Figure 8.2-6
Vegetation Metal Sampling Locations

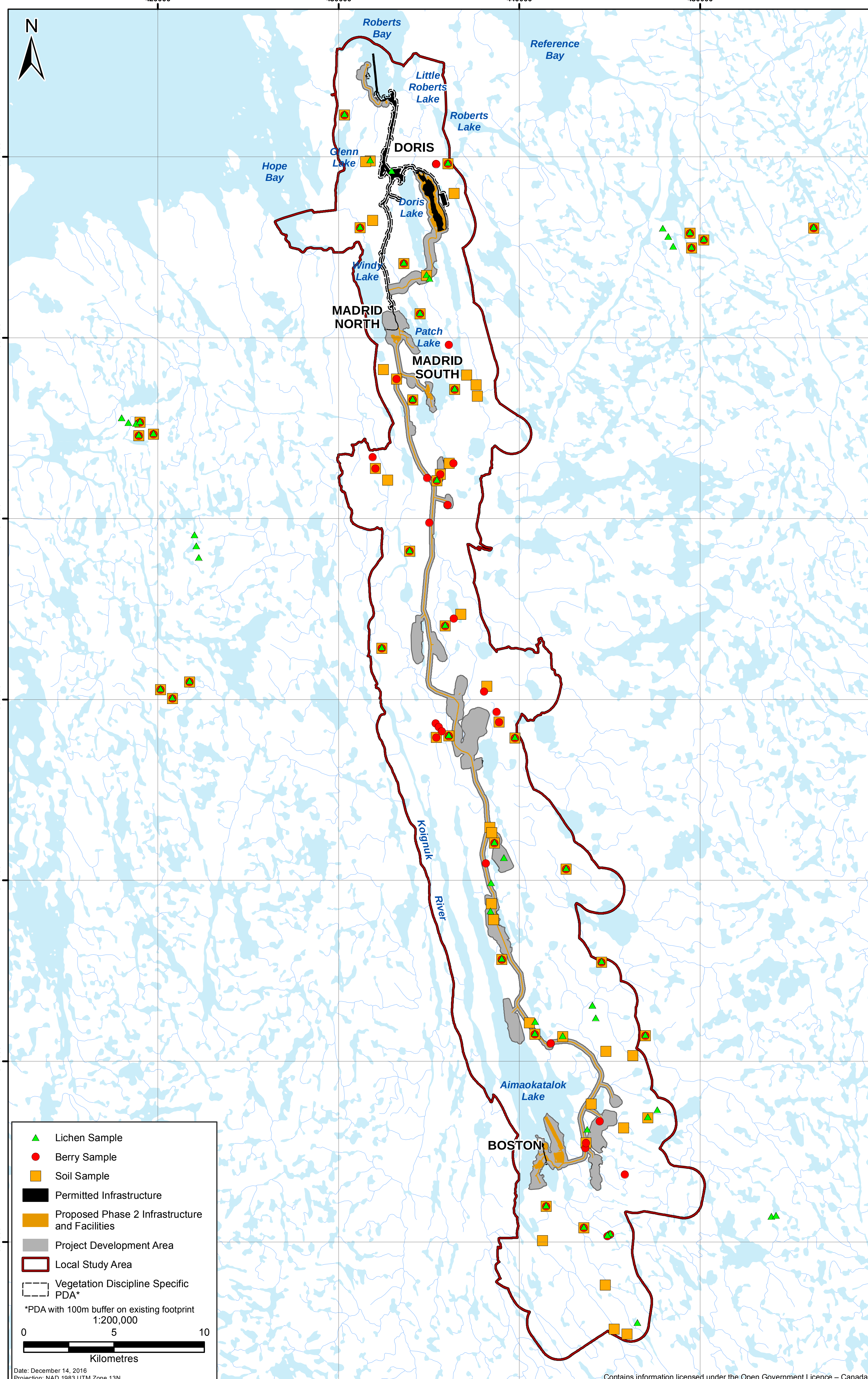


Table 8.2-8 presents metal concentrations for *Empetrum nigrum, Arctostaphylos alpina*, and *Vaccinium* sp. Table 8.2-9 presents metal concentrations for *Flavocetraria cucullata or F. nivalis*.

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

Parameter	Detection Limit	N	Standard Deviation	Minimum	Mean	Median	95th Percentile	Maximum
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
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

Parameter	Detection Limit	N	Standard Deviation	Minimum	Mean	Median	95th Percentile	Maximum
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
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 Phase 2 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, 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 Phase 2 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, Section 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 2015; 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 Phase 2 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, Section 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, Section 9 and Human Health and Environmental Risk Assessment Volume 6, Section 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 Reclamation and Closure, Volume 3, Section 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, Section 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, Section 9)*;*
- *Discuss the potential of invasive vegetative species (weedy species) from shipping 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, Section 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 Hope Bay Phase 2 Project were conducted in each of the five Kitikmeot communities as described in Section 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 2015). 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 2015). 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 2015). 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 2015; D. E. 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 2015).

