project (Gould 1988). The study provides data on species richness by ecological community type along the Hood River near Bathurst Inlet. Ecosystems were comprised of a mosaic of types but tended towards rich riparian and wetland types, similar to ecosystems in the LSA. Species richness averages for vascular plants, bryophytes, and lichens were used to characterize species richness for each ecosystem class (Table 8.5-6; Gould 1988). Ecosystem classes were correlated between the mapping for the Project and classifications compiled by Gould, and species richness classes were identified and assigned to each ecosystem type (Table 8.5-6).

Only the Dwarf Shrub-Heath and Eriophorum Tussock Meadow types were rated high for plant species diversity; 5 ecosystem types were rated moderate; 11 were rated low; 4 were rated very low, and water bodies were not rated (nil). Eriophorum Tussock Meadow was the most abundant ecosystem type and is estimated to have high plant species richness as it provides high microhabitat diversity for plant species.

Figure 8.5-2
Ecosystem Loss within Footprints and Project Development Areas

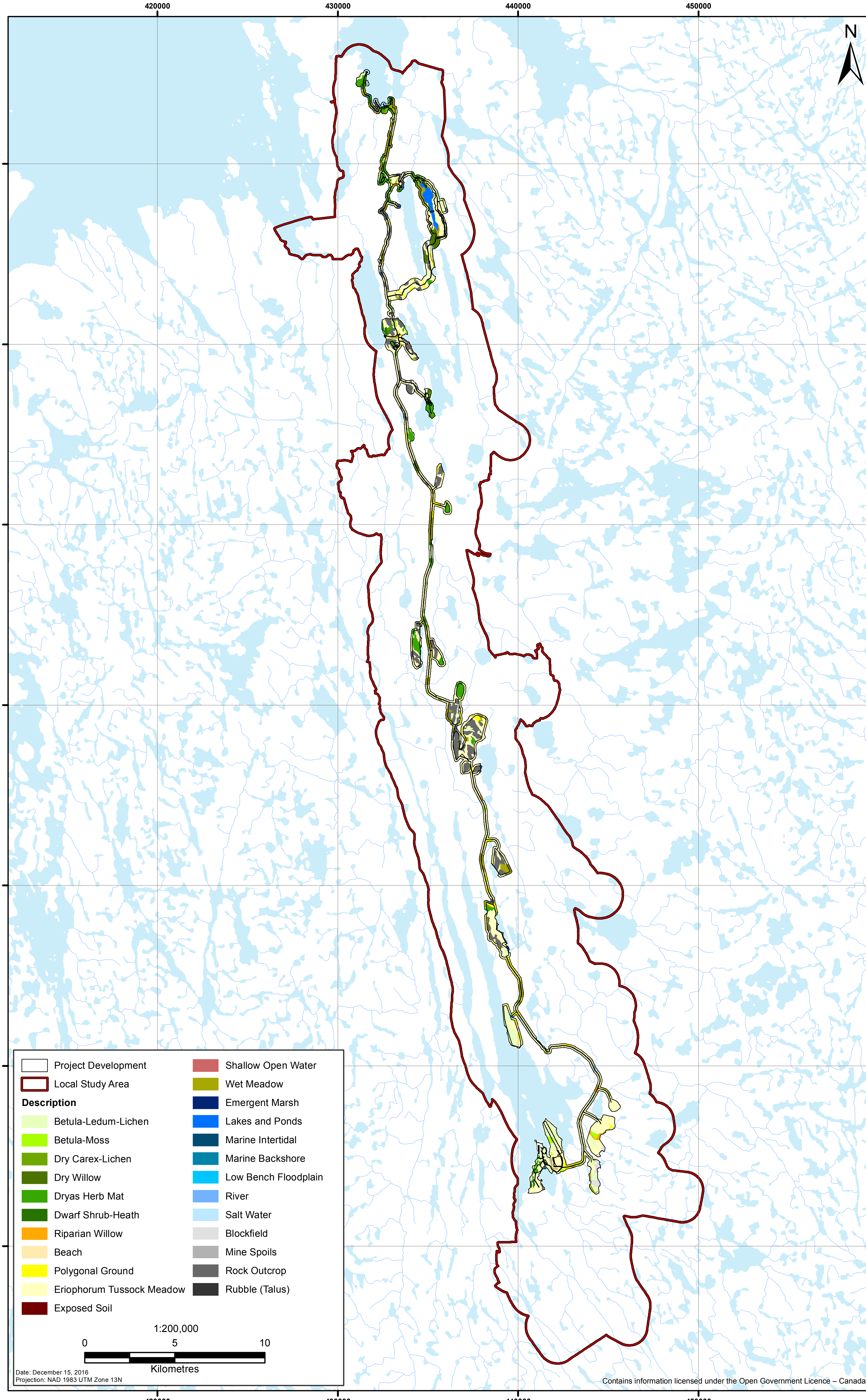


Table 8.5-5. Hope Bay Project Ecosystem Loss within the PDA and Footprint

TEM Map Code	Ecosystem Type	LSA	Hope Bay Footprint Loss		Hope Bay PDA Loss	
		ha	ha	%	ha	%
BA	Barren	5.8	0.1	< 0.1%	0.5	< 0.1%
BE	Beach	20.9	0.2	< 0.1%	1.8	< 0.1%
BI	Blockfield	979.1	17.4	< 0.1%	30.3	0.1%
BL	Betula-Ledum-Lichen	7,075.8	258.5	0.5%	619.2	1.1%
BM	Betula-Moss	1,708.4	36.0	< 0.1%	148.3	0.3%
CL	Dry Carex-Lichen	527.1	58.8	0.1%	93.4	0.2%
DH	Dryas Herb Mat	4,344.8	230.8	0.4%	539.7	0.9%
DW	Dry Willow	1,243.8	23.5	< 0.1%	90.1	0.2%
EM	Emergent Marsh	751.1	5.5	< 0.1%	34.4	0.1%
ES	Exposed Soil	77.5	0.1	< 0.1%	1.6	< 0.1%
FP	Low Bench Floodplain	122.8	0.2	< 0.1%	3.2	< 0.1%
LA & PD	Lakes and Ponds	8,214.6	73.5	0.1%	85.8	0.1%
MB	Marine Backshore	17.7	0.6	< 0.1%	5.5	< 0.1%
MI	Marine Intertidal	3.3	0.1	< 0.1%	0.7	< 0.1%
MS	Mine Spoils	16.9	2.5	< 0.1%	5.9	< 0.1%
OW	Shallow Open Water	10.6	0.0	< 0.1%	0.0	< 0.1%
PG	Polygonal Ground	2,569.3	27.0	< 0.1%	170.6	0.3%
RI	River	797.6	0.7	< 0.1%	9.5	< 0.1%
RO	Rock Outcrop	3,280.4	228.8	0.4%	449.4	0.8%
RU	Rubble (Talus)	19.6	0.0	< 0.1%	2.1	< 0.1%
RW	Riparian Willow	1,229.5	32.8	0.1%	112.6	0.2%
SH	Dwarf Shrub-Heath	741.8	25.6	< 0.1%	66.5	0.1%
SW	Salt Water	741.1	1.1	< 0.1%	22.5	< 0.1%
TM	Eriophorum Tussock Meadow	15,630.1	464.3	0.8%	1539.3	2.8%
WM	Wet Meadow	6,210.4	207.7	0.4%	673.2	1.2%
Total		**56,340.0**	**1,695.8**	**3%**	**4,706.1**	**8.4%**

Table 8.5-6. Ecosystem Types and Vegetation Species Diversity Classes within the Local Study Area

Map Code	Description	Diversity Class Range	Diversity Class	Total LSA (ha)	Percent of LSA
BA	Barren	5 - 11	Very Low	5.8	< 0.1%
BE	Beach	20-25	Moderate	20.9	< 0.1%
BI	Blockfield	12 - 20	Low	979.1	1.7%
BL	Betula-Ledum-Lichen	20 - 25	Moderate	7,075.8	12.6%
BM	Betula-Moss	12 - 20	Low	1,708.4	3.0%
CL	Dry Carex-Lichen	20 - 25	Moderate	527.1	0.9%
DH	Dryas Herb Mat	20 - 25	Moderate	4,344.8	7.7%
DW	Dry Willow	20 - 25	Moderate	1,243.8	2.2%
EM	Emergent Marsh	5 - 11	Very Low	751.1	1.3%
ES	Exposed Soil	5 - 11	Very Low	77.5	0.1%

