Keeyask Generation Project

Environmental Impact Statement

Supporting Volume

Terrestrial Environment

KEEYASK
Hydropower Limited Partnership

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SECTION 2

HABITAT AND ECOSYSTEMS

Hydropower Limited Partnership

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2.0 TERRESTRIAL HABITAT AND ECOSYSTEMS

This section of the Terrestrial Environment Supporting Volume (TE SV) presents the assessment of Project **effects** on **terrestrial habitat** and ecosystems using the approach described in Section 1.1.

The terrestrial habitat and ecosystems section begins with an overview of the habitat and ecosystems concepts, including how these concepts were used to structure the assessment (Section 2.1). Section 2.2 describes the approach and methods that are generally applicable to the entire terrestrial habitat and ecosystems assessment. Since habitat data contributes to the measured indicators for most of components of the terrestrial habitat and ecosystems assessment, much of this section relates to the habitat mapping and habitat field studies.

Section 2.3 is an overview of Keeyask terrestrial habitat and ecosystems, to provide the context and foundation for the remainder of the assessment. This section focuses on the environmental setting in terms of the patterns, processes and dynamics that are most relevant for terrestrial ecosystems, including the plant and **wildlife** components. This section also presents details on potential Project effects on terrestrial habitat. **Ecosystem functions**, **mitigation** and residual Project effects are addressed in the key topic sections.

Key topics, which consist of **valued environmental components** (VECs) and **supporting topics**, were used to focus the assessment (Section 1.1). Each key topic is addressed individually in Sections 2.4 to 2.9. The key topic sections are organized as follows:

- describe the methods and information sources used to conduct the assessment;
- describe the **existing environment** including historical conditions, current conditions and current trends;
- predict and assess potential Project effects before mitigation, including consideration of other past and existing developments and activities;
- identify credible mitigation measures where potential effects are greater than desired;
- assess residual Project effects after mitigation, including consideration of other past and existing developments and activities;
- evaluate the **uncertainty** of Project effects predictions; and
- describe **monitoring** and follow-up measures.

The **cumulative effects** of the Project combined with reasonably foreseeable future developments and activities are evaluated in Section 2.10. Section 2.11 evaluates the sensitivity of Project effects predictions to future climate change.

2.1 INTRODUCTION

An **ecosystem** is a functional unit comprised of the living and the non-living things in an area, as well as the relationships between all of these things (for further details see Section 1.1). **Habitat** is the place where an **organism** or a **population** lives. Because all natural areas are habitat for something, "terrestrial habitat" in the TE SV refers to all land habitat for all **species**. Habitat for a particular species is identified with a species prefix such as moose habitat or jack pine habitat.

Wetlands and **upland**s are the two major types of terrestrial habitat and ecosystems. Wetlands are land areas where periodic or prolonged water saturation at or near the soil surface shapes ecosystem patterns and processes (National Wetlands Working Group 1997). Uplands are all land areas that are not wetlands. As is the case throughout Manitoba's **boreal** forest, large fires were the dominant natural **driver** (*i.e.*, controlling factor) in **study area** uplands (Section 2.5). **Groundwater**, surface water and **water nutrient regime**s are the key drivers in most wetlands, and among the **driving factor**s in the remaining ones (Keddy 2010).

According to hydrological connections criteria (National Wetlands Working Group 1997), the two major types of wetlands in the Keeyask regional ecosystem were shoreline and **inland wetland**s. **Shoreline wetland**s were located along the shorelines of a **waterbody** (*i.e.*, surface water areas larger than 0.5 ha) while inland wetlands were all remaining wetlands. The dominant drivers for inland wetlands were depth to groundwater and wildfire whereas water level fluctuations, water flows and waves were the dominant drivers for shoreline wetlands. Ice scouring was also important for Nelson River shoreline wetlands.

Keeyask terrestrial habitat and ecosystems were classified into three major ecological zones, upland, inland wetland and **shore zone**, as illustrated in Photo 2-1 because their dominant **driver**s, or controlling factors, were dramatically different. Dominant drivers were critical to understanding ecosystem dynamics and predicting potential Project effects. Differences in dominant drivers strongly influenced the types of contextual information assembled for the **environmental assessment**, how field studies were designed and how field data were analyzed. Consequently, these major ecological zones were used throughout the terrestrial habitat and ecosystems assessment.