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 Phase 2 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, Section 7, and permafrost and ground stability are assessed in Volume 4, Section 6.

8.4 SPATIAL AND TEMPORAL BOUNDARIES

The spatial boundaries selected to shape this assessment were determined by the Phase 2 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 Phase 2 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 spatial and temporal boundaries of the assessment consider both the incremental potential effects of the Phase 2 Project, as well as the total potential effects of the additional Phase 2 Project activities in combination with the Existing and Approved Projects including regional exploration 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 Sections 8.4.1, 8.4.2, and 8.4.3.

8.4.1 Project Overview

Through a staged approach, the Hope Bay Project is scheduled to achieve mine operations in the Hope Bay Greenstone Belt through mining at Doris, a bulk sample followed by commercial mining at Madrid North and South, and mining of the Boston deposit. To structure the assessment, the Hope Bay Project is broadly divided into: 1) the Approved Projects (Doris and exploration), and 2) the Phase 2 Project (this application).

8.4.1.1 The Approved Projects

The Approved Projects include:

1. the Doris Project (NIRB Project Certificate 003, NWB Type A Water Licence 2AM-DOH1323);
2. the Hope Bay Regional Exploration Project (NWB Type B Water Licence B 2BE-HOP1222);
3. the Boston Advanced Exploration Project (NWB Type B Water Licence 2BB-BOS1217); and
4. the Madrid Advanced Exploration Project (NWB Type B Water Licence under Review).

<u>The Doris Project</u>

Following acquisition of the Hope Bay Project by TMAC in March of 2013, planning and permitting, advanced exploration and construction activities have focused on bringing Doris into gold production in early 2017. In 2016, the Nunavut Impact Review Board and Nunavut Water Board (NWB) granted an amendment to the Doris Project Certificate and Doris Type A Water Licence respectively, to expand mine operations to six years and mine the full Doris deposit. Mining and milling rates were increased to a nominal 1,000 tpd to 2,000 tpd.

The Doris Project includes the following:

- the Roberts Bay offloading facility: marine jetty, barge landing area, beach and pad laydown areas, fuel tank farm/transfer station, and quarries;

- the Doris Site: camp, laydown area, service complex (e.g., workshop, wash bay), quarries, fuel tank farm/transfer station, potable water treatment, waste water treatment, incinerators, explosives storage, and diesel power plant;
- Doris Mine works and processing: underground portal, temporary waste rock pile, ore stockpile, and processing plant;
- water use for domestic, drilling and industrial uses, and groundwater inflows to underground development;
- Tailings Impoundment Area (TIA): Schedule 2 designation of Tail Lake with two dams (North and South dams), roads, pump house, and quarry;
- all-weather roads and airstrip, winter airstrip, and helicopter pads; and
- water discharge from the TIA will be directed to the outfall in Roberts Bay.

Hope Bay Regional Exploration Project

The Hope Bay Regional Exploration Project has been ongoing since the 1990s. Much of the previous work for the program was based out of the Windy Lake (closed in 2008) and Boston sites (put into care and maintenance in 2011). All exploration activities are currently based from the Doris Site with plans for some future exploration at the Boston Site. Components and activities for the Hope Bay Regional Exploration Project include:

- staging of drilling activities out of Doris or Boston sites; and
- operation of exploration drills in the Hope Bay Belt area, which are supported by helicopter.

Boston Advanced Exploration

The Boston Advanced Exploration Project, which operates under a Type B Water Licence, includes:

- the Boston exploration camp, sewage and greywater treatment plant, fuel storage and transfer station, landfarm, and a heli-pad;
- mine works consisting of underground development for exploration drilling and bulk sampling, temporary waste rock pile, and ore stockpile;
- potable water and industrial water taken from Aimaokatalok Lake; and
- treated sewage and greywater discharged to the tundra.

Since the construction of Boston will require the reconfiguration of the entire site, construction and operation of all aspects of the Boston Site will be considered as part of the Phase 2 Project for the purposes of the assessment.

Madrid Advanced Exploration

In 2014, TMAC applied for an advanced exploration permit to conduct a bulk sample at the Madrid North and Madrid South sites, which are approximately 4 km south of the Doris Site. The program includes extraction of a 50,000 tonne bulk sample, which will be trucked to the mill at the Doris Site for processing and placement of tailings in the TIA. All personnel will be housed at the Doris Site.

The Water Licence application is currently before the NWB. Madrid advanced exploration includes constructing and operating of the following at each of the sites:

- Madrid North and Madrid South: workshop and office, laydown area, diesel generator, emergency shelter, fuel storage facility/transfer station, contact water pond, and quarry;
- Madrid North and Madrid South mine works: underground portal and works, waste rock pad, ore stockpile, compressor building, brine mixing facility, saline storage tank, air heating facility, and vent raises; and
- a road from the Doris Site to Madrid with branches to Madrid North, Madrid North vent raise, and the Madrid South portal.