Map Code	Description	Diversity Class Range	Diversity Class	Total LSA (ha)	Percent of LSA
FP	Low Bench Floodplain	12 - 20	Low	122.8	0.2%
LA & PD	Lakes and Ponds	12 - 20	Nil	8,214.6	14.6%
MB	Marine Backshore	12 - 20	Low	17.7	< 0.1%
MI	Marine Intertidal	12 - 20	Low	3.3	< 0.1%
MS	Mine Spoils	5 - 11	Very Low	16.9	< 0.1%
OW	Shallow Open Water	12 - 20	Low	10.6	< 0.1%
PG	Polygonal Ground	12 - 20	Low	2,569.3	4.6%
RI	River	12 - 20	Nil	797.6	1.42%
RO	Rock Outcrop	12 - 20	Low	3,280.4	5.8%
RU	Rubble (Talus)	12 - 20	Low	19.6	< 0.1%
RW	Riparian Willow	12 - 20	Low	1,229.5	2.2%
SH	Dwarf Shrub-Heath	26 - 33	High	741.8	1.3%
LA & PD	Salt Water	12 - 20	Nil	741.1	1.3%
TM	Eriophorum Tussock Meadow	26 - 33	High	15,630.1	27.7%
WM	Wet Meadow	12 - 20	Low	6,210.4	11.0%
Total				**56,340.0**	**100.0%**

Source: Adapted from Gould (1998)

Madrid-Boston – Loss of Vegetation Species Diversity

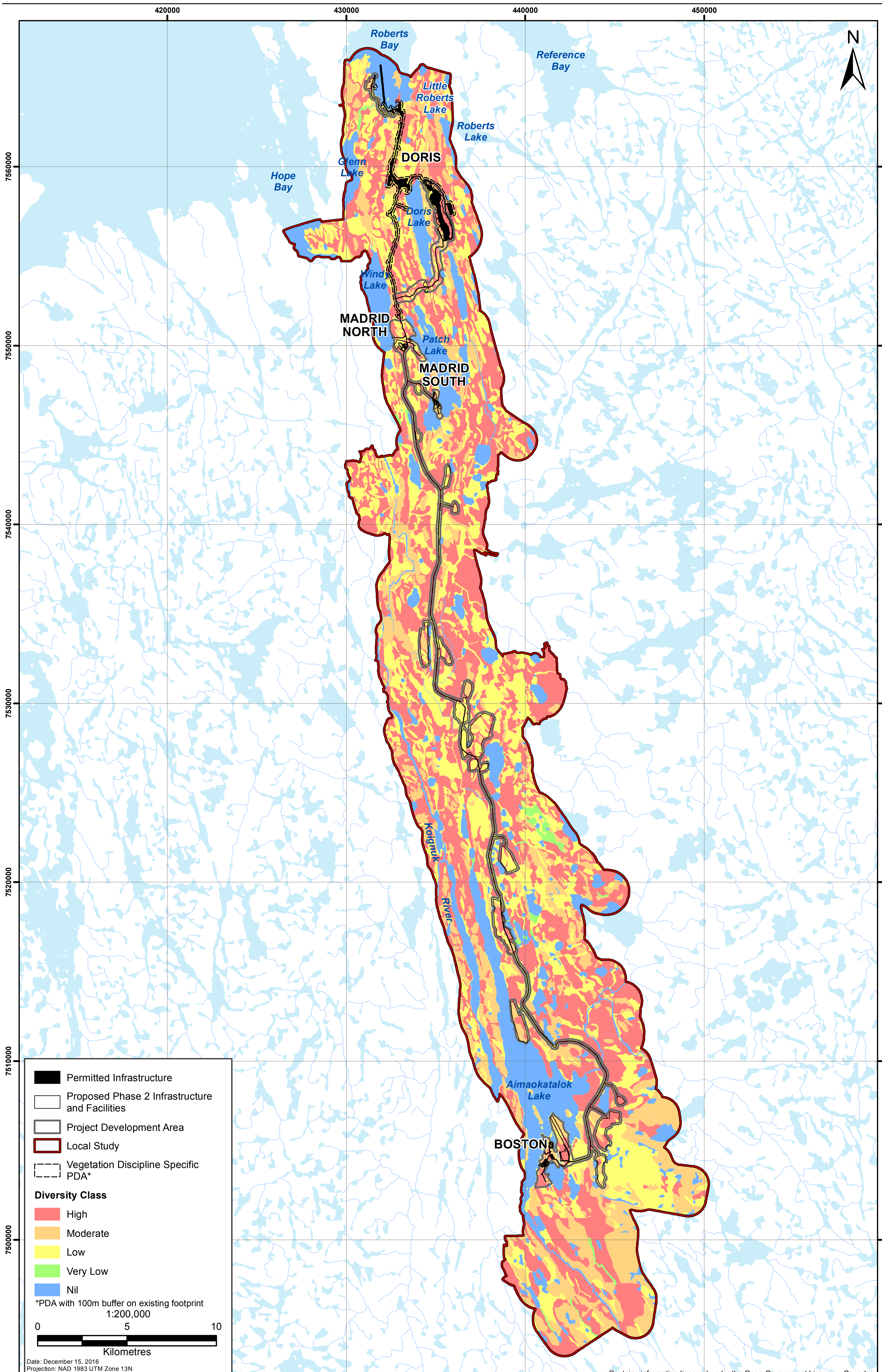
Losses of species diversity class were similar in the high (1,457 ha, 2.6%), moderate (1,186 ha, 2.1%) and low (1,414 ha, 2.5%) species diversity classes (Table 8.5-7; Figure 8.5-3). Effects in the high class are mostly attributable to loss of Eriophorum Tussock Meadow, the most abundant ecosystem in the LSA.

Table 8.5-7. Madrid-Boston Loss of Vegetation Species Diversity by Diversity Classes within Footprints and Project Development Area

	LSA	Madrid-Boston Footprint Loss		Madrid-Boston PDA Loss	
Species Diversity Class	**ha**	**ha**	**%**	**ha**	**%**
High	16,372	421.1	0.7%	1,456.6	2.6%
Moderate	13,212	538.5	1.0%	1,185.8	2.1%
Low	16,151	494.5	0.9%	1,413.6	2.5%
Very Low	851	6.2	0.0%	42.0	0.1%
Nil (Non-vegetated and Water)	9,753	3.2	0.0%	90.9	0.2%
Total	**56,340**	1,463.5	2.6%	4,188.9	7.4%

Based on the assessment, residual effects due to Madrid-Boston are predicted for vegetation species diversity due to loss. Residual effects are carried forward to the next section for characterizations according to the defined criteria and significance determination.

Figure 8.5-3
Project Effects to Vegetation Species Diversity Classes within Footprints and Project Development Areas



Hope Bay Project – Loss of Vegetation Species Diversity

Loss of vegetation species diversity for the Hope Bay Project will occur during Construction/Operation of Madrid-Boston and for previously permitted activities and infrastructure for the Hope Bay Project, which precedes Madrid-Boston. Loss assessed as part of the Hope Bay Project is due to clearing and grubbing associated with construction of Madrid-Boston and previously permitted activities and infrastructure. During Operation, there will be very limited localized losses that are assessed within the PDA for the Hope Bay Project.

Losses of species diversity class were similar in the high (1,606 ha, 2.9%), moderate (1,344 ha, 2.4%) and low (1,596 ha, 2.8%) species diversity classes (Table 8.5-8; Figure 8.5-3). Effects in the high class are mostly attributable to loss of Eriophorum Tussock Meadow, the most abundant ecosystem in the LSA.

