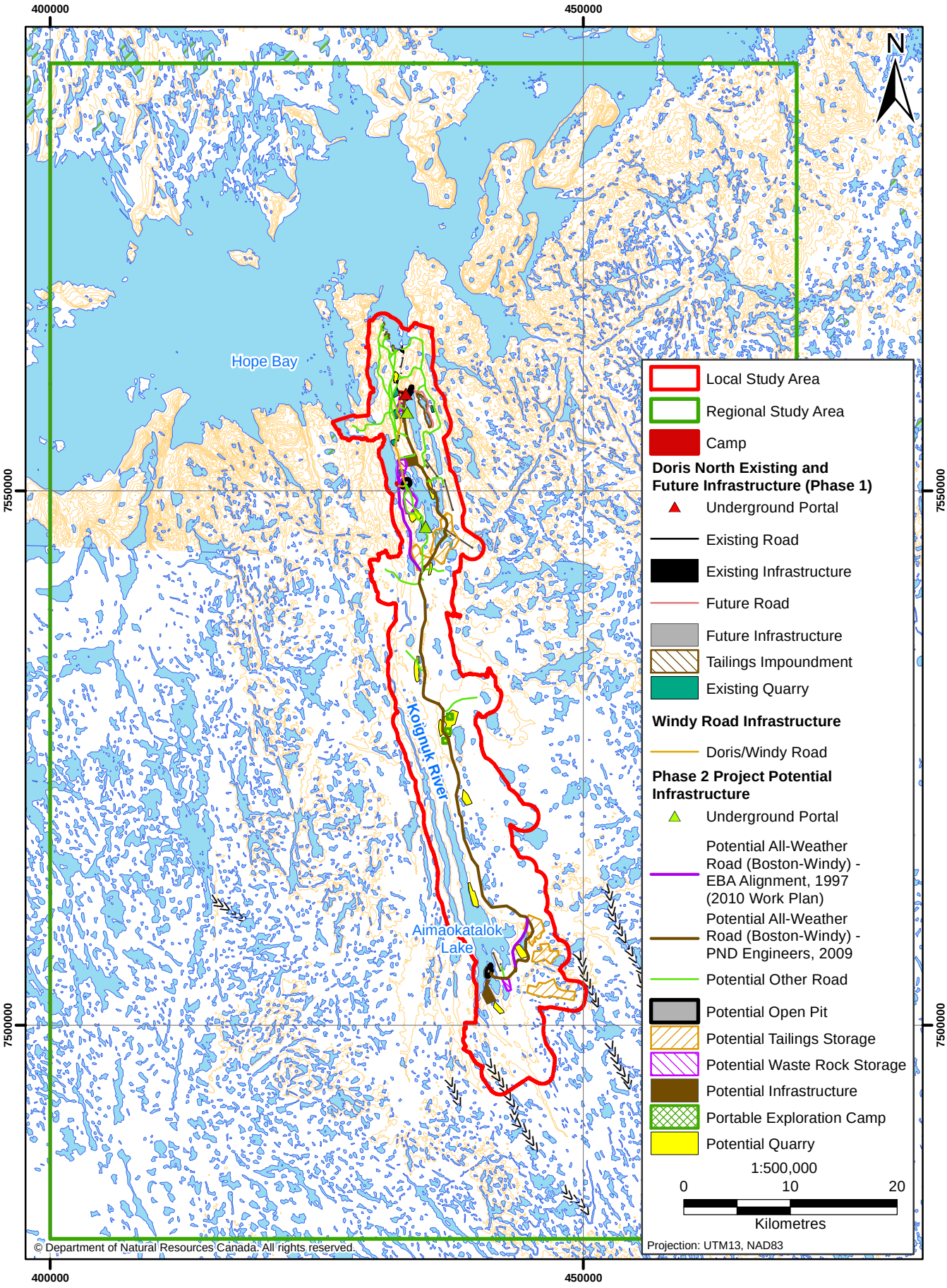

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Hope Bay Project Ecosystem Study Area Boundaries

Figure 2.1-1

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Figure 2.2-1

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Arctic Ecozones and Ecoregions

Figure 2.2-1

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2.2.2 Background Information

A comprehensive site level ecological classification system has not been developed for Nunavut or the Northwest Territories. A coarse level vegetation classification system was developed for the West Kitikmeot/Slave Study (WKSS) region (RWED 2000; and Matthews and Epp 2001), which includes the Project area (Golder 2009). Multiple local ecosystem classification projects have been completed for the Project area (Rescan 1997; Burt 2003) from which Golder (2009) created a preliminary regional Ecosystem Land Classification (ELC). The ELC was developed to compare local ecosystems with the broad level WKSS classification system, and to enable the assessment of environmental impacts at both local and regional levels (Golder 2009). The ELC correlation to local ecosystem classifications did not include marine influenced ecosystems, with the exception of a beach (dune) vegetation type, because the WKSS classification does not contain equivalent units. These types are also generally considered to be too small to map at a regional level (Golder 2009). Furthermore, it was unclear in Golder (2009) whether the Marine Intertidal and Marine Backshore ecosystem units were included in the Beach (Dune) ELC unit. The Dry Willow (DW), Low Bench Floodplain (FP), and Polygonal Ground (PG) ecosystem units found in Rescan (1997) were not included in the Golder (2009) classification.

Table 2.2-1 was adapted from Golder (2009) to show the correlation between the WKSS ELC units and local ecosystem mapping units. The table was simplified by removing the Golder ELC associated plant community type and associated plant community subtype columns. The Burt (2003) Classification Column was converted to the Rescan 1997 ecosystem types that this report is largely based upon. Figure 2.2-2 presents the RSA with the WKSS ELC units and the LSA boundary.

Table 2.2-1. Modified Correlation of Regional ELC Units with the WKSS and Rescan 1997 Classification

ELC Code	WKSS ELC Unit	Local Ecosystem Unit(s)	Area (ha)	% of RSA
0	Unclassified	NA	7,674	1
1	Lichen Veneer	Carex-Lichen (CL)	10,507	1.4
2	Deep Water	Lakes (LA) and Salt Water (SW)	108,899	14.1
3	Esker Complex	Carex-Lichen (CL) and Dwarf Shrub-Heath (SH)	1,533	0.2
4	Wetland (Sedge Meadow)	Wet Meadow (WM), Polygonal Ground (PG) and Emergent Marsh (EM)	37,192	4.8
5	Shallow Water	Ponds (PD) and Shallow Open Water (OW)	150,709	19.6
6	Tussock/Hummock	Eriophorum Tussock Meadow (TM)	60,898	7.9
7	Heath Tundra	Dryas Herb Mat (DH) and Betula-Ledum-Lichen (BL)	127,670	16.6
10	Bedrock Association	Rock Outcrop (RO) and Carex-Lichen (CL)	31,086	4
11	Riparian Tall Shrub	Riparian Willow (RW)	18,649	2.4
13	Heath/Boulder	Carex-Lichen (CL) and Dwarf Shrub-Heath (SH)	11,943	1.6
14	Heath/Bedrock	Dryas Herb Mat (DH) and Carex-Lichen (CL)	128,042	16.6
15	Boulder Association	Blockfield (BI)	4,790	0.6
16	Bare Ground	Barren (BA) and Exposed Soil (ES)	5,972	0.8
17	Low Shrub	Dry Willow (DW) and Betula-Moss (BM	38,936	5.1
18	Gravel Deposit	Barren (BA) and Exposed Soil (ES)	25,500	3.3
TOTAL			**770,000**	**100**