8.4.1.2 The Phase 2 Project

The Phase 2 Project includes the construction and operation of commercial mining at the Madrid (North and 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 Phase 2 Project, for the purposes of the assessment, are the reclamation and closure and post-closure of unaltered components of the Doris Project as currently permitted and approved.

<u>Construction</u>

Phase 2 construction will use the infrastructure associated with Approved Projects.

Additional infrastructure to be constructed for the proposed Phase 2 Project includes:

- expansion of the Doris TIA (raising of the South Dam, construction of West Dam, and development of a west road to facilitate access);
- construction of an off-loading cargo dock at Roberts Bay (including a fuel pipeline, expansion of the fuel tank farm and laydown area);
- construction of infrastructure at Madrid North and Madrid South to accommodate mining;
- complete development of the Madrid North and Madrid South mine workings;
- construction of a process plant, fuel storage, power plant, and laydown at Madrid North;
- all weather access road (AWR) and tailings line from Madrid North to the south end of the TIA;
- AWR linking Madrid to Boston with associated quarries;
- all infrastructure necessary to support mining activities at Boston including construction of a new camp at Boston and associated support facilities, additional fuel storage, laydown area, ore pad, waste rock pad, process plant, airstrip, diesel power plant, and dry-stack tailings management area (TMA) at Boston; and
- infrastructure necessary to support ongoing exploration activities at both Madrid and Boston.

<u>Operation</u>

Phase 2 Project represents the staged development of the Hope Bay Belt beyond the Doris Project (Phase 1). Phase 2 operation includes:

- mining of the Madrid North, Madrid South, and Boston deposits;
- transportation of ore from Madrid North, Madrid South and Boston to Doris for processing, and transportation of concentrate from process plants at Madrid North and Boston to Doris for final gold refining once the process plants at Madrid North and Boston are constructed;

- use of Roberts Bay and Doris facilities, including processing at Doris and maintaining and operating the Robert's Bay outfall for discharge of water from the TIA;
- operation of a process plant at Madrid North to concentrate ore, and disposal of tailings at the Doris TIA;
- operation of a process plant at Boston to concentrate ore, and disposal of tailings to the Boston TMA; and
- ongoing use and maintenance of transportation infrastructure (cargo dock, jetty, roads, and quarries).

Reclamation and Closure

At Reclamation and Closure, all sites will be deactivated and reclaimed in the following manner (see Volume 3, Section 5.5):

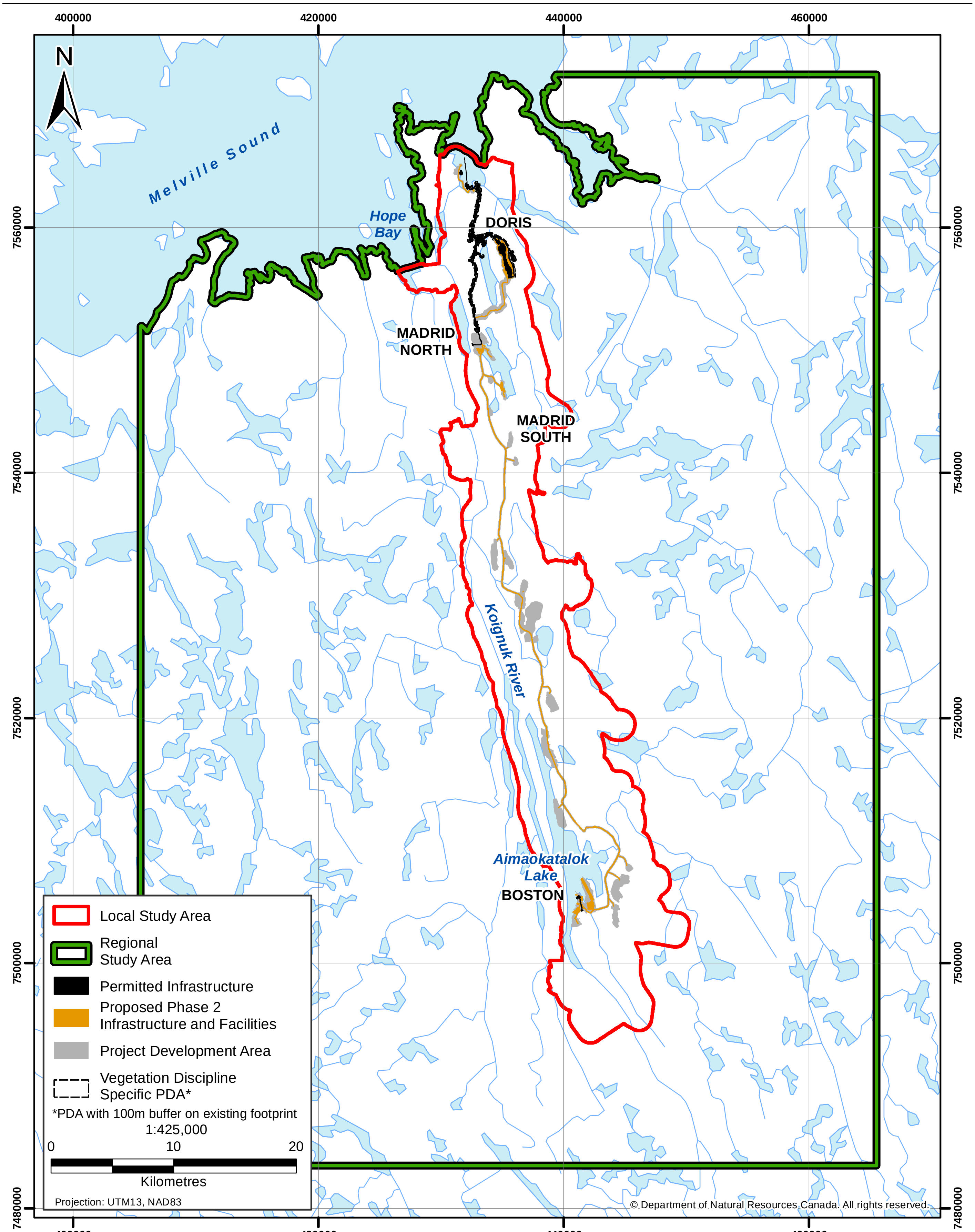
- Camps and associated infrastructure, laydown areas and quarries, buildings and physical structures will be decommissioned. All foundations will be re-graded to ensure physical and geotechnical stability and promote free-drainage, and any obstructed drainage patterns will be re-established.
- Using non-hazardous landfill, facilities will receive a final quarry rock cover which will ensure physical and geotechnical stability.
- Mine waste rock will be used as structural mine backfill.
- The Doris TIA surface will be covered 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 All-Weather Road 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. The balance of the berms will be left in place to prevent localised 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 Phase 2 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.