Table 8.5-8. Hope Bay Project Potential Loss of Vegetation Species Diversity by Diversity Classes within Footprints and Project Development Area

	LSA	Hope Bay Project Footprint Loss		Hope Bay Project PDA Loss	
Species Diversity Class	**ha**	**ha**	**%**	**ha**	**%**
High	16,372	489.9	0.9%	1,605.8	2.9%
Moderate	13,212	571.8	1.0%	1,344.2	2.4%
Low	16,151	550.6	1.0%	1,595.9	2.8%
Very Low	851	8.2	0.0%	42.4	0.1%
Nil (Non-vegetated and Water)	9,753	75.3	0.1%	117.8	0.2%
Total	**56,340**	1,695.8	3.0%	4,706.1	8.4%

Based on the assessment, residual effects due to the Hope Bay Project are predicted for vegetation species diversity due to loss. Residual effects are carried forward to the next section for characterizations according to the defined criteria and significance determination.

Loss of Vegetation Productivity

Vegetation productivity is a measure of the annual net primary productivity (ANPP). It is the expression of plant species growth rates that is influenced by ecosystem properties and climatic conditions. The least productive communities are cryptogram communities such as blockfields and rock outcrops. The highest ANPP values are found in ecosystems such as riparian willow communities. As ANPP increases so does above ground biomass, which can indicate greater forage availability and increased habitat values.

To assess potential effects to primary productivity, published ANPP values for land cover types were assigned by corresponding the ecosystem types with the ecosystems and ANPP values reported in the literature (Bliss and Matveyeva 1992; Gould et al. 2003; Walker 1999). Five classes were used to group productivity ranges for the ecosystem types including: Very Low for generally barren or largely unvegetated types such as Dry Carex-Lichen; Low for sparsely vegetated types or those with very low prostrate vegetation cover such as Dryas Herb Mat; Moderate for hemi-prostrate shrub or sedge dominated meadows such as Wet Meadows; High for erect dwarf shrub complexes such as the Dwarf Shrub-Heath; and Very High for low shrub dominated ecosystems such as Riparian Willow ecosystems (Table 8.5-9).

Table 8.5-9. Vegetation Productivity Classes and Annual Productivity Estimates within the Local Study Area

Map Code	Description	Productivity Class Range	Productivity Class	Total LSA (ha)	Percent of LSA
BA	Barren	< 20	Very Low	5.8	< 0.1%
BE	Beach	< 20	Very Low	20.9	< 0.1%
BI	Blockfield	< 20	Very Low	979.1	1.7%
BL	Betula-Ledum-Lichen	< 20	Very Low	7,075.8	12.6%
BM	Betula-Moss	< 20	Very Low	1,708.4	3.0%
CL	Dry Carex-Lichen	< 20	Very Low	527.1	0.9%
DH	Dryas Herb Mat	20 - 50	Low	4,344.8	7.7%
DW	Dry Willow	20 - 50	Low	1,243.8	2.2%
EM	Emergent Marsh	50 - 150	Moderate	751.1	1.3%
ES	Exposed Soil	< 20	Very Low	77.5	0.1%
FP	Low Bench Floodplain	20 - 50	Low	122.8	0.2%
LA & PD	Lakes and Ponds			8,214.6	14.6%
MB	Marine Backshore	< 20	Very Low	17.7	< 0.1%
MI	Marine Intertidal	20 - 50	Low	3.3	< 0.1%
MS	Mine Spoils	< 20	Very Low	16.9	< 0.1%
OW	Shallow Open Water	< 20	Very Low	10.6	< 0.1%
PG	Polygonal Ground	20 - 50	Low	2,569.3	4.6%
RI	River			797.6	1.42%
RO	Rock Outcrop	< 20	Very Low	3,280.4	5.8%
RU	Rubble (Talus)	< 20	Very Low	19.6	< 0.1%
RW	Riparian Willow	250 – 1,000	Very High	1,229.5	2.2%
SH	Dwarf Shrub-Heath	150 - 250	High	741.8	1.3%
LA & PD	Salt Water			741.1	1.3%
TM	Eriophorum Tussock Meadow	20 - 50	Low	15,630.1	27.7%
WM	Wet Meadow	50 - 150	Moderate	6,210.4	11.0%
Total				**56,340.0**	**100.0%**

Madrid-Boston – Loss of Vegetation Productivity

Most Madrid-Boston effects occurred in ecosystems associated with low vegetation productivity (2,080 ha, 3.7%), followed by effects to ecosystems with very low productivity (1,265 ha, 2.2%). There are 753 ha that occur in moderate, high, and very high classes which comprise 1.4% of the LSA (Table 8.5-10 and Figure 8.5-4).

Based on the assessment, residual effects due to the Project are predicted for vegetation productivity due to loss. Residual effects are carried forward to the next section for characterizations according to the defined criteria and significance determination.

Figure 8.5-4
Project Effects to Vegetation Productivity Classes within Footprints and Project Development Areas

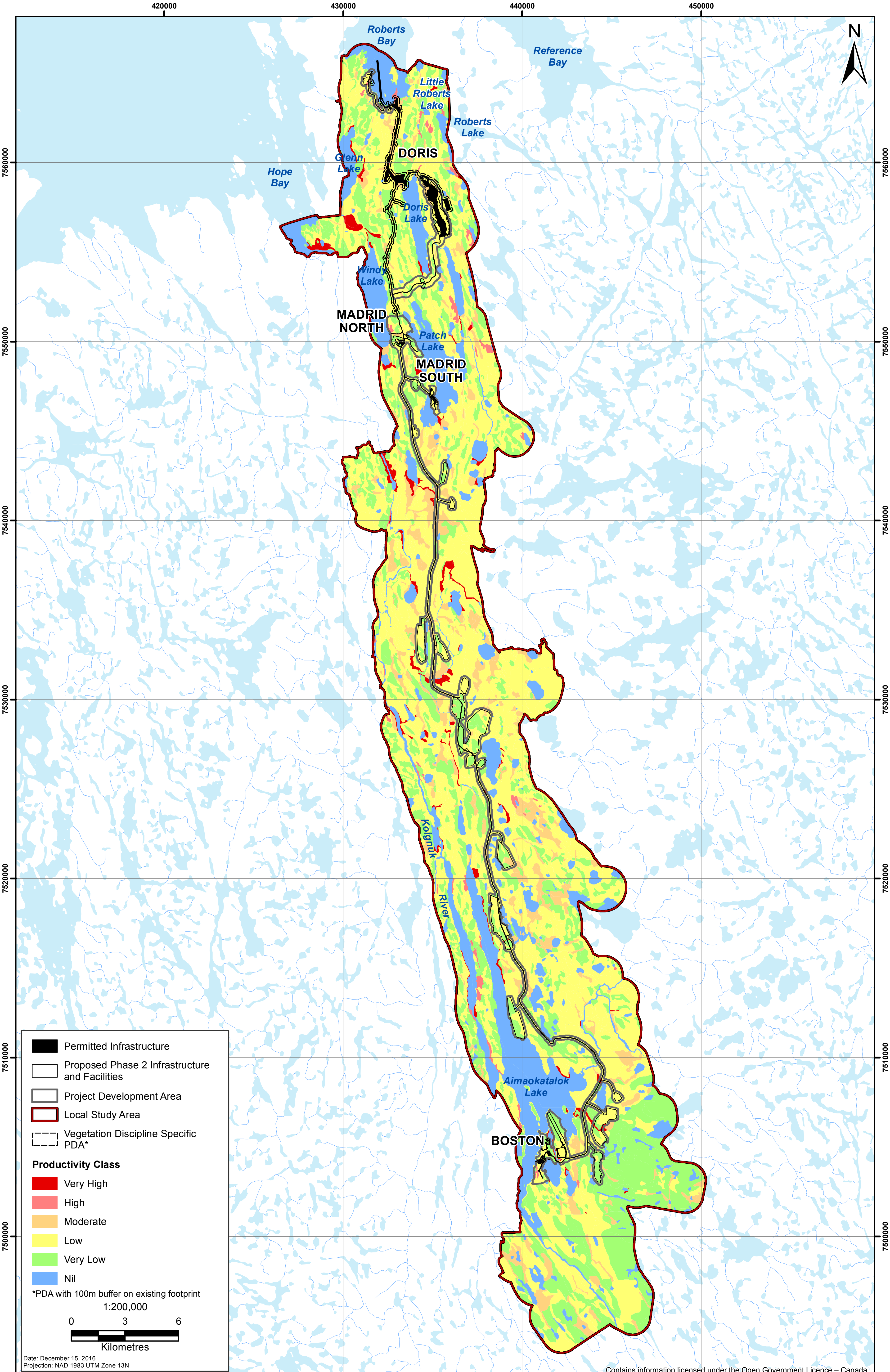


Table 8.5-10. Madrid-Boston Loss of Vegetation Productivity Classes within the PDA and Footprint