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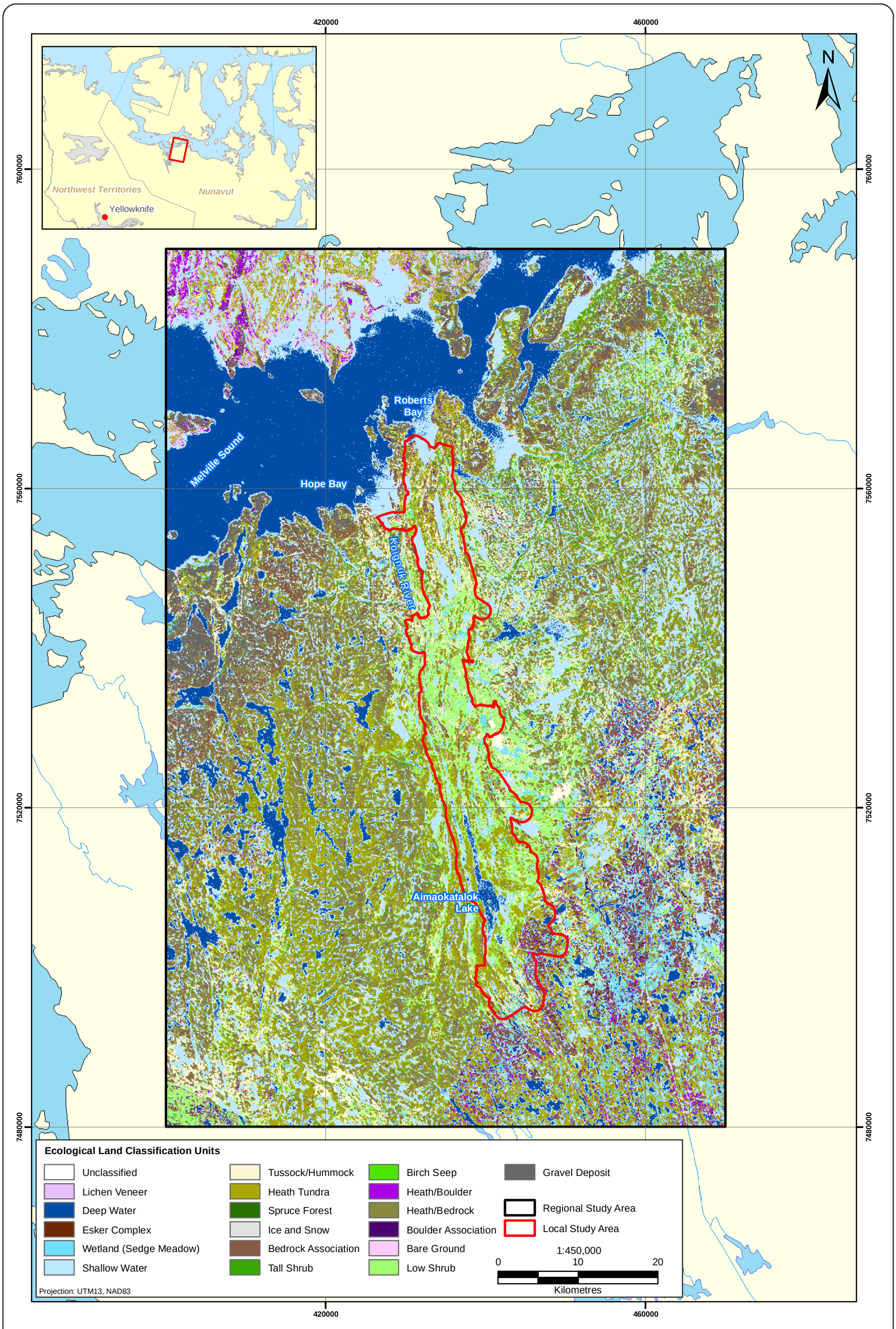

Figure 2.2-2

NEWMONT NORTH AMERICA

Regional Study Area WKSS Ecosystem Land Classification

Figure 2.2-2

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2.2.3 Local Study Area Ecological Classification

As described above, a comprehensive site level ecological classification system has not been developed for Nunavut or the Northwest Territories. Over a period of two years (1996 and 1997) Rescan created a preliminary local ecosystem classification system for the Project area (Appendix 1). The system used a variety of multivariate statistical analyses of 412 field plots to develop 13 unique ecosystem units. Each unit is defined by distinct assemblages of plant species and environmental conditions (soil moisture and nutrients, parent material, drainage, etc.; Rescan 1997). These ecosystem units are defined at a scale that can be distinguished at the scale of mapping. Finer-scale differences in plant associations also occur in the area, many of which are wetland associations that were documented during the wetland field surveys (See Wetlands section in the Results chapter).

Table 2.2-2 provides a brief summary of the mapped ecosystem units adapted from the 1997 Rescan report. Detailed descriptions of the ecosystem units are provided in Chapter 3 of this report. The descriptions have been modified to reflect the larger study area and additional sample plot data. In addition to mapped ecosystem types, 11 non-vegetated map codes were used to describe other features such as lakes, rivers and rock outcrop (Table 2.2-3). The non-vegetated map codes and descriptions are adapted from the *Standard for Terrestrial Ecosystem Mapping in British Columbia* (RIC 1998).

Table 2.2-2. General Ecosystem Units

General Ecosystem Unit	Map Code	Description
Dry Carex-Lichen	CL	Dry, nutrient poor community restricted to exposed bedrock outcrops characterized by a sparse cover of sedges, lichens and dwarf shrubs.
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.
Dryas-Herb Mat	DH	Dry to mesic, poor to medium nutrient community occurring on very thin, poorly developed soils on bedrock outcrops and moirainal deposits dominated by Arctic avens and a high diversity of dwarf shrubs and herbs.
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.
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.
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.
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.
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.
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.
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.

(continued)

Table 2.2-2. General Ecosystem Units (completed)

General Ecosystem Unit	Map Code	Description
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).
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.
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.
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.

Table 2.2-3. Non-vegetated Map Units

Non-Vegetated Map Unit Names	Code	Description
Barren	BA	Land devoid of vegetation due to extreme climatic or edaphic conditions.
Beach	BE	The area that expresses sorted sediments reworked in recent time by wave action. It may be formed at the edge of fresh or salt water bodies.
Blockfield	BI	Level or gently sloping areas that are covered with moderately sized or large, angular blocks of rock derived from the underlying bedrock or drift by weathering and/or frost heave, and that have not undergone any significant downslope movement.
Exposed soil	ES	Any area of exposed soil that is not included in any of the other definitions. It includes areas of recent disturbance, such as mud slides, debris torrents, avalanches, and human-made disturbances (e.g., pipeline rights-of-way) where vegetation cover is less than 5%.
Lake	LA	A naturally occurring static body of water, greater than 2 m deep in some portion. The boundary for the lake is the natural high water mark.
Mine spoils	MS	Discarded overburden or waste rock moved so that ore can be extracted in a mining operation.
Shallow open water	OW	A wetland composed of permanent shallow open water and lacking extensive emergent plant cover. The water is less than 2 m deep.
Pond	PD	A naturally occurring static body of water, greater than 2 m deep in some portion. The boundary for the pond is the natural high water mark.
River	RI	A watercourse formed when water flows between continuous, definable banks. The flow may be intermittent or perennial. An area that has an ephemeral flow and no channel with definable banks is not considered a river.
Rock outcrop	RO	A gentle to steep, bedrock escarpment or outcropping, with little soil development and sparse vegetative cover.
Rubble	RU	Rubble is common on the ground surface in and adjacent to alpine areas, on ridgetops, gentle slopes and flat areas due to the effects of frost heaving.
Salt water	SW	Any body of water that contains salt or is considered to be salty.

2.3 FIELD GUIDE AND REFERENCE DATA

The following guide books 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. Coupé (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.
- Porsild, A. E. and W. J. Cody. 1980. Vascular Plants of Continental Northwest Territories. National Museums of Canada. Ottawa, ON, Canada.