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



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 Phase 2.

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

8.4.3 Temporal Boundaries

The Project represents a significant development in the mining of the Hope Bay Greenstone Belt. Even though the Phase 2 Project spans the conventional Construction, Operation, Reclamation and Closure, and Post-closure phases of a mine project, Phase 2 is a continuation of development currently underway. Phase 2 has four separate operational sites: Roberts Bay, Doris, Madrid (North and South), and Boston and three mine sites: Madrid North, Madrid South and Boston. Development, operation and closure of the Phase 2 Project will overlap mining and post-mining activities at the existing Doris mine. 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 during Phase 2.

For the purposes of the EIS, distinct phases of the Phase 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, Section 2 (Project Description).

The assessment also considers a Temporary Closure phase should there be a suspension of Phase 2 Project activities during periods when the it becomes uneconomical due to market conditions. During this phase, the Phase 2 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
Existing and Approved Projects	0	2019 - 2040	24	• **Existing and Approved Developments**
Construction	1 - 4	2019 - 2022	4	• **Roberts Bay:** construction of marine dock and additional fuel facilities (Year 1 – Year 2); • **Doris**: expansion of the Doris TIA and site (Year 1); • **Madrid North:** construction of process plant and road to Doris TIA (Year 1); • **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	14	• **Roberts Bay**: shipping operations (Year 1 – Year 14) • **Doris**: mining (Year 1 - 4); milling and infrastructure use (Year 1 – Year 14); • **Madrid North:** mining (Year 1 – 13); ore transport to Doris mill (Year 1 -13); ore processing and concentrate transport to Doris mill (Year 2 – Year 13); • **Madrid South:** mining (Year 11 – Year 14); ore transport to Doris mill (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 13); ore transport to Doris mill (Year 4 – Year 5); processing ore (Year 6 – Year 13); and concentrate transport to Doris mill (Year 6 – Year 13).
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); mining, milling, 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 Phase 2 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 Phase 2 Project on the environment and follows the general methodology provided in Volume 2, Section 4 (*Effects Assessment Methodology*), and comprises a number of steps that collectively assess the manner in which the Phase 2 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 Phase 2 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 Phase 2 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 Phase 2 in isolation;
5. Identify residual effects of Phase 2 in combination with the residual effects of Approved Projects; and
6. Determine the significance of combined residual effects.

To assess potential interaction between the Phase 2 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 Phase 2 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) Phase 2 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, 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 shipping 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 Phase 2 and Hope Bay Project

Project	PDA (ha)	Footprint Area (ha)	Percent Footprint of PDA
Phase 2	4,030.7	1,224.5	30.0
Hope Bay Project	4,569.2	1,341.0	29.3

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 shipping results in primarily marine invasive species such algae, crustaceans, and molluscs not terrestrial invasive plant species (Ruiz et al.). 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, shipping 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. 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 and sedimentation 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.