	LSA	Madrid-Boston Footprint Loss		Madrid-Boston PDA loss	
Productivity	**ha**	**ha**	**%**	**ha**	**%**
Very High	1,229.5	28.4	0.1%	110.3	0.2%
High	741.8	19.0	0.0%	46.6	0.1%
Moderate	6,961.5	179.3	0.3%	596.6	1.1%
Low	23,914.1	655.5	1.2%	2,079.9	3.7%
Very Low	13,739.7	578.1	1.0%	1,264.6	2.2%
Nil (Non-vegetated and Water)	9,753.3	3.2	0.0%	90.9	0.2%
Total	**56,340.0**	**1,463.5**	**2.6%**	**4,188.9**	**7.4%**

Hope Bay Project – Loss of Vegetation Productivity

Loss of vegetation productivity for the Hope Bay Project will occur during Construction/Operation of Madrid-Boston and for previously permitted activities and infrastructure that support the Hope Bay Project, which precedes Madrid-Boston. Loss of vegetation productivity assessed as part of the Hope Bay Project is due to clearing and grubbing associated with construction of Madrid-Boston and previously permitted activities and infrastructure. During Operation, there will be very limited localized losses that are assessed within the PDA for the Hope Bay Project.

Similar to Madrid-Boston, most Hope Bay Project effects occurred in ecosystems associated with low vegetation productivity (2,344 ha, 4.2%), followed by effects to ecosystems with very low productivity (1,358 ha, 2.5%) and moderate productivity (708 ha, 1.3%). There are 67 ha and 113 ha that occur in high, and very high classes respectively, which comprise 0.3% of the LSA (Table 8.5-11 and Figure 8.5-4).

Table 8.5-11. Hope Bay Project Potential Loss of Vegetation Productivity Classes within the PDA and Footprint

	LSA	Hope Bay Project Footprint Loss		Hope Bay Project PDA Loss	
Productivity	**ha**	**ha**	**%**	**ha**	**%**
Very High	1,229.5	32.8	0.1%	112.6	0.2%
High	741.8	25.6	0.0%	66.5	0.1%
Moderate	6,961.5	213.2	0.4%	707.6	1.3%
Low	23,914.1	745.9	1.3%	2,343.6	4.2%
Very Low	13,739.7	603	1.1%	1,358.0	2.4%
Nil (Non-vegetated and Water)	9,753.3	75.3	0.1%	117.8	0.2%
Total	**56,340.0**	**1,695.8**	**3.0%**	**4,706.1**	**8.4%**

Based on the assessment, residual effects due to the Hope Bay Project are predicted for vegetation productivity due to loss. Residual effects are carried forward to the next section for characterizations according to the defined criteria and significance determination.

<u>Loss of Special Landscape Features</u>

Special Landscape Features were included in the assessment based on their rarity or their ability to support unique habitat types that provide materials for tools, hunting opportunities, travel corridors, habitat for rare plant species, habitat for animals including bird species, denning places, forage habitat, and security habitat for wildlife such as wolverine. The distribution of the landscape features in the LSA, PDA, and Project Footprint are show in Table 8.5-12. These were grouped into five classes: riparian ecosystems, Dwarf Shrub Heath (which was also includes eskers complexes), sensitive or rare wetlands, rock dominated ecosystems including cliffs, and beach and marine areas.

Table 8.5-12. Madrid-Boston Loss of Special Landscape Features within the PDA and Footprint

Special Landscape Features	TEM Map Code	LSA ha	Madrid-Boston Footprint Loss		Madrid-Boston PDA Loss	
			ha	%	ha	%
Riparian ecosystems and floodplains	FP	1229.5	0.2	0.0%	3.1	0.0%
	RW	122.8	28.4	0.2%	110.3	0.7%
Total		1352.3	28.6	0.2%	113.4	0.7%
Dwarf Shrub Heath (Can contain esker complexes)	SH	741.8	19	0.1%	46.6	0.3%
Total		741.8	19	0.1%	46.6	0.3%
Sensitive or rare wetlands	EM	751.1	5.2	0.0%	34.1	0.2%
	OW	10.6	0	0.0%	5	0.0%
	PG	2,569.3	24.2	0.1%	161.6	1.0%
	WM	6,210.4	174.1	1.1%	562.5	3.4%
Total		9,541.4	203.5	1.2%	763.2	4.6%
Bedrock cliff and Bedrock-lichen veneer ecosystems	BI	979.1	17.4	0.1%	30.1	0.2%
	CL	527.1	58.7	0.4%	86.7	0.5%
	RO	3,280.4	215.2	1.3%	390.4	2.4%
Total		4,786.6	291.3	1.8%	507.2	3.1%
Beaches, marine backshores and intertidal areas	BE	20.9	0	0.0%	0	0.0%
	MB	17.7	0.2	0.0%	3.2	0.0%
	MI	3.3	0	0.0%	0	0.0%
Total		41.9	0.2	0.0%	3.2	0.0%
Grand Total		16,464.0	542.6	3.3%	1,433.6	8.7%

Madrid-Boston - Loss of Special Landscape Features

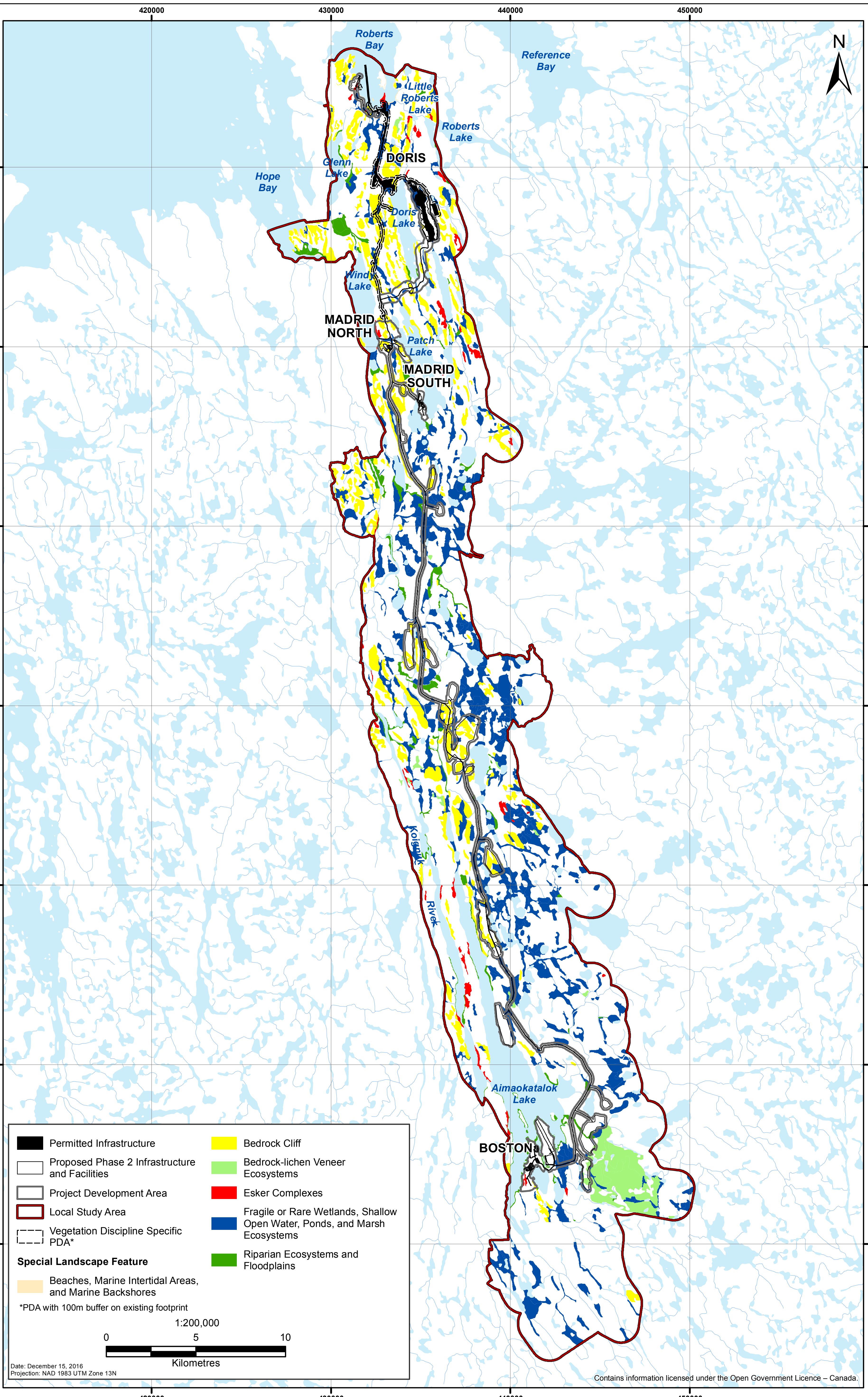
Loss of Special Landscape Features associated with Madrid-Boston activities and infrastructure is shown in Table 8.5-12 and Figure 8.5-5. In total, 1,434 ha are lost in the PDA. This represents 2.5% of total area in the LSA and 8.7% of the total area associated with Special Landscape Features in the LSA. The greatest loss occurs to Wet Meadows (562 ha; 3.4%).