In addition to the field guides, previous studies were used to generate lists of species known to occur in the Project area, and for general ecological information. Numerous online data sources were also used for identification (such as Flora of the Canadian Arctic Archipelago).

2.4 ECOSYSTEM MAPPING

Ecosystem mapping is the process of using ecological features such as terrain, soil, and vegetation to delineate meaningful units on a map. Terrestrial Ecosystem Mapping (TEM) requires mapping 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. The second involves the identification of ecosystems, which are mapped within the terrain polygons. Each ecosystem within a polygon is recorded as a decile on a scale from one to ten, which represents its proportional area within the polygon (e.g., 70% Wet Meadow, 20% Emergent Marsh and 10% Betula-Moss) (RIC 1998). There are a maximum of three deciles per polygon. Decile 1 contains the most dominant ecosystem unit. Decile 2 and 3 contain the second and third most dominant ecosystem units, respectively.

2.4.1 Local Study Area Mapping

Preliminary mapping of 16,115 ha of the Project area was completed in 1997 (Rescan 1997). An additional 40,023 ha were mapped in 2010 to characterize the ecosystems within an expanded Project area, which includes the potential Phase 2 Project infrastructure (Figure 2.4-1). The total area mapped was 56,138 ha. Ecosystems mapped were those defined by the local study area ecological classification.

The 1997 mapping was completed using 1:15,000 aerial photos and digitized via mono restitution (Rescan 1997). Detailed methodology for the preliminary mapping can be found in the Rescan (1997) Environmental Data Report. The expanded Project area was mapped in 2010 using 0.6 m QuickBird anaglyph satellite images from 2008. Anaglyph images create a stereoscopic 3D effect with the use of specialized anaglyph glasses (chromatically opposite lens of red and cyan). The images utilize two colour layers that are offset to provide a depth (3D) effect when viewed with the anaglyphic glasses. While the resolution of the anaglyph images is of lower quality than hard copy aerial photos, it allows for the interpretation of topological and bioterrain features. Terrain features were digitized in ArcGIS 9.3 directly on the anaglyph images. Terrain classification, and subsequent ecosystem delineation and classification, was completed on the matching 2008 2D QuickBird satellite imagery using both Natural Colour and False-Colour Infrared (FCIR) coverage.

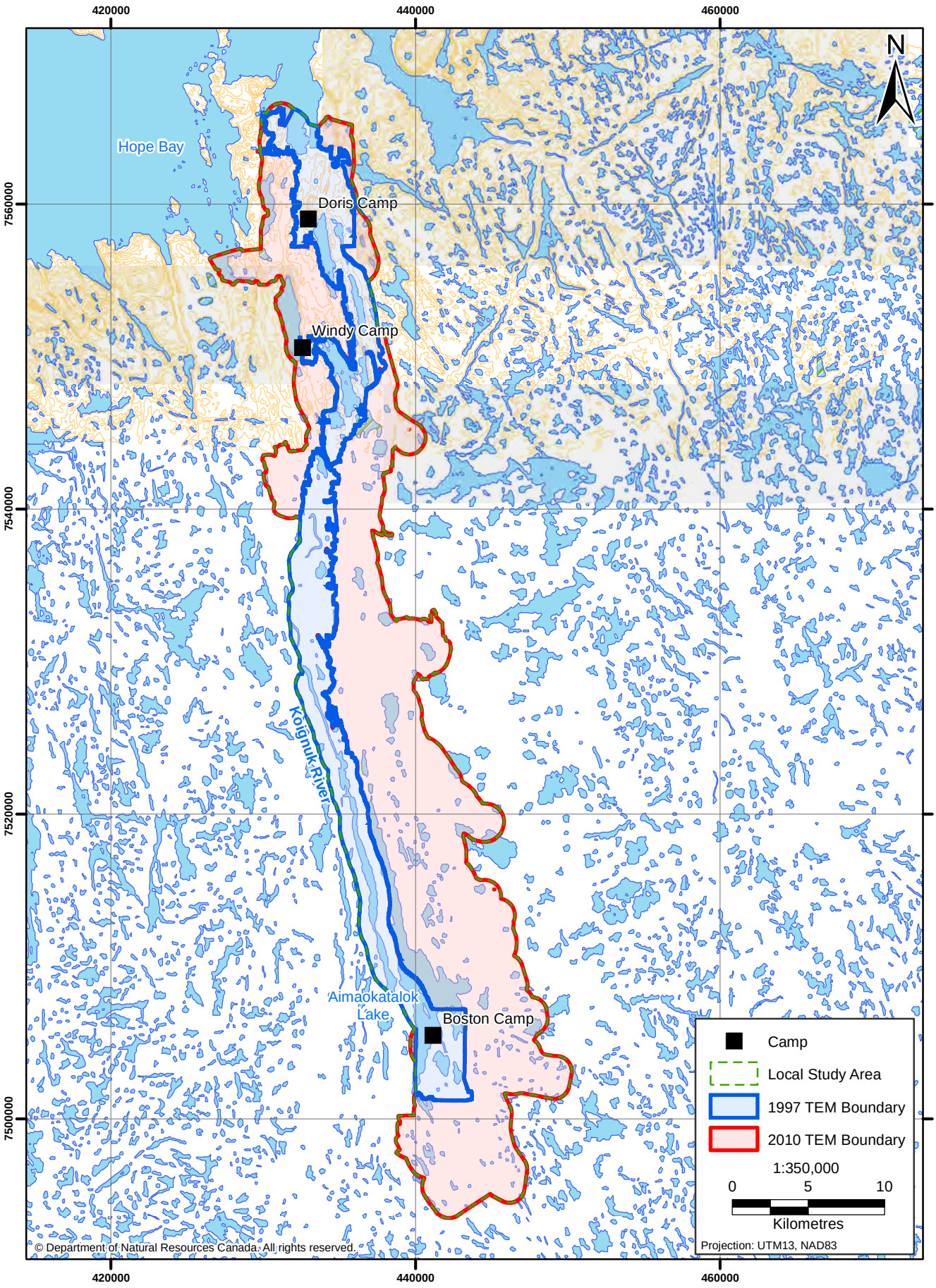

Figure 2.4-1

Local Study Area Mapped Boundaries

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The 2010 mapping was matched where possible with the boundaries of the 1997 terrain and ecosystem polygons; however, in many areas the difference in mapping techniques (and resolution of the imagery that was used) resulted in discontinuous polygon boundaries. As well, the 2010 imagery contained areas of cloud and cloud shadow (particularly in the southeast) where interpretation was difficult. These areas were focused on during field surveys to ensure polygon delineation and classification was correct.

2.5 FIELD SURVEYS

Terrestrial and wetland field studies were conducted by Rescan in July and August, 2010. Terrestrial field teams consisted of a plant ecologist, a wildlife biologist, a soil scientist and a local Inuit assistant. The wetland field teams consisted of a plant ecologist and a local Inuit assistant.

The objective of the field studies was to identify the ecosystems and vegetation types, and map their distribution within the expanded Project area. The study area covered the potential Phase 2 Project infrastructure, including the all-whether access road to Boston. Data collected in 2010 builds on the existing work conducted in 1996 and 1997 by Westroad Resource Consultants Ltd. (Rescan 1997), and provides presence/absence information for rare species and invasive species.

General site and vegetation characteristics were assessed in plots measuring 20 m x 20 m (variable plot dimensions were used to capture linear ecosystems). Site locations were selected based on pre-existing mapping information as well as representative landform types, soil texture, soil drainage, species composition, and physiognomy according to RIC standards (RIC 1998). Field surveys were timed to optimize plant identification (e.g., during flowering and/or fruiting).