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, Section 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 1987). 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 Phase 2 Project that indicate the majority of dustfall is predicted within 500 m of most infrastructure and 250 of roads (Volume 4, Section 2; Appendix V4-2I).

Other potential minor degradation effects to vegetation VECs related to the Phase 2 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 Phase 2 Project design (Volume 3, Section 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, Section 4, and potential effects to permafrost and snow accumulations are discussed in Volume 4, Section 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 Phase 2 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

Project Component / Activity	Phase 2 Effect			
	Vegetation		Special Landscape Features	
	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 Boston 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 Site		X		X
Operation of the Boston 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 Phase 2 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 Phase 2 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 Phase 2 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. Where possible setbacks were applied to the features listed in Table 7.6-1. 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 Reclamation and Closure Plan (Volume 8, Annex 27) 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.

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 8, Annex 4) 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 3) 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* (Volume 8, Annex 15) outlines the safe handling requirements, storage, transportation, disposal, and reporting of hazardous materials at Project sites.

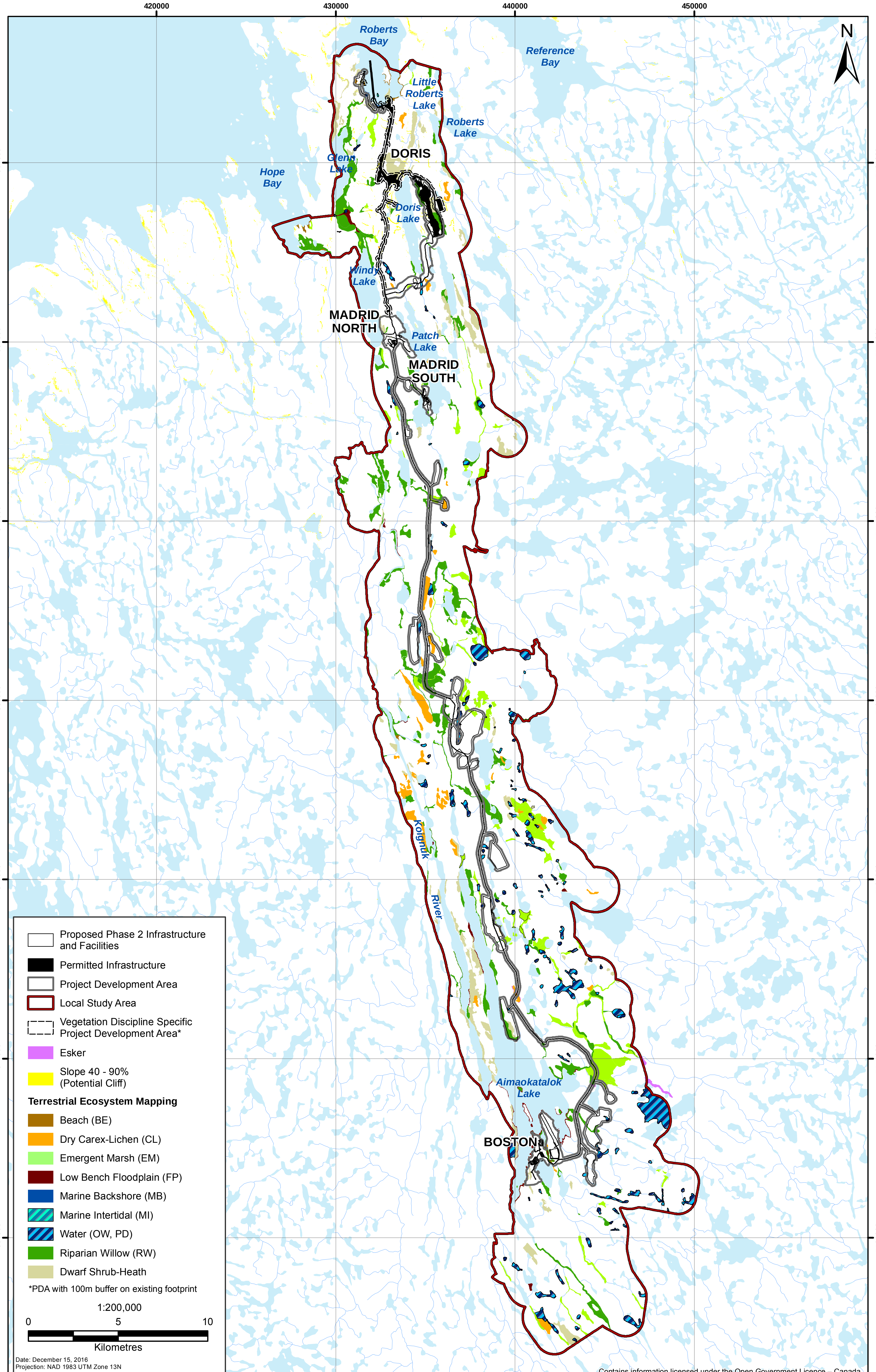
8.5.3.3 Mitigation Measures for Specific Potential Effects or VECs

<u>Rare Plant and Lichen Mitigation Measures</u>

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.