Based on the assessment, residual effects due to Madrid-Boston are predicted for Special Landscape Features due to loss. Residual effects are carried forward to the next section for characterizations according to the defined criteria and significance determination.

Hope Bay Project - Loss of Special Landscape Features

Loss of Special Landscape Features for the Hope Bay Project will occur during Construction/Operation of Madrid-Boston and for previously permitted activities and infrastructure the Hope Bay Project, which precedes Madrid-Boston. Loss of Special Landscape Features assessed as part of the Hope Bay Project is due to clearing and grubbing associated with construction of the Project and previously permitted activities and infrastructure. During Operation, there will be very limited localized losses that are assessed within the PDA for the Hope Bay Project.

Figure 8.5-5
Project Effects to Special Landscape Feature within Footprints and Project Development Areas



Loss of Special Landscape Features associated with Hope Bay Project activities and infrastructure is shown in Table 8.5-13 and Figure 8.5-5. In total, 1,642 ha are lost in the Hope Bay Project PDA. This represents 2.9% of total area in the LSA and 10.0% of the total area associated with Special Landscape Features in the LSA. The greatest loss occurs to Wet Meadows (673 ha; 4.1%). Footprint losses are 3.7% (605 ha) of the 16,433 ha of Special Landscape Features in the LSA.

Table 8.5-13. Hope Bay Project Potential Loss of Special Landscape Features within the PDA and Footprint

Special Landscape Features	TEM Map Code	LSA	Hope Bay Project Footprint Loss		Hope Bay Project PDA Loss	
		ha	ha	%	ha	%
Riparian ecosystems and floodplains	RW	1229.5	32.8	0.2%	112.6	0.7%
	FP	122.8	0.2	0.0%	3.2	0.0%
Total		1352.3	33.0	0.2%	115.8	0.7%
Dwarf Shrub Heath (Can contain esker complexes)	SH	741.8	25.6	0.2%	66.5	0.4%
Total		741.8	25.6	0.2%	66.5	0.4%
Sensitive or rare wetlands	EM	751.1	5.5	0.0%	34.4	0.2%
	OW	10.6	-	0.0%	-	0.0%
	PG	2,569.3	27.0	0.2%	170.6	1.0%
	WM	6,210.4	207.7	1.3%	673.2	4.1%
Total		9,541.4	240.2	1.5%	878.2	5.3%
Bedrock cliff and Bedrock-lichen veneer ecosystems	BI	979.1	17.4	0.1%	30.3	0.2%
	CL	527.1	58.8	0.4%	93.4	0.6%
	RO	3,280.4	228.8	1.4%	449.4	2.7%
Total		4,786.6	305.0	1.9%	573.1	3.5%
Beaches, marine backshores and intertidal areas	BE	20.9	0.2	0.0%	1.8	0.0%
	MB	17.7	0.6	0.0%	5.5	0.0%
	MI	3.3	0.1	0.0%	0.7	0.0%
Total		41.9	0.9	0.0%	8.0	0.0%
Grand Total		16,464.0	604.7	3.7%	1,641.6	10.0%

Based on the assessment, residual effects due to the Hope Bay Project are predicted for Special Landscape Features due to loss. Residual effects are carried forward to the next section for characterizations according to the defined criteria and significance determination.

8.5.4.2 Alteration of Vegetation and Special Landscape Features

Localized alteration of Vegetation and Special Landscape Features due to soil compaction or erosion, changes in permafrost or snow depth, or invasive plant species will be largely mitigated through the mitigation measures outlined in Section 8.5.3.3. Where effects remain after the application of mitigation measures, these are not expected to occur outside of the PDA. The exception to this are potential effects from fugitive dust which may affect areas outside the PDA.

To assess fugitive dust, an air quality model was developed for the Project for the Construction and Operation phases; this model incorporated mitigation measures intended to protect air quality (Volume 4, Chapter 2, Air Quality Effect Assessment) and *the Air Quality Management Plan*

(Annex V8-2). Predictions for fugitive dust deposition to soil during construction and operation are included in Volume 6, Chapter 5 (Appendices V6-5H and V6-5I).

The quantitative air modelling results indicate that fugitive dust will not result in exceedances of Canadian Council of Ministers of the Environment (CCME 2016) agriculture guidelines for metal concentrations in soils (for Barium, the more conservative residential/parkland guidelines were used). Where baseline metal concentrations exceed CCME guidelines (chromium, copper, and nickel), Project effects will result in minor increases to soil concentrations of these metals (< 10%) which are not predicted to cause risks to human health (Volume 6, Chapter 5, Human Health and Environmental Risk Assessment). Therefore, vegetation is not expected to be negatively altered by the Project due to fugitive dust, airborne emissions, or other media, and potential degradation is not discussed further.

As alteration effects on Vegetation indicators and Special Landscape Features are modelled and predicted to occur within the PDA boundary, no residual effects due to alteration are predicted. This is because total loss of all VECs within the PDA was assumed. This a precautionary approach as it is difficult to accurately spatially assess the potential effects on Vegetation and Special Landscape indicators related to dust, invasive species, and soil compaction. Potential effects related to water quality and quantity are assessed in Volume 5, Chapter 4 (Freshwater Water Quality) and Volume 5, Chapter 1 (Surface Hydrology).

The effects due to airborne fugitive dust fall, airborne contaminants from emission sources on vegetation quality are assessed in the Human Health and Environmental Risk Assessment (Volume 6, Chapter 5) and potential impacts related to air quality on soil eutrophication/acidification are identified in Landforms and Soils (Volume 4, Chapter 7).

The human health and ecological risk assessment (Volume 6, Chapter 5) evaluated potential changes in the quality of environmental media (e.g., soil, vegetation, and water) due to Hope Bay Project pre-construction activities, the combined Doris and Phase 2 Projects, and the potential for increased risk of adverse health effects in ecological receptors (e.g., caribou). The assessment determined that Hope Bay Project effects on environmental media quality were negligible; thus, there is no potential increase in risk of adverse health effects due to either the Madrid-Boston or Hope Bay Project activities. Therefore, the effects of environmental contaminants and bioaccumulation is not considered as a residual effect on Vegetation.

As no residual effects due to alteration of Vegetation and Special Landscape Features are predicted, alteration of Vegetation and Special Landscape Features is excluded from further assessment.

8.5.5 Characterization of Residual Effects

Project residual effects are the effects that are remaining after mitigation and management measures are taken into consideration. If the implementation of mitigation measures eliminates a potential effect and no residual effect is identified on that VEC, the effect is eliminated from further analyses. If the proposed implementation controls and mitigation measures are not sufficient to eliminate an effect, a residual effect is identified and carried forward for additional characterization and a significance determination. Residual effects of the Project and Hope Bay Project can occur directly or indirectly. Direct effects result from specific environment interactions with activities and components, and VECs. Indirect effects are the result of direct effects on the environment that lead to secondary or collateral effects on VECs.