In addition to the ground inspections, numerous visual observations were taken to document the ecosystems traversed between formal survey locations. Both types of information are used to refine the ecosystem mapping. Detailed surficial material and soils information was also recorded and is discussed in the *2010 Terrain and Soil Baseline Report* (Rescan 2010).

2.5.1 Terrestrial Ecosystems

Field data was collected according to the prepared Field Data Collection Forms (Appendix 2). At each location, the following attributes were recorded:

- Project ID;
- Surveyor;
- Date;
- Photograph Numbers;
- GPS coordinates in Universal Transverse Mercator (UTM);
- Aspect (slope direction);
- Dominant/indicator plant species;
- Percent composition (terrestrial plots)/cover (wetland plots) of vegetation layers and species;
- Plant species and vegetation communities at risk and invasive plants;
- Soil texture;
- Soil Moisture Regime (Table 2.5-1); and
- Soil Nutrient Regime (Table 2.5-2).

Additional soils and terrain information was also collected as indicated on the Field Data Collection Form and in the *2010 Terrain and Soil Baseline Report* (Rescan 2010).

Table 2.5-1. Soil Moisture Regime (SMR) from the Standard for Terrestrial Ecosystem Mapping in British Columbia.

Code	Class	Description	Primary water source
0	Very xeric	Water removed extremely rapidly in relation to supply; soil is moist for a negligible time after precipitation	precipitation
1	Xeric	Water removed very rapidly in relation to supply; soil is moist for brief periods following precipitation	precipitation
2	Subxeric	Water removed rapidly in relation to supply; soil is moist for short periods following precipitation	precipitation
3	Submesic	Water removed readily in relation to supply; water available for moderately short periods following precipitation	precipitation
4	Mesic	Water removed somewhat slowly in relation to supply; soil may remain moist for a significant, but sometimes short period of the year. Available soil moisture reflects climatic inputs	precipitation in moderate- to fine-textured soils and limited seepage in coarse- textured soils
5	Subhygric	Water removed slowly enough to keep soil wet for a significant part of growing season; some temporary seepage and possibly mottling below 20 cm	precipitation and seepage
6	Hygric	Water removed slowly enough to keep soil wet for most of growing season; permanent seepage and mottling; gleyed colours common	seepage
7	Subhydric	Water removed slowly enough to keep water table at or near surface for most of year; gleyed mineral or organic soils; permanent seepage < 30 cm below surface	seepage or permanent water table
8	Hydric	Water removed so slowly that water table is at or above soil surface all year; gleyed mineral or organic soils	permanent water table

Table 2.5-2. Soil Nutrient Regime (SNR) from the Standard for Terrestrial Ecosystem Mapping in British Columbia.

Code	Soil Nutrient Regime
A	Very poor
B	Poor
C	Medium
D	Rich
E	Very Rich

**adapted from Standard for Terrestrial Ecosystem Mapping in British Columbia (RIC. 1998).*

2.5.2 Wetland Ecosystems

In addition to the local ecosystem classification used for mapping the LSA, the Federal Wetland Class (Table 2.5-3) was used to classify wetlands during ground field surveys. Wetland class cannot be distinguished from satellite imagery.

Table 2.5-3. Description of Federal Wetland Classes

Federal Wetland Class	Description
Bog	Nutrient poor peatland, receiving water exclusively from precipitation.
Fen	Nutrient medium peatland, receiving water from groundwater and precipitation.
Marsh	Nutrient rich mineral wetland; vegetation dominated by graminoids, forbs, shrubs and emergent plants.
Swamp	Nutrient rich mineral wetland; vegetation dominated by woody plants > 1 m in height.
Shallow open water	Wetland with free surface water up to 2 m depth; less than 25% of surface area occluded by emergent or woody plants.

Source: (Warner and Rubec 1997)

Wetland sites 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 are further subdivided into forms. Form classification is based upon surface morphology, surface pattern, water type, and characteristics of the soil (Warner and Rubec 1997).

Field data was collected using the field data sheets provided in Appendix 3. Sampling sites were selected based on the National Topographic Database (NTDB) mapping and proximity to proposed infrastructure features. A Wetland Habitat Inspection Form (WHIF) was used to collect the above-mentioned field information, as well as the following:

- Wetland class and form;
- Plant species present;
- Hydrodynamic index;
- Soil types;
- pH/conductivity;
- Site diagram; and
- Wildlife sightings.

Survey plots measured 400 m^2 in large wetlands. In smaller wetlands, the boundary of the plot extended to the outer edge of the wetland vegetation. A series of soil cores were taken throughout each plot to determine the representative soil type for each wetland. A GPS coordinate was recorded at the centre of each plot, and photos were taken in each direction covering a full 360 degrees. Other significant features, such as landforms, unique vegetation, rare plants, invasive plants and wildlife, were also noted.

2.6 ECOSYSTEMS AND PLANTS OF INTEREST

There is little information available for vegetation communities at risk in Nunavut or the Northwest Territories because there is no formal site level ecological classification system in use. Without an established taxonomic methodology available, it is difficult to identify communities at risk (since these communities have not yet been defined within Nunavut).

2.6.1 Sensitive or At Risk Ecosystems

Sensitive ecosystems are easily degraded by disturbance (McPhee et al. 2000), and are often remnants of the natural ecosystems that once occupied a much larger area (BC Ministry of Environment 2007).

Sensitive ecosystems are dependent on specialized habitats and/or complex ecological processes (Farmer 1993; McPhee et al. 2000).

In the absence of a Territorial system for identifying sensitive ecosystems, the ecosystem units mapped in the Project area have been assessed for local sensitivity and rarity. The analyses have been generalised into three groups of ecosystem units based on landscape position: marine, lowland, and upland. The rarity assessment was based on the occurrence of ecosystem units in the LSA compared to the much larger RSA. Although the mapping techniques and classification differ, generalized conclusions can be made regarding the regional occurrence of the mapped ecosystem units.

2.6.2 At Risk Plant Species

A formal ranking system for identification or status determination for plant species potentially at risk has not been established in Nunavut. Thus, The NWT Department of Environmental and Natural Resources database was used to create a list of species at risk known to occur within Nunavut (Appendix 4).

The resultant plant list was used to identify potential habitat that may support rare species. The locations of individual plants of interest cannot be predicted using the available satellite imagery; however, rare plant habitat is often associated with fine-scale and uncommon landscape features (Williston et al., 2004; Alberta Native Plant Council 2000) that can be targeted during field surveys.

Field surveys for rare/at risk plants were conducted in conjunction with general field surveys. A list of dominant plants in each field plot was recorded and evaluated for the presence of rare/at risk plants according to the Northwest Territories General Status Ranking Program or NWT GSRP (NWT Department of Environment and Natural Resources 2010). Systematic rare plant surveys were not conducted during the 2010 field season.

2.6.3 Invasive Plant Species

Invasive plants or weeds generally refer to species (native or non-native) that have the ability to out-compete native species when introduced into natural settings (Haber 1997). Typically, invasive plants aggressively establish in disturbed areas, thereby decreasing biodiversity (Polster 2005).

An invasive plant council or other formal means of determining the status of potentially invasive plants has not been established in Nunavut. Thus, the NWT GSRP invasive plant risk levels have been adopted for use in this report.

The NWT GSRP has been collecting information on plant species that are present within the NWT since 1999. Its purpose is to create a knowledge base that can be used to determine the status of any particular plant species. The NWT GSRP online database allows users to query information regarding the likelihood of a plant species occurring in a defined area. The online database also identifies plant status (prevalence, rare, alien etc.). The NWT GSRP identifies four levels of risk to the environment associated with invasive plants (NWT Department of Environment and Natural Resources 2010):

> **High** - Typically invades natural and disturbed habitats quickly, and is hard to eradicate. These plants can have severe ecological impacts on physical processes, plant or animal communities, and vegetation structure. Reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. They usually have very broad ecological amplitude (i.e. range of tolerance).
>
> **Moderate** - Usually invades anthropogenic disturbed habitats and invades some natural habitats. These species are invasive but their ecological impacts are usually moderate. They may be locally persistent and problematic, but distribution is usually limited.