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



Invasive Plant Species Mitigation Measures

Due to the remote location of the Project, the focus of invasive plant species prevention will be on reducing the probability of the introduction and spread of invasive plant species.

Prior to transport to the site, all vehicles (bulldozers, mine trucks, excavators, etc.) will be thoroughly inspected. 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.

Management and mitigation measures for invasive plant management include minimizing soil degradation (i.e., erosion). Erosion control will be established as soon as feasible, the methods of which will be determined by the timing of salvage.

It is anticipated that the implementation of these measures will be highly effective at preventing the establishment of invasive plant species on the Project site.

In the event that invasive plants are observed on site, a detection and eradication program will be developed for invasive plants. This program will include the implementation of a detection and inventory system and a control and monitoring program. The ecological cause (disturbance, favourable light conditions, compacted soil, etc.) and likely succession of the invasive plant population will be used to help select an ecologically appropriate treatment option(s). Treatment options include mechanical, chemical, biological, or a combination of these methods using an ecology based approach, commonly referred to as integrated pest management. Cleared sites with be monitored once per year to ensure they are re-vegetated: 1) with seeds (and/or plants) suitable for the local area and ecosystems; 2) during the appropriate growing season and conditions to ensure maximum survival rate and to avoid establishment of invasive plants; and 3) to facilitate the re-establishment of ecological functions and their associated attributes (e.g., species diversity and productivity).

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* (Volume 8, Annex 19), the *Wildlife Mitigation and Monitoring Plan* (Volume 8, Annex 22), and the *Water Management Plan* (Volume 8, Annex 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 (Volume 8, Annex 27).

Water Quality and Quantity

Water Quality and quantity will be monitored and potential effects mitigated according to the Site *Water Management Plan* (Volume 8, Annex 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 *Phase 2 Aquatic Effects Monitoring Plan*

(Volume 8, Annex 21). Water quality discharges to tundra will also meet guidelines established under the water license as described in the *Domestic Wastewater Treatment Management Plan* (Volume 8, Annex 5). 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.

<u>Dust Mitigation Measures</u>

The *Air Quality Management Plan* (Volume 8, Annex 19) outlines the various mitigation measures employed specifically to reduce dust and air emissions caused by the Phase 2 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 Volume 8, Annex 19. 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 (Volume 8, Annex 27).

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, Section 5) and in *Terrestrial Wildlife and Wildlife Habitat* (Volume 4, Section 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.

<u>Contaminant Mitigation</u>

The *Spill Contingency Plan* (Volume 8, Annex 4) 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* (Volume 8, Annex 3) outlines the procedures associated with the shipping, 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 (Appendix V3-2C) to determine fill requirements over tundra to ensure preservation of permafrost for infrastructure construction;

- thermal modelling of the Boston TMA (Appendix B of Appendix V3-2F);
- thermal modelling of the North, South and West Dams at the Doris TIA (Appendix C of Appendix V3-3F);
- 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* (Volume 8, Annex 19) indicates exceedances of air quality requirements;
- the *Wildlife Mitigation and Monitoring Program* (Volume 8, Annex 22) describes planned monitoring of adverse effects on wildlife or wildlife habitat; and
- the *Water Management Plan, Hope Bay Project* (Volume 8, Annex 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 Phase 2 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).

Project effects to Vegetation and Special Landscape Features are indicated by area loss or alteration for each indicator. The assessment compares the pre-Phase 2 distribution of the indicators with post-Phase 2 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 Phase 2 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, invasive plant species, soil characteristics, permafrost, snow accumulation, and possible contamination due to accidents or malfunctions.

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 Phase 2 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 Phase 2 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 Phase 2 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 Phase 2 Project design, effects to Special Landscape Features are expected.
	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.

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 Phase 2 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 Phase 2 Project design.

For Phase 2, 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. Phase 2 assessment also considers the effects that result during Operation for Phase 2.

For the Hope Bay Project, loss was assessed for both Phase 2 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 Phase 2 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

Phase 2 - 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 Phase 2 Project Footprint and PDA (Figure 8.5-2). The largest proportional loss of mapped ecosystems in the LSA is Eriophorum Tussock Meadow (1,348 ha; 2.4%), 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 556 ha (1.0%) will be lost due to Phase 2 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 Phase 2 development is 4,030 ha or 7.2% of ecosystems in the LSA.