8.5.5.1 *Definitions for Characterization of Residual Effects*

To determine the significance of residual effect, each potential negative residual effect is characterized by a number of attributes consistent with those defined in of the EIS Guidelines (Section 7.14, Significance Determination for the Hope Bay Project; NIRB). A definition for each attribute and the contribution that it has on significance determination is provided in Table 8.5-14.

Table 8.5-14. Attributes to Evaluate Significance of Potential Residual Effects

Attribute	Definition and Rationale	Impact on Significance Determination
Direction	The ultimate long-term trend of a potential residual effect - positive, neutral, or negative.	Positive, neutral, and negative potential effects on Vegetation and Special Landscape Features are assessed, but only negative residual effects are characterized and assessed for significance.
Magnitude	The degree of change in a measurable parameter or variable relative to existing conditions. This attribute may also consider complexity – the number of interactions (Project phases and activities) contributing to a specific effect.	The higher the magnitude, the higher the potential significance.
Duration	The length of time over which the residual effect occurs.	The longer the length of time of an interaction, the higher the potential significance.
Frequency	The number of times during the Project or a Project phase that an interaction or environmental/ socio-economic effect can be expected to occur.	Greater the number times of occurrence (higher the frequency), the higher the potential significance.
Geographic Extent	The geographic area over which the interaction will occur.	The larger the geographical area, the higher the potential significance.
Reversibility	The likelihood an effect will be reversed once the Project activity or component is ceased or has been removed. This includes active management for recovery or restoration.	The lower the likelihood a residual effect will be reversed, the higher the potential significance.

The Effects Assessment Methodology (Volume 2, Chapter 4) describes the criteria used to evaluate potential residual effects. The criteria include direction of change, magnitude, duration, frequency, geographic extent, reversibility, probability of an effect, and confidence in the prediction.

The significance determination represents the effects on the sustainability of Vegetation and Special Landscape Features and their capacity to meet the present and future needs. While the assessment of potential loss occurs at the indicator level, the final magnitude for significance determination is based upon the effects assessed for the VEC, not at the indicator level for specific ecosystems or landscape features.

Section 7.4 of the EIS Guidelines (NIRB) provided guidance, attributes, and criteria for the determination of significance for residual effects. Also, the Canadian Environmental Assessment Agency's *Determining Whether a Project is Likely to Cause Significant Adverse Environmental Effects (*CEA Agency 1994*)* also guided the evaluation of significance for identified residual effects. The significance of residual effects is based on comparing the predicted state of the environment with and without the Project, including a judgment as to the importance of the changes identified.

Thresholds for assessing magnitude for Vegetation and Special Landscape Feature for loss and alteration do not presently exist for Arctic ecosystems. Research has indicated that as total habitat declines both population size and the number of wildlife species decline (not necessarily in a linear relationship) and that thresholds for wildlife often occur somewhere between 30 to 70% of habitat loss, depending on the ecosystem and wildlife species of interest (Mace et al. 1996; Mace and Waller 1997; Mace 2004; Schwartz et al. 2006; Interagency Conservation Strategy Team 2007; Price, Holt, and Kremsater 2007).

As effects to Vegetation and Special Landscape Features represent effects to wildlife, the selection of magnitude classes is consistent with the methodology for the wildlife habitat assessments. While loss of vegetation and habitat greater than 30% can be considered unacceptable (Price, Roburn, and MacKinnon 2009), a lower value was selected to align with the precautionary approach being taken by the Hope Bay Project. The threshold value of 20% for high magnitude was selected based on the concept of maintaining ecosystem group representation. It has been suggested that poorly represented or rare ecosystems, such as wetlands, be offered greater protection (Bunnell et al. 2003; Wells et al. 2003).

Magnitude classes include negligible magnitude, where there is assumed to be no detectable change to baseline distributions, low magnitude (1% to 10% loss), medium magnitude (10.1% to 20% loss), and high magnitude, where loss is assumed to result in a long-lasting effect on the distribution or availability of vegetation communities in the LSA. Loss greater than 20.1% of Vegetation or Special Landscape Features relative to their LSA availability was considered a high magnitude effect. The magnitude classes in Table 8.5-15 were identified using threshold values from literature for loss and disturbance of wildlife habitat.

Table 8.5-15. Definitions of Magnitude Criteria for Vegetation and Special Landscape Features Residual Effects

Magnitude Class	Description
Negligible	Loss less than 1% of VEC availability in the LSA
Low	Loss between 1% to 10% of VEC availability in the LSA
Moderate	Loss between 10.1% to 20% of VEC availability in the LSA
High	Loss greater than > 20.1% VEC availability in the LSA

For the determination of significance, each attribute is characterized. The characterizations and criteria for the characterizations are provided in Table 8.5-16. Each of the criteria contributes to the determination of significance.

Table 8.5-16. Criteria for Residual Effects for Environmental Attributes

Attribute	Characterization	Criteria
Direction	Positive	Beneficial
	Variable	Both beneficial and undesirable
	Negative	Undesirable
Magnitude	Negligible	Loss less than 1% of VEC availability in the LSA
	Low	Differing from the average value for the existing Loss from 1% to 10% of VEC availability in the LSA
	Moderate	Loss between 10.1% to 20% of VEC availability in the LSA
	High	Loss greater than > 20.1% VEC availability in the LSA

(continued)

Table 8.5-16. Criteria for Residual Effects for Environmental Attributes (completed)

Attribute	Characterization	Criteria
Duration	Short	Up to 4 years (Construction phase)
	Medium	Greater than 4 years and up to 17 years (4 years Construction phase, 10 years Operation phase, 3 years Reclamation and Closure phase)
	Long	Beyond the life of the Project
Frequency	Infrequent	Occurring only occasionally
	Intermittent	Occurring during specific points or under specific conditions during the Project
	Continuous	Continuously occurring throughout the Project life
Geographic Extent	Project Development Area (PDA)	Confined to the PDA
	Local Study Area (LSA)	Beyond the PDA and within the LSA
	Regional Study Area (RSA)	Beyond the LSA and within the RSA
	Beyond Regional	Beyond the RSA
Reversibility	Reversible	Effect reverses within an acceptable time frame with no intervention (0 to 25 years)
	Reversible with effort	Active intervention (effort) is required to bring the effect to an acceptable level (25 to 100 years)
	Irreversible	Effect will not be reversed (> 100 years)

Probability of Occurrence or Certainty

Prior to the determination of the significance for negative residual effects, the probability of the occurrence or certainty of the effect is evaluated. For each negative residual effect, the probability of occurrence is categorized as unlikely, moderate, or likely. Table 8.5-17 presents the definitions applied to these categories.

Table 8.5-17. Definition of Probability of Occurrence and Confidence for Assessment of Residual Effects

Attribute	Characterization	Criteria
Probability of occurrence or certainty	Unlikely	Some potential exists for the effect to occur; however, current conditions and knowledge of environmental trends indicate the effect is unlikely to occur.
	Moderate	Current conditions and environmental trends indicate there is a moderate probability for the effect to occur.
	Likely	Current conditions and environmental trends indicate the effect is likely to occur.
Confidence	High	Baseline data are comprehensive; predictions are based on quantitative terrestrial ecosystem mapping; effect relationship is well understood.
	Medium	Baseline data are comprehensive; predictions are based on quantitative terrestrial ecosystem mapping; effect relationship is generally understood, however, there are assumptions based on other similar systems to fill knowledge gaps.
	Low	Baseline data are limited; predictions are based on qualitative data; effect relationship is poorly understood.

Determination of Significance

The evaluation of significance was determined based on the residual effects characterization. The criteria used in assessing significance for Vegetation and Special Landscape Features include:

Not significant: The direction of effects can be positive to negative. The magnitude of effects can be negligible to moderate, and the duration of effects can be short to long. Frequency of effects can be infrequent to continuous, and the geographic extent must be limited to the LSA. Potential effects can be reversible within 25 years to irreversible (greater than 100 years required).

Significant: The direction of effects is negative. The magnitude of effects is high and the duration of is long. Frequency of effects can be infrequent to continuous. Geographic extent must extend beyond the LSA and may be within the RSA or beyond the RSA and has regional geographic extent, and effects can be reversible with effort (25 to 100 years) or irreversible (greater than 100 years required).