Low - Tends to invades anthropogenic disturbed habitats and some natural habitats with natural disturbances. These species are invasive but their ecological impacts are low or there was not enough information to justify a higher score. Ecological amplitude and distribution are generally very limited, but these species may be locally persistent.

Potential - These plants can invade disturbed habitats if conditions are correct. These species can be invasive but there was not enough information to justify a higher score. Ecological amplitude and distribution are generally very limited, but these species may be locally persistent.

Field surveys for invasive plants were conducted in conjunction with general field surveys. The list of plants in each field plot was recorded and evaluated for the presence of invasive plants according to the NWT Environment and Natural Resources databases (Northwest Territories Environment and Natural Resources 2010).

2.7 BASELINE METAL CONCENTRATIONS IN PLANT TISSUES

The objective of the metals analysis was to quantify background tissue metal concentrations in plants that grow within the study area. Results from the baseline metals analysis may be used for country foods assessments and/or future monitoring programs.

Two lichen species, *Flavocetraria cucullata* and *Flavocetraria nivalis,* were targeted for collection. These species were selected for metals sampling based on the following criteria:

- known bioaccumulator of metals;
- likelihood of being a food source for animals, particularly caribou; and
- frequency of occurrence and ease of collection.

In total, 18 plant tissue samples were collected from 18 sites within the LSA during field surveys in July and August, 2010 ((*F. cucullata* (n = 8) and *F. nivalis* (n=10)). Aggregate samples of one species per site were sampled. The above-ground tissue was collected and any debris present on the tissue was removed before samples were placed into a plastic sampling bag.

Samples were sent to ALS Laboratory Group in Burnaby, BC, for analysis. Parameters analysed include percent moisture and metals (Table 2.7-1; Appendix 5). Variation in detection limits (Table 2.7-1; Appendix 5) was due to calibration differences in the test equipment.

Results were summarized by location (i.e., South or North end of the Belt; Figure 2.7-1).

In the South end of the belt, the following samples were collected and summarized together:

- *F. nivalis*: D65, D62, D63, D89, D93, D97, D86, D114, D116, and D125;
- *F. cucullata*: D82, D114, D73, 010, and 011.

In the North end of the belt, the following samples were collected and summarized together:

- *F. cucullata*: 021, 023, and 024.

Table 2.7-1. Plant Tissue Metals Analyzed and their Realized Detection Limits

Parameter	Unit	Detection Limit (Range) (mg/kg wwt)	Parameter	Unit	Detection Limit (Range) (mg/kg wwt)
Physical Tests					
Moisture	%				
Metals			**Metals (cont'd)**		
Aluminum (Al)	mg/kg wwt	0.4	Molybdenum (Mo)	mg/kg wwt	0.004
Antimony (Sb)	mg/kg wwt	0.002	Nickel (Ni)	mg/kg wwt	0.02
Arsenic (As)	mg/kg wwt	0.004	Phosphorus (P)	mg/kg wwt	100 - 225
Barium (Ba)	mg/kg wwt	0.01	Potassium (K)	mg/kg wwt	400 - 900
Beryllium (Be)	mg/kg wwt	0.002	Rhenium (Re)	mg/kg wwt	0.002
Bismuth (Bi)	mg/kg wwt	0.002	Rubidium (Rb)	mg/kg wwt	0.01
Boron (B)	mg/kg wwt	0.2	Selenium (Se)	mg/kg wwt	0.02
Cadmium (Cd)	mg/kg wwt	0.002	Silver (Ag)	mg/kg wwt	0.001
Calcium (Ca)	mg/kg wwt	10 - 23	Sodium (Na)	mg/kg wwt	400 - 900
Cesium (Cs)	mg/kg wwt	0.001	Strontium (Sr)	mg/kg wwt	0.01
Chromium (Cr)	mg/kg wwt	0.04	Tellurium (Te)	mg/kg wwt	0.004
Cobalt (Co)	mg/kg wwt	0.004	Thallium (Tl)	mg/kg wwt	0.0004
Copper (Cu)	mg/kg wwt	0.02	Thorium (Th)	mg/kg wwt	0.002
Gallium (Ga)	mg/kg wwt	0.004	Tin (Sn)	mg/kg wwt	0.004
Iron (Fe)	mg/kg wwt	0.2	Titanium (Ti)	mg/kg wwt	0.01
Lead (Pb)	mg/kg wwt	0.004	Uranium (U)	mg/kg wwt	0.0004
Lithium (Li)	mg/kg wwt	0.02	Vanadium (V)	mg/kg wwt	0.004
Magnesium (Mg)	mg/kg wwt	20 - 45	Yttrium (Y)	mg/kg wwt	0.002
Manganese (Mn)	mg/kg wwt	0.004	Zinc (Zn)	mg/kg wwt	0.1
Mercury (Hg)	mg/kg wwt	0.001	Zirconium (Zr)	mg/kg wwt	0.04

Summaries are based on total wet weight, which represent *in situ* conditions under which wildlife might consume these plants. Results were summarized separately by species because uptake, allocation, and concentration of various metals differ by species (Garty 2001; Pugh, Dick, and Fredeen 2002; Naeth and Wilkinson 2008).

Metal concentrations below the detection limit were replaced by half the value of the detection limit for summary calculations. Although this methodology for addressing missing values does not capture the true frequency distribution of concentrations (Nosal, Legge, and Krupa 2000), assigning values to undetectable concentrations in this manner is common practice. It is assumed that the values are not zero, but the level of risk (i.e., with regards to human health) is low enough not to warrant additional statistical analyses.

Control sites were not identified for this summary, but can be established for future monitoring based on these analyses and once the locations of infrastructure have been confirmed. The majority of fugitive dust created during the lifetime of the Project is expected to settle within 500 m, which can further be used as a guide for selecting future monitoring sites (US EPA 1995; Auerbach, Walker, and Walker 1997).