Table 8.5-4. Phase 2 Ecosystem Loss within the PDA and Footprint

TEM Map		LSA	Phase 2 Footprint loss		Phase 2 PDA loss	
Code	Ecosystem Type	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	0.1	< 0.1%	30.1	0.1%
BL	Betula-Ledum-Lichen	7,075.8	177.8	0.3%	555.7	1.0%
BM	Betula-Moss	1,708.4	20.7	< 0.1%	139.1	0.2%
CL	Dry Carex-Lichen	527.1	48.9	0.1%	86.7	0.2%
DH	Dryas Herb Mat	4,344.8	166.8	0.3%	424.8	0.8%
DW	Dry Willow	1,243.8	17.3	< 0.1%	79.8	0.1%
EM	Emergent Marsh	751.1	4.1	< 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	0.0	< 0.1%	3.1	< 0.1%
LA & PD	Lakes and Ponds	8,214.6	72.2	0.1%	72.9	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	0.6	< 0.1%	5.8	< 0.1%
OW	Shallow Open Water	10.6	0.1	< 0.1%	5.0	< 0.1%
PG	Polygonal Ground	2,569.3	22.5	< 0.1%	161.5	0.3%
RI	River	797.6	0.7	< 0.1%	9.5	< 0.1%
RO	Rock Outcrop	3,280.4	179.0	0.3%	346.2	0.6%
RU	Rubble (Talus)	19.6	0.0	< 0.1%	-	< 0.1%
RW	Riparian Willow	1,229.5	28.8	0.1%	110.3	0.2%
SH	Dwarf Shrub-Heath	741.8	17.9	< 0.1%	46.6	0.1%

TEM Map Code	Ecosystem Type	LSA ha	Phase 2 Footprint loss		Phase 2 PDA loss	
			ha	%	ha	%
SW	Salt Water	741.1	0.5	< 0.1%	5.7	< 0.1%
TM	Eriophorum Tussock Meadow	15,630.1	342.1	0.6%	1,348.5	2.4%
WM	Wet Meadow	6,210.4	124.0	0.2%	560.0	1.0%
Total		**56,340.0**	**1224.5**	**2.2%**	**4,030.6**	**7.2%**

Based on the assessment, residual effects due to Phase 2 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 Phase 2 and for previously permitted activities and infrastructure for the Hope Bay Project, which precedes Phase 2. Loss assessed as part of the Hope Bay Project is due to clearing and grubbing associated with construction of Phase 2 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.

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 (1,512; 2.7%), Wet Meadow (662; 1.2%) and Betula-Ledum-Lichen (585: 1.0%). 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 4,569 ha or 8.1% 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.

Loss of Vegetation Species Diversity

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; Pollock et al. 1998: Gould and Walker 1997).

A rating system to assess Phase 2 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).