Confidence

The knowledge or analysis that supports the prediction of a potential residual effect—in particular with respect to limitations in overall understanding of the environment and/or the ability to foresee future events or conditions—determines the confidence in the determination of significance. In general, the lower the confidence, the more conservative the approach to prediction of significance must be. The level of confidence in the prediction of a significant or non-significant potential residual effect qualifies the determination, based on the quality of the data and analysis and their extrapolation to the predicted residual effects. "Low" is assigned where there is a low degree of confidence in the inputs, "medium" when there is moderate confidence and "high" when there is a high degree of confidence in the inputs. Where rigorous baseline data were collected and scientific analysis performed, the degree of confidence will generally be high. Table 8.5-17 provides descriptions of the confidence criteria.

Residual effects identified in the Project-related effects assessment are carried forward to assess the potential for cumulative interactions with the residual effects of other projects or human activities and to assess the potential for transboundary impacts should the effects linked directly to the activities of the Project inside the Nunavut Settlement Area (NSA), which occurs across provincial, territorial, international boundaries or may occur outside of the NSA.

8.5.5.2 Characterization of Residual Effect for Vegetation

This section characterizes the residual effects using the residual effects descriptors from the preceding section and provides a significance determination for each of the residual effects. For each residual effect, the rating for each criterion and a brief description is provided to justify the rating. Determination of significance is based on the combination of criteria described in the preceding section.

Loss of Vegetation

Madrid-Boston Residual Effects

Loss associated primarily with clearing and grubbing during construction for Madrid-Boston will result in the loss of 4,189 ha or 7.4% of the area of Vegetation VEC. Magnitude is low as loss of Vegetation is between 1 to 10% of the availability of Vegetation indicators in the LSA (Table 8.5-18).

The duration of effects is long, as the recovery time of arctic ecosystems after even light trampling or disturbance can be up to 25 years. Disturbances due to clearing and grubbing activities for Project infrastructure are severe and return to baseline conditions within 100 years is not predicted. Disturbance due to clearing and grubbing are infrequent as most clearing will be completed during the Construction phase. The geographic extent of loss to Vegetation will be contained within the PDA. Actual loss of Vegetation in the PDA will be closer to total Footprint size (1,464 ha), but residual effects have been characterized using the PDA as the loss boundary to provide a conservative estimate of Project effects and allow for flexibility in final infrastructure siting. The loss of Vegetation is considered irreversible (over 100 years) due to the extremely slow recovery processes for arctic vegetation.

Table 8.5-18. Summary of Residual Effects and Overall Significance Rating for Vegetation and Special Landscape Features – Madrid-Boston

Residual Effect	Attribute Characteristic						Overall Significance Rating		
	Direction (*positive, variable, negative*)	**Magnitude** (negligible, *low, moderate, high*)	**Duration** (*short, medium, long*)	**Frequency** (*infrequent, intermittent, continuous*)	**Geographic Extent** (PDA, *LSA, RSA, beyond regional*)	**Reversibility** (*reversible, reversible with effort, irreversible*)	**Probability** (*unlikely, moderate, likely*)	**Significance** *(not significant, significant)*	**Confidence** (*low, medium, high*)
Vegetation									
Loss	Negative	Low	Long	Infrequent	PDA	Irreversible	Likely	Not Significant	High
Special Landscape Features									
Loss	Negative	Low	Long	Infrequent	PDA	Irreversible	Likely	Not Significant	Moderate

The probability of loss due to clearing is likely as Project effects due to clearing are predictable and well understood. Residual effects to the Vegetation VEC are **not significant** as the magnitude is low and the geographic extent of the effects are limited to the PDA (Table 8.5-18). As 93% of the LSA is not affected, sufficient representation of vegetation types and functions exists within the LSA to continue to support existing uses. The confidence in the declaration of not significant is high. Ecosystem mapping is a well-established method for documenting vegetation communities and assessing potential effects to them.

Hope Bay Project Residual Effects

Loss associated primarily with the Hope Bay Project, which includes Madrid-Boston, will affect 4,706 ha of the area of mapped ecosystem communities in the LSA. Total loss is 8.4% of the Vegetation in the LSA. Magnitude is low but bordering on moderate as loss effects are < 10.1% of the availability of Vegetation indicators in the LSA (Table 8.5-19).

The duration of effects is long, as the recovery time of arctic ecosystems occurs over decades or centuries. Disturbances due to permitted activities and infrastructure will be severe and return to baseline conditions within 100 years is not predicted. Disturbance was assessed as intermittent as clearing will take place for previously permitted activities and infrastructure prior to disturbances associated with the Madrid-Boston Construction Phase. The geographic extent of loss to Vegetation will be contained within the PDA. Actual loss of Vegetation in the PDA will be closer to total Footprint size (1,696 ha, 3% of the LSA), but residual effects have been characterized using the PDA as the loss boundary. The loss of Vegetation is considered irreversible (over 100 years) due to the extremely slow recovery processes for arctic vegetation.

The probability of loss due to clearing is likely as Hope Bay Project effects due to clearing are predictable and well understood. Residual effects to the Vegetation VEC are **not significant** as the magnitude is low and the geographic extent of the effects are limited to the PDA (Table 8.5-19). The confidence in the declaration of not significant is high. Ecosystem mapping is a well-established method for documenting vegetation communities and assessing potential effects to them.

8.5.5.3 Characterization of Residual Effect for Special Landscape Features

<u>Loss of Special Landscape Features</u>

Madrid-Boston Residual Effects

Loss associated primarily with clearing and grubbing during construction for Madrid-Boston will affect 1,4.4 ha or 8.7 % of the area occupied by Special Landscape Features due to Madrid-Boston Effects. To assess magnitude, total loss of Special Landscape Features was compared to the total area of Special Landscape Features in the LSA. Based on this, magnitude is low as loss effects are between 1 to 10% of the availability of Special Landscape Features indicators in the LSA (Table 8.5-18). The duration of effects is long due to slow recovery rates in the arctic. Disturbance due to clearing and grubbing activities for Project infrastructure are severe and return to baseline conditions within 100 years is not predicted. Disturbance due to clearing and grubbing are infrequent as most clearing will be completed during the Construction phase. The geographic extent of loss to Special Landscape Features will be contained within the PDA. Actual loss of Special Landscape Features in Footprints in the PDA will be closer to 543 ha, but residual effects have been characterized using the PDA. The loss of Special Landscape Features is considered irreversible (over 100 years) due to the extremely slow recovery processes for arctic vegetation.

Table 8.5-19. Summary of Residual Effects and Overall Significance Rating for Vegetation and Special Landscape Features - Hope Bay Project

Residual Effect	Attribute Characteristic						Overall Significance Rating		
	Direction (*positive, variable, negative*)	**Magnitude** (negligible, *low, moderate, high*)	**Duration** (*short, medium, long*)	**Frequency** (*infrequent, intermittent, continuous*)	**Geographic Extent** (PDA, *LSA, RSA, beyond regional*)	**Reversibility** (*reversible, reversible with effort, irreversible*)	**Probability** (*unlikely, moderate, likely*)	**Significance** (*not significant, significant)*	**Confidence** (*low, medium, high*)
Vegetation									
Loss	Negative	Low	Long	Intermittent	PDA	Irreversible	Likely	Not Significant	High
Special Landscape Features									
Loss	Negative	Low	Long	Intermittent	PDA	Irreversible	Likely	Not Significant	Moderate

The probability of loss due to clearing is likely as Project effects due to clearing are predictable and well understood. Residual effects to the Special Landscape Features VEC are **not significant** as the magnitude is low and the geographic extent of the effects are limited to the PDA (Table 8.5-18). The confidence in the declaration of not significant is high. Ecosystem mapping is a well-established method for documenting rare and unique ecosystems and assessing potential effects to them; however, ecosystem types that are less than 2 ha may not be mapped at a 1:20,000 mapping scale, so confidence in the assessment is moderate.