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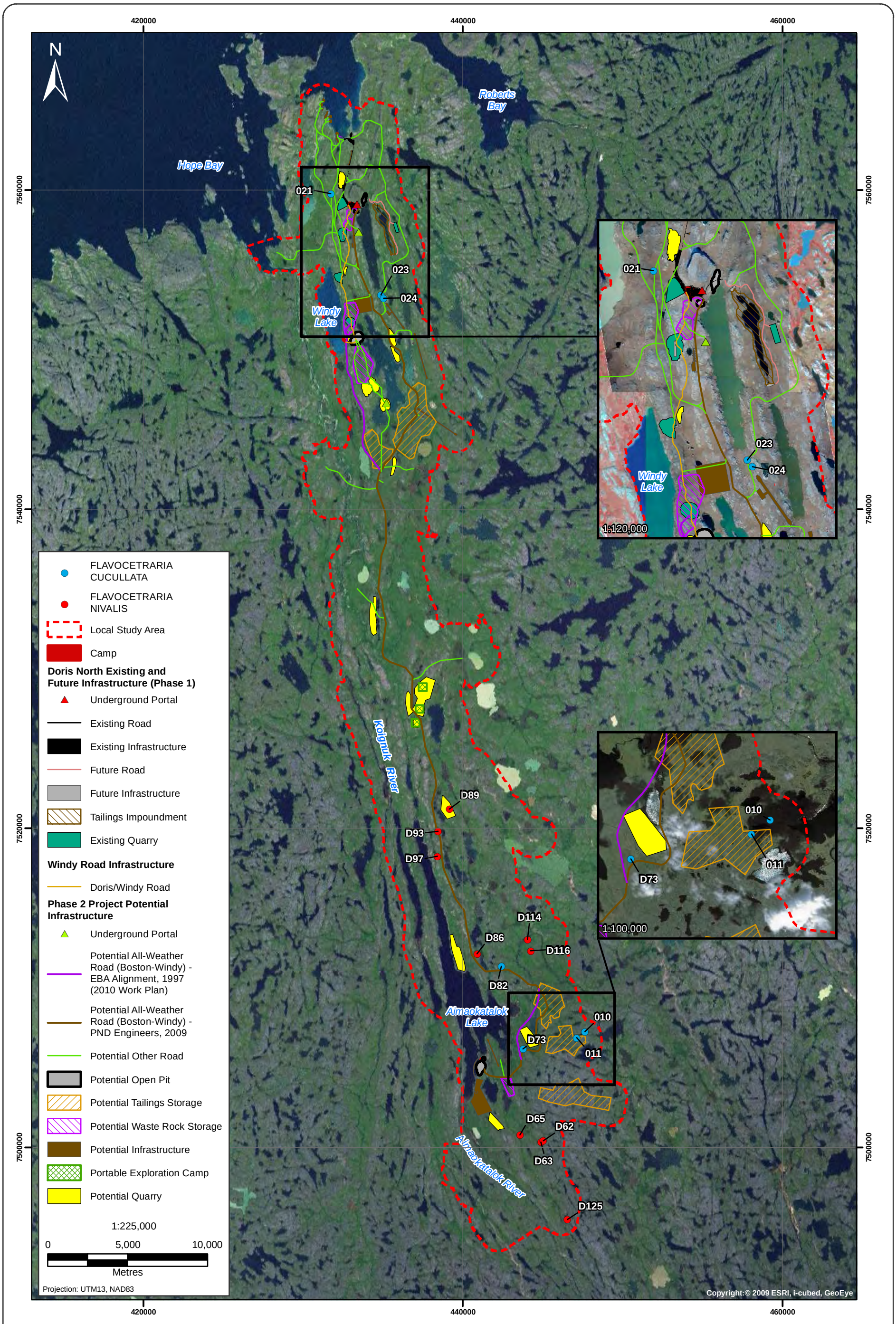

Figure 2.7-1

NEWMONT NORTH AMERICA

Lichen Tissue Sampling Locations for Metal Analyses

Figure 2.7-1

Rescan Engineers & Scientists

3. Results and Discussion

3. Results and Discussion

This chapter describes the results of local ecosystem mapping (Section 3.1), field surveys (Section 3.2), ecosystems and plants of interest (Section 3.3) and metal concentrations of plant tissues (Section 3.4). The collected field data is reported in Appendix 6.

Results of the local ecosystem mapping are grouped into three categories. Each category shares similar characteristics in terms of vegetation and parent materials. Marine ecosystem units are strictly limited to the edge of the active marine environment. 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 encompass the extensive lower slopes and plains, and generally occur on lacustrine, marine and fluvial deposits. Non-vegetated map units are not described in additional detail.

- Marine Ecosystems
  - Marine intertidal (MI)
  - Marine backshore (MB)
- Upland Ecosystems
  - Dry Carex-Lichen (CL)
  - Dryas Herb Mat (DH)
  - Betula-Ledum-Lichen (BL)
  - Dwarf Shrub Heath (SH)
- Lowland Ecosystems
  - Eriophorum Tussock Meadow (TM)
  - Dry Willow (DW)
  - Riparian Willow (RW)
  - Low Bench Floodplain (FP)
  - Wet Meadow (WM)
  - Emergent Marsh (EM)
  - Polygonal Ground (PG)
  - Betula-Moss (BM)

Many of the lowland ecosystem units are described at two levels. At the local ecosystem mapping level they are described as single ecosystem units based on attributes and boundaries discernable on the satellite imagery. Most of these wet ecosystems (including the EM, WM, OW and PG), however, are more accurately described as wetland complexes based on characteristics not readily identified by satellite image interpretation. Therefore, they are described in greater detail in the wetland section of this chapter.

Table 3-1 presents a summary of the local ecosystem mapping from 1997 and 2010 and the area of each ecosystem unit mapped (excluding the more detailed wetland classifications). A total of 1,069 ecosystem polygons were mapped in 1997 and 1,993 ecosystem polygons were mapped in 2010. Due to different mapping methodologies (aerial photos vs. satellite imagery) and study area boundaries, four mapping units used in 1997 were not used in 2010, and one new unit was added in 2010. Refer to Rescan (1997) for additional ecosystem unit descriptions and the methodology used to

develop the classifications. The labelled TEM map is provided in Appendix 7 and the descriptions of the corresponding TEM map codes are provided in the TEM legend (Appendix 8).

Table 3-1. Local Ecosystem Mapping Summary

Map Code	Description	1997 TEM (ha)	2010 TEM (ha)	Total LSA (ha)	Percent of LSA
BA	Barren	5.78	0.00	5.78	0.01
BE	Beach	12.44	74.73	87.17	0.15
BI	Blockfield	0.00	345.72	346	0.61
BL	Betula-Ledum-Lichen	1280.27	7494.43	8,775	15.59
BM	Betula-Moss	339.96	1677.33	2,017	3.58
CL	Dry Carex-Lichen	86.91	580.21	667	1.19
DH	Dryas Herb Mat	1713.07	3179.09	4,892	8.69
DW	Dry Willow	946.33	743.20	1,690	3
EM	Emergent Marsh	1.65	1342.43	1,344	2.39
ES	Exposed Soil	1.79	101.60	103	0.18
FP	Low Bench Floodplain	90.84	36.95	128	0.23
LA & PD	Lakes and Ponds	2875.72	2983.40	5,859	8.01
MB	Marine Backshore	12.31	55.94	68.25	0.12
MI	Marine Intertidal	3.34	0.00	3.34	0.01
MS	Mine Spoils	5.71	10.07	15.78	0.03
OW	Shallow Open Water	10.56	0.00	10.56	0.02
PG	Polygonal Ground	218.17	1651.81	1,870	3.32
RI	River	568.81	210.55	779	1.38
RO	Rock Outcrop	1270.87	3761.58	5,032	8.94
RU	Rubble	19.62	0.00	19.62	0.03
RW	Riparian Willow	258.33	1839.86	2,098	3.73
SH	Dwarf Shrub-Heath	391.72	719.30	1,111	1.97
SW	Salt Water	392.74	58.39	451	0.8
TM	Eriophorum Tussock Meadow	4457.09	7171.10	11,628	20.66
WM	Wet Meadow	1147.70	6127.57	7,275	12.93
TOTAL		16,112	40,165	56,277	100

Wetlands within the LSA are widely distributed and comprise approximately 19 % 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).

3.1 LOCAL ECOSYSTEM CLASSIFICATION AND MAPPING

3.1.1 Marine Ecosystems

3.1.1.1 Marine Backshore (MB)

Marine Backshore (MB) areas were mapped and surveyed in 1997 (Rescan 1997). Further surveying of the MB ecosystem unit was not required in 2010 because its occurrence was largely limited to areas surveyed in 1997.

The MB ecosystem unit occurs upslope of the Marine Intertidal (MI) unit. It is characterized by thick deposits of marine sands and is similar in appearance to a sand dune (Plate 3.1-1). Occurrences of this ecosystem unit are restricted to small protected bays and inlets with shallow slopes along a coastline that is dominated by steep, rocky shores. MB ecosystems comprise 0.12% (68 ha) of the LSA, while the non-vegetated Beach (BE) map unit that occurs in similar locations covers an additional 0.15% (87 ha) of the LSA.

Plate 3.1-1. Typical Marine Backshore (MB) ecosystem unit.