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

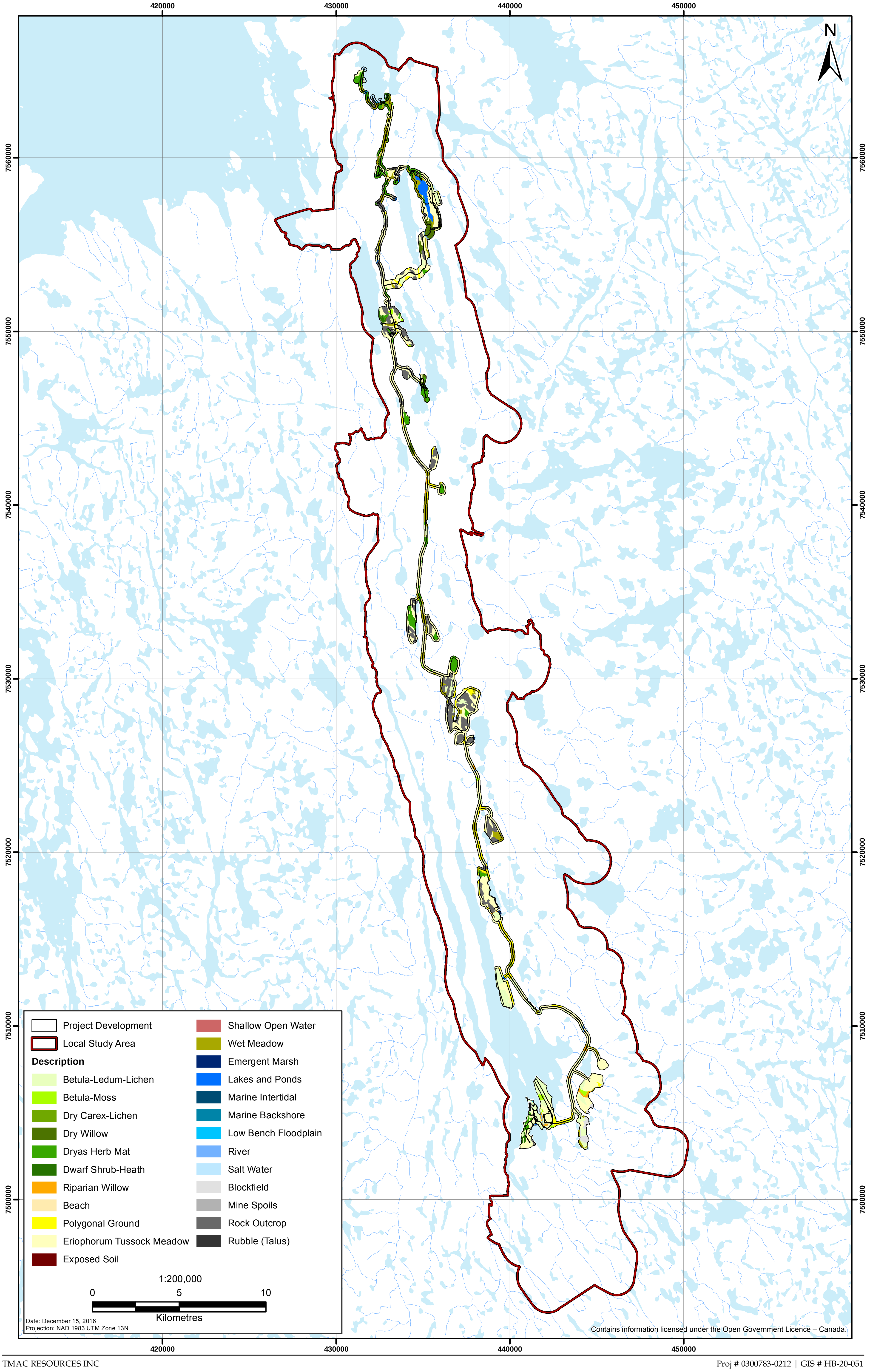


Table 8.5-5. Hope Bay Project Ecosystem Loss within the PDA and Footprint

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	0.1	< 0.1%	30.1	0.1%
BL	Betula-Ledum-Lichen	7,075.8	184.4	0.3%	584.6	1.0%
BM	Betula-Moss	1,708.4	21.6	< 0.1%	142.7	0.3%
CL	Dry Carex-Lichen	527.1	49.0	0.1%	89.5	0.2%
DH	Dryas Herb Mat	4,344.8	185.2	0.3%	516.7	0.9%
DW	Dry Willow	1,243.8	18.1	< 0.1%	87.9	0.2%
EM	Emergent Marsh	751.1	4.1	< 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	0.0	< 0.1%	3.5	< 0.1%
LA & PD	Lakes and Ponds	8,214.6	72.3	0.1%	79.4	0.1%
MB	Marine Backshore	17.7	0.6	< 0.1%	5.6	< 0.1%
MI	Marine Intertidal	3.3	0.1	< 0.1%	0.7	< 0.1%
MS	Mine Spoils	16.9	0.6	< 0.1%	5.9	< 0.1%
OW	Shallow Open Water	10.6	0.2	< 0.1%	6.3	< 0.1%
PG	Polygonal Ground	2,569.3	23.8	< 0.1%	170.5	0.3%
RI	River	797.6	0.7	< 0.1%	9.5	< 0.1%
RO	Rock Outcrop	3,280.4	191.0	0.3%	423.7	0.8%
RU	Rubble (Talus)	19.6	0.0	< 0.1%	2.1	< 0.1%
RW	Riparian Willow	1,229.5	28.8	0.1%	111.1	0.2%
SH	Dwarf Shrub-Heath	741.8	24.3	< 0.1%	66.2	0.1%
SW	Salt Water	741.1	0.8	< 0.1%	21.2	< 0.1%
TM	Eriophorum Tussock Meadow	15,630.1	387.9	0.7%	1,511.6	2.7%
WM	Wet Meadow	6,210.4	147.2	0.3%	662.0	1.2%
Total		**56,340.0**	**1,341.3**	**2.4%**	**4,569.2**	**8.1%**

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**	**100.00%**

Source: Adapted from Gould (1998)

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.

Phase 2 – Loss of Vegetation Species Diversity

Losses of species diversity class were similar in the high (1,395 ha, 2.5%), moderate (1,147 ha, 2.0%) and low (1,354 ha, 2.4%) 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. Phase 2 Loss of Vegetation Species Diversity by Diversity Classes within Footprints and Project Development Area

	LSA	Phase 2 Footprint Loss		Phase 2 PDA Loss	
Species Diversity Class	**ha**	**ha**	**%**	**ha**	**%**
High	16,372	360.0	0.6%	1,395.1	2.5%
Moderate	13,212	410.9	0.7%	1,147.1	2.0%
Low	16,151	375.3	0.7%	1,353.6	2.4%
Very Low	851	4.9	0.0%	42.0	0.1%
Nil (Non-vegetated and Water)	9,753	73.5	0.1%	93.0	0.2%
Total	**56,340**	**1,224.5**	**2.2%**	**4,030.7**	**7.2%**

Based on the assessment, residual effects due to Phase 2 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.