Hope Bay Project Residual Effects

Loss associated primarily with Hope Bay Project will affect 1,641ha or 10.0% of the Special Landscape Features in the LSA. As described previously, this is relative to the total abundance of Special Landscape Features in the LSA not the total area of the LSA to ensure effects are assessed relative to availability. Magnitude is low but very close to moderate as loss effects 10.0% of the availability of Special Landscape Features indicators in the LSA (Table 8.5-19). Actual Footprint losses are anticipated to be closer to 3.7%, which is part of the rationale for not assessing magnitude as moderate magnitude. The duration of effects is long, as the recovery time of arctic ecosystems after even light trampling or disturbance can be up to 25 years. Disturbances due to permitted activities and infrastructure will be severe and return to baseline conditions within 100 years is not predicted. Disturbance was assessed as intermittent as clearing will take place for previously permitted activities and infrastructure prior to disturbances associated with Madrid-Boston Construction Phase. The geographic extent of loss to Special Landscape Features will be contained within the PDA. The loss of Special Landscape Features is considered irreversible (over 100 years) due to the extremely slow recovery processes for arctic vegetation.

The probability of loss to Special Landscape Features due clearing is predictable and well understood. Residual effects to the Special Landscape Features VEC are **not significant** as the magnitude is low and the geographic extent of the effects are limited to the PDA. Ecosystem mapping is a well-established method for documenting rare and unique ecosystems and assessing potential effects to them; however, ecosystem types that are less than 2 ha may not be mapped at a 1:20,000 mapping scale, so confidence in the assessment is moderate.

8.6 CUMULATIVE EFFECTS ASSESSMENT

As residual effects due to loss of Vegetation and Special Landscape Features are predicted for both the Madrid-Boston and Hope Bay Projects and there is potential for interactions with residual effects from other projects, cumulative effects are assessed.

8.6.1 Methodology Overview

8.6.1.1 Approach to Cumulative Effects Assessment

The general methodology for cumulative effects assessment (CEA) is described in Volume 2, Chapter 4, and focuses on the following activities:

1. Identify the potential for Project-related (Madrid-Boston and the complete Hope Bay Project) residual effects to interact with residual effects from other human activities and projects within specified assessment boundaries. Key potential residual effects associated with past, existing, and reasonably foreseeable future projects were identified using publicly available information or, where data was unavailable, professional judgment was used (based on previous experience in similar geographical locations) to approximate expected environmental conditions.

2. Identify and predict potential cumulative effects that may occur and implement additional mitigation measures to minimize the potential for cumulative effects.
3. Identify cumulative residual effects after the implementation of mitigation measures.
4. Determine the significance of any cumulative residual effects.

8.6.1.2 Assessment Boundaries

The CEA considers the spatial and temporal extent of Project-related residual effects on VECs combined with the anticipated residual effects from other projects and activities to assist with analyzing the potential for a cumulative effect to occur.

<u>Spatial Boundaries</u>

The RSA was selected as a suitable boundary for the cumulative effects assessment, as the RSA encompasses the maximum area where the Project effects to Vegetation and Special Landscape Features could interact spatially with residual effects from other past, present, or reasonably foreseeable future projects and activities (Figure 8.2-1). It encompasses the regional setting for the Project and implicitly considers ecological factors.

<u>Temporal Boundaries</u>

The temporal boundaries for the CEA go beyond the phases of the Project, beginning before major industrial resource development actions were undertaken in the region, and extending into the future. It is not possible to precisely predict which other human actions will occur after the end of Post-Closure; however, an extrapolation of a likely future development scenario for the next several decades—based on information available today—is provided.

8.6.2 Potential Interactions of Residual Effects with Other Projects

With respect to Project residual effects, loss of Vegetation and Special Landscape Features were identified as negative residual effects of Madrid-Boston and the complete Hope Bay Project that could interact cumulatively with other past, present, or future projects or activities.

Only one past project was identified in the RSA that could interact with Madrid-Boston or Hope Bay Project residual effects: Roberts / IDA Bay. No present or reasonably foreseeable future projects were identified in the RSA that have the potential to act cumulatively.

Roberts/IDA Bay were silver mines operated by the Roberts Mining Company between 1973 to 1975. Remediation of the sites was completed in 2008 by Quantum Murray LP under contract to Indian and Northern Affairs Canada. The total area disturbed was less than 4 ha for both sites, which have been restored to conform to natural landforms in the area.

As Roberts/IDA Bay has been reclaimed and the disturbance area was small, less than 2 ha for each mine site, no cumulative interactions are predicted with either Madrid-Boston or Hope Bay Project residual effects. Therefore, no cumulative effects are predicted.

8.7 TRANSBOUNDARY EFFECTS

The EIS Guidelines (NIRB) define transboundary effects as those effects linked directly to the activities of the Project inside the NSA, which occur across provincial, territorial, international boundaries or may occur outside of the NSA (NIRB 2012a). Transboundary effects of the Project have the potential to act cumulatively with other projects and activities outside the NSA.

The Madrid-Boston and Hope Bay Project effects assessed in Section 8.5.1 for Vegetation and Special Landscape Features are predicted to remain in the PDA and LSA, and no cumulative residual effects are predicted (Section 8.6). These effects are all contained within the boundaries which are within Nunavut. Transboundary effects are not predicted and are not further addressed.

8.8 IMPACT STATEMENT

The assessment of potential effects on plant communities, ecosystems, and unique or sensitive landforms for Madrid-Boston and the complete Hope Bay Project was assessed using two VECs: Vegetation, and Special Landscape Features. The potential effects assessed included loss due to clearing and grubbing and alteration associated with potential changes in permafrost, water quality or quantity, soil conditions, snow deposition, potential contaminants, and dust.

Direct loss and alteration of Vegetation and Special Landscape Features are predicted to occur primarily during the Construction phase for Madrid-Boston, adding to losses occurring during the construction of the existing and approved components of the Hope Bay Project. To assess loss and alteration to Vegetation and Special Landscape Features, indicators were identified.

Vegetation indicators included ecosystem types, species diversity, and productivity; and Special Landscape indicators included riparian ecosystems, rare or sensitive wetlands, ecosystems that can contain esker complexes, cliffs, bedrock lichen and outcrop ecosystems, and beaches and marine intertidal areas.

Mitigation measures were developed to reduce potential effects to Vegetation and Special Landscape Features including avoidance, minimization of effects, and restoration on-site environmental values. As effects due to alteration were not identified outside the PDA boundaries after mitigation, alteration was excluded from further assessment.

The loss of Vegetation within the PDA will result in effects to ecosystem abundance, species diversity, and vegetation productivity. Total loss of ecosystems and Vegetation in the PDA will result in 4,189 ha and a 7.4% reduction of availability in the LSA for Madrid-Boston and a 4,727 ha (8.4%) reduction associated with the Hope Bay Project. The greatest change in baseline ecosystem distribution due to Madrid-Boston and the Hope Bay Project results in the loss of 1,348 ha and 1,512 ha of Eriophorum Tussock Meadow (TM) respectively.

Loss of Special Landscape Features in the PDA will result in a total loss of 1,388 ha and an 8.4% reduction in availability in the LSA for Madrid-Boston and 1,665 ha and a 10.1% reduction of availability associated with the Hope Bay Project. The greatest changes to Special Landscape Features were observed in Wetland Meadows, which provide 664 ha of wetland habitat. Losses for individual features are all below 10% of their respective baseline distributions.

Loss of Vegetation and Special Landscape Features was restricted to the PDA and magnitude for Madrid-Boston and the Hope Bay Project was assessed as low for both VECs, except for magnitude for the Hope Bay Project which was moderate for Special Landscape Features.

Residual effects due to loss of Vegetation for Madrid-Boston and the Hope Bay Project are assumed to be irreversible but **Not Significant** as ecosystems and Vegetation lost in the PDA are common within the LSA boundary and the RSA (Table 8.5-18 and 8.5-19).

Residual effects due to loss of Special Landscape Features are assumed to be irreversible but **Not Significant** as effects are limited to the PDA. The features occur throughout the LSA and the RSA and will continue to support traditional uses and wildlife habitat (Tables 8.5-18 and 8.5-19).

The two Project residual effects were included in a cumulative effects assessment, the boundary of which was the Vegetation and Special Landscape Features RSA. However, as no spatial overlap with past, present, or foreseeable future projects was identified, no cumulative interactions were identified and no transboundary effects will occur.

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