The MB unit is very dry (Soil Moisture Regime, SMR, of 1) and nutrient poor (Soil Nutrient Regime, SNR, of A) with poorly developed coarse textured soils. Organic inputs are limited due to sparse vegetation cover. Vegetation is limited to salt tolerant species such as lyme-grass (*Elymus arenarius* ssp. *mollis*), seabeach sandwort (*Honckenya peploides*), seaside plantain (*Plantago juncoides* var. *glauca*), and northern sweet-vetch (*Hedysarum mackenzii*). Cover is generally less than 50% with shrubs, moss, and lichens generally absent.

3.1.1.2 Marine Intertidal (MI)

Marine Intertidal (MI) areas were mapped and surveyed in 1997 (Rescan 1997). No additional surveying or mapping of the MI ecosystem unit was required in 2010 as the 1997 surveys provided sufficient coverage.

The MI unit is limited to intertidal flats and gently sloping shorelines in northern portions of the LSA and comprises less than 0.01% (3 ha) of the mapped area. It occurs on veneers of marine sand often overlaying marine clays that often have buried organic layers (Plate 3.1-2). These areas are frequently inundated with saltwater, often from wave action, which largely preclude soil development. MI units are very wet (SMR of 7 or 8) and medium to rich (SNR C to D).

Plate 3.1-2. Typical MI ecosystem unit (left) and upslope MB (right).

Vegetation is variable, ranging from 50 to 90% cover. Shrubs, mosses and lichens are generally absent. The MI unit is characterized by a simple community of salt tolerant species dominated by creeping alkaligrass (*Puccinelia phryganodes*) and Hoppner sedge (*Carex subspathacea*), while Pacific silverweed (*Potentilla egedii*), scurvygrass (*Cochlearia officinalis*), *Carex amblyorhyncha*, and low chickweed (*Stellaria humifusa*) occurs in variable amounts upslope of the ocean where the MI often transitions into the MB unit.

3.1.2 Upland Ecosystems

3.1.2.1 Dry Carex – Lichen (CL)

The Dry Carex-Lichen (CL) unit is the driest and most nutrient-limited unit in the study area. It occurs in small to large patches (generally discontinuous) on crests and upper slopes underlain by coarse washed till, glaciofluvial materials, or weathered bedrock (Plate 3.1-3). Slopes typically range from zero to fifteen percent and are water shedding. Sands comprise the typical soil matrix, although coarse loamy sands and silt loams occasionally occur. Soil development is minimal and generally restricted to thin layers over bedrock or weathered bedrock. High coarse fragment content (35 to > 70%) is typical.

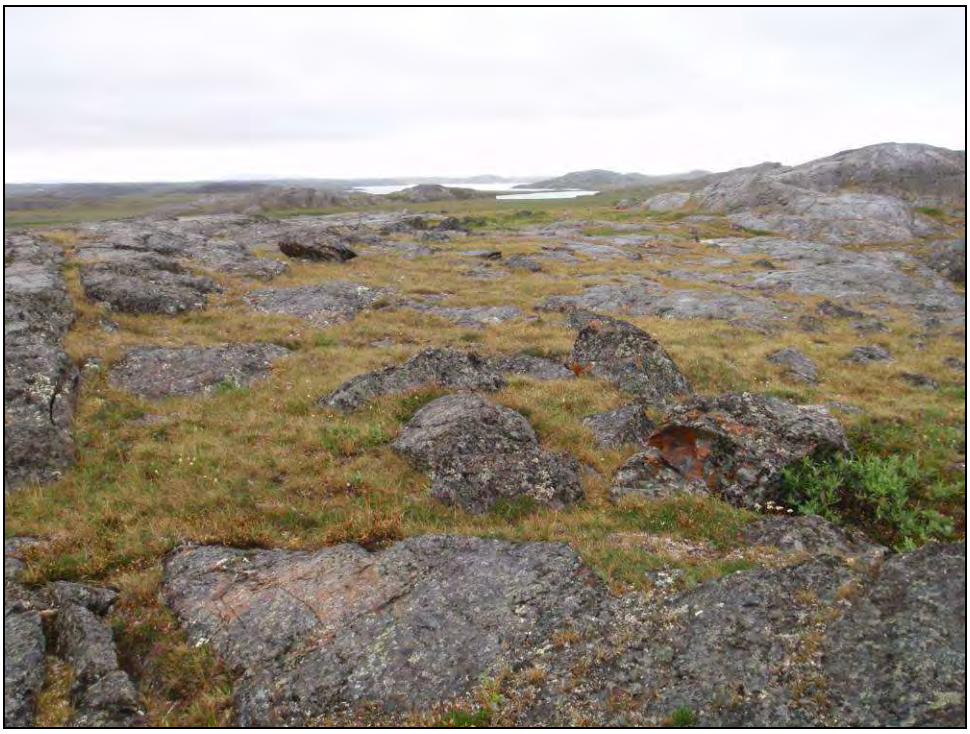

Plate 3.1-3. Typical Dry Carex-Lichen (CL) ecosystem unit interspersed with bedrock outcrops.

Communities with characteristics intermediate between the CL and Dryas Herb Mat (DH) ecosystems are common but the transition between the two is typically rapid. CL typically occurs in small patches (often 25% or less vegetated) on bedrock outcrops where thin soils accumulate, and in association with DH, and non-vegetated types including rock outcrops (RO) and exposed soil (ES). CL ecosystems comprise just over one percent (667 ha) of the LSA. The type is likely under-represented in the ecosystem mapping due to its generally sparse cover that often does not extend to 10% of an ecosystem polygon (the smallest mappable component of a polygon).

Harsh environmental conditions limit the number and type of plant species that occur in the CL. Total vegetation cover is strongly influenced by microsites (generally small depressions) which allow for greater soil development, water retention, and reduced wind exposure. This microtopographical affinity results in highly variable cover. For example, dwarf shrubs may range from 1 to 78% cover, herbs from 1 to 45% cover, and moss and lichens from 0.1 to 85% cover.

Thin and poorly developed soils, limited soil moisture and nutrients, and severe wind exposure limit the extent and diversity of vegetation cover in the CL. Common dwarf shrub species include Arctic willow (*Salix arctica*) and Arctic avens (*Dryas integrifolia*). Herbaceous cover is typically dominated by curly sedge (*Carex rupestris*) with variable occurrence of alpine sweetgrass or holy grass (*Hierochloe alpina*), moss campion (*Silene acaulis* var. *exscapa*), prickly saxifrage (*Saxifraga tricuspidata*), purple saxifrage (*S. oppositifolia*), and Arctic oxytrope (*Oxytropis arctica*). Crustose and foliose (*Cetraria* spp.) lichens are typically abundant, while moss cover is highly variable (Rescan 1997).

3.1.2.2 Dryas Herb Mat (DH)

The Dryas Herb Mat (DH) unit occurs on well drained sites with limited or no seepage. It often occurs on mid to upper slopes (2 to 25% slope) of bedrock outcrops in conjunction with CL and non-vegetated

bedrock or weathered bedrock (Plate 3.1-4). In southern regions it also occurs on flat and gently sloped areas in conjunction with block fields and on shallow soils over bedrock. It is the fifth most common ecosystem unit in the LSA, comprising 8.7% (4,892 ha) of the total mapped area. DH typically occurs on shallow veneers and mantles of sandy till, and occasionally on glacial fluvial, aeolian, or weathered bedrock with high coarse fragment contents (35 to 70%). Frost boils and solifluction are relatively common. Relative soil moisture is typically xeric (1) or subxeric (2), and occasionally submesic (3) or mesic (4). Soil development is variable, but generally limited and highly active. Relative soil nutrients range from poor (B) to medium (C).

Plate 3.1-4. Typical Dryas Herb Mat (DH) ecosystem unit.

Arctic avens (*Dryas integrifolia*) is typically the dominant species in the DH unit. Dwarf shrubs such as alpine bilberry (*Vaccinium uliginosum* var. *alpinum*), Arctic willow (*Salix arctica*), and net-veined willow (*Salix reticulata*) occur in variable amounts. Curly sedge (*Carex rupestris*) is the most common herbaceous species. Other herbs that commonly occur include Liquoriceroot (*Hedysarum alpinum*), Maydell's oxytrope (*Oxytropis maydelliana*), Arctic heather *(Cassiope tetragona*), Lapland rosebay (*Rhododendron lapponicum*), Arctic oxytrope (*Oxytropis arctica*), woolly and capitate louseworts (*Pedicularis lanata*, *P. capitata*), and single-spike sedge (*Carex scirpodea*). The diversity and abundance of herbaceous cover is highly variable and associated with microsites that provide deeper soils, increased water availability, and shelter from wind exposure.

Plant species characteristic of the DH unit commonly persist downslope, resulting in transitional communities with characteristics intermediate between DH and SH ecosystems (Rescan 1997). The DH unit typically occurs in similar locations as CL, and is immediately upslope of SH, and occasionally BL and DW.

3.1.2.3 Betula Ledum Lichen (BL)

The Betula Ledum Lichen (BL) unit occurs almost exclusively on level-to-gentle hillslopes overlain by washed till of variable thickness. It occasionally occurs on glaciofluvial outwash, sandy marine sediments, fine colluvium and alluvial slopes. BL is the second most common vegetation type in the LSA, comprising 15% (11,628 ha) of the mapped area. It typically occurs in extensive areas upslope of TM (and occasionally BM) where glacial lacustrine and glacial marine lower slopes and plain turn to

organic veneers over till, and below bedrock outcrops containing SH, DH, and CL (Plate 3.1-5). BL occurs on 0 to 18% slopes, are slightly to strongly water shedding, and often contain frost boils and evidence of solifluction. In flatter terrain, mainly in southern portions of the LSA, the BL ecosystem units contain a substantial exposed boulder component and are typically associated with patches of DH, TM, WM, and extensive block fields (Plate 3.1-6).

Plate 3.1-5. Fine textured Betula Ledum Lichen (BL) ecosystem unit typical of northern portions of the LSA.

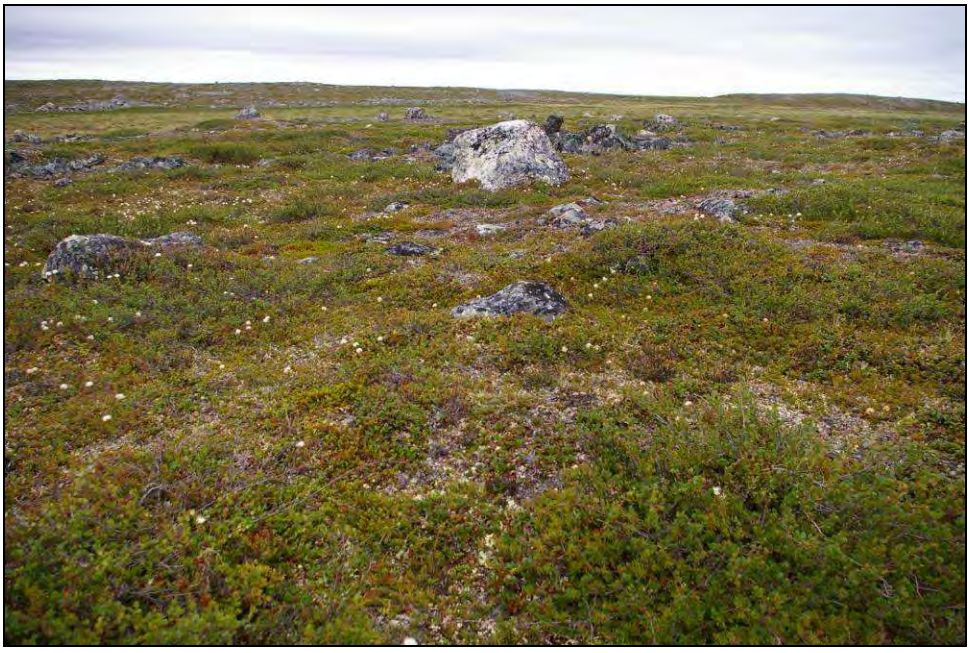

Plate 3.1-6. Bouldery Betula Ledum Lichen (BL) ecosystem unit typical of southern portions of the LSA.

Soil textures are predominantly sands and loamy sands, with occasional occurrences of silts and clays. Coarse fragments range from 0 to 65% and are predominantly gravels and cobbles. Relative soil moisture regime is subxeric (2) to subhygric (5), and rarely xeric (1). Relative soil nutrient regime is very poor (A) to medium (C). Coarse, well-drained and often nutrient-deficient soils limit the diversity and abundance of herbs and mosses, which results in low total ground cover (range: 80-100% including shrubs, herbs, mosses and lichens), relative to more productive ecosystems (which often have a total ground cover of greater than 100%).

Dwarf birch and northern Labrador tea (*Ledum decumbens*) are typically the dominant shrubs, although several willow species occur. Alpine bilberry and lingonberry (*Vaccinium vitis-idaea* var. *minus*) are typically present and occasionally abundant. Alpine bearberry (*Arctostaphylos alpina*) and crowberry (*Empetrum nigrum*) are usually present at low cover, while several *Carex* and *Eriophorum* species occur in variable amounts. Arctic heather, Maydell's oxytrope, and alpine sweet-grass are typically present in trace amounts.

Occurrences of the BL that contain high boulder cover are frequent in the north and south ends of the study area. Based on the initial 1997 field data this boulder association was believed to represent a distinct unit; however, the analysis did not support such a distinction, as vegetation and environmental conditions overlap significantly with the typical BL unit. This condition is typically found on slopes and crests of rock outcrops and occasionally on glaciofluvial deposits (*i.e.* eskers and outwash). The unit is characterized by less northern Labrador tea (0-15%) and generally higher cover of lichens, crowberry, and alpine bearberry than the typical BL unit (Rescan 1997).

3.1.2.4 Dwarf Shrub Heath (SH)

The Dwarf Shrub Heath (SH) ecosystem unit occurs on moderate to steep rocky slopes of till or colluvium (Plate 3.1-7). It generally occurs at the base of rock outcrops with extensive solifluction, cryoturbated soils, and frost boils (Plate 3.1-8). It is relatively uncommon in the LSA, accounting for 2.0% (1,111 ha) of the mapped area. Soil texture is variable and ranges from silty loam to sand. It is generally well drained with coarse fragments ranging from 20 to 70%. Relative soil moisture is subxeric (2) to mesic (4), with a single plot indicating subhygric (5) conditions. Relative soil nutrients are generally poor (B) to occasionally medium (C).

This ecosystem unit is highly variable, but always contains a component of Arctic heather (*Cassiope tetragona*). It contains variable microtopography in the form of boulder and rock outcrops and often forms an uneven, stepped slope. The variable microtopography and active, variable soils result in a diverse, somewhat unpredictable assemblage of species. Aspect is also an important factor in species occurrence. Western slopes generally contain drier species, while eastern slopes have late snow packs resulting in high moisture adapted species and a higher moss cover. Common species include dwarf birch (*Betula nana*), (*Vaccinium vitis-idaea* var. *minus*), crowberry (*Empetrum nigrum*), and several *Salix* and *Saxifraga* species. Moss and lichen cover is variable and often diverse.

The SH unit typically occurs in distinct communities with abrupt transitions to adjacent ecosystem units. TM and BL often occur immediately downslope from SH units, with occasional occurrences of DW. Upslope communities are generally CL and non-vegetated units such as RO and ES.