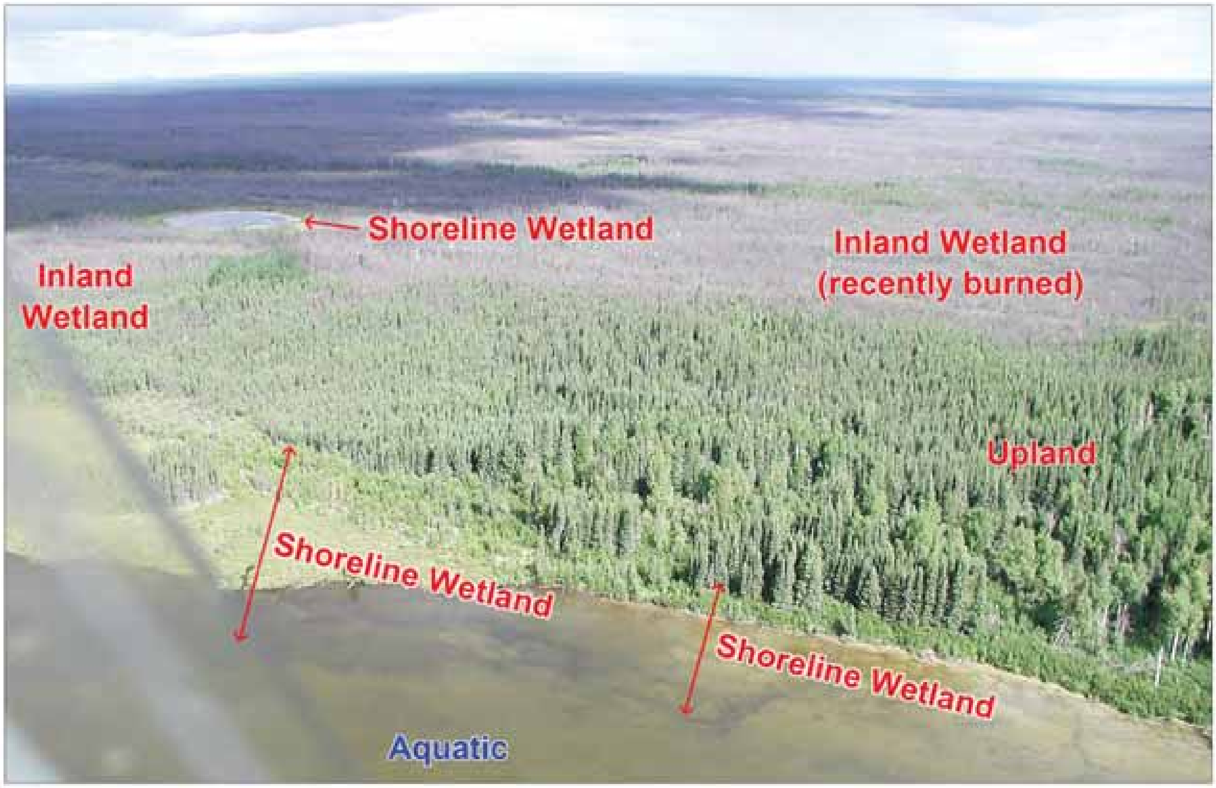


Photo 2-1: Broad Ecological Zones in the Regional Study Area

At any given shoreline location, different plant species were typically arranged into bands that reflect a transition in the typical range of growing season water depths (Photo 2-2). To capture the strong influence that **water regime** has on shoreline wetland ecosystems, the shore zone was subdivided into water depth **duration** zones (*i.e.*, littoral, lower beach, upper beach, inland edge and inland) using the number of days that growing season water depths exist over a particular depth range. Photo 2-2 illustrates the water depth duration zones and the dominant type of vegetation that is typically found within each duration zone. The shore zone also included areas where ice scouring extended into the upland ecological zone. It should be noted that some authors refer to the inland edge as the **riparian** zone.

Photo 2-2 also shows the wetland classes used to map Keeyask wetlands (see Section 2.3.1 for definitions of the wetland classes). Although water depth duration zone, dominant vegetation type and wetland class were strongly associated with each other, distinctions in how these **attribute**s were distributed within the shore zone will be explained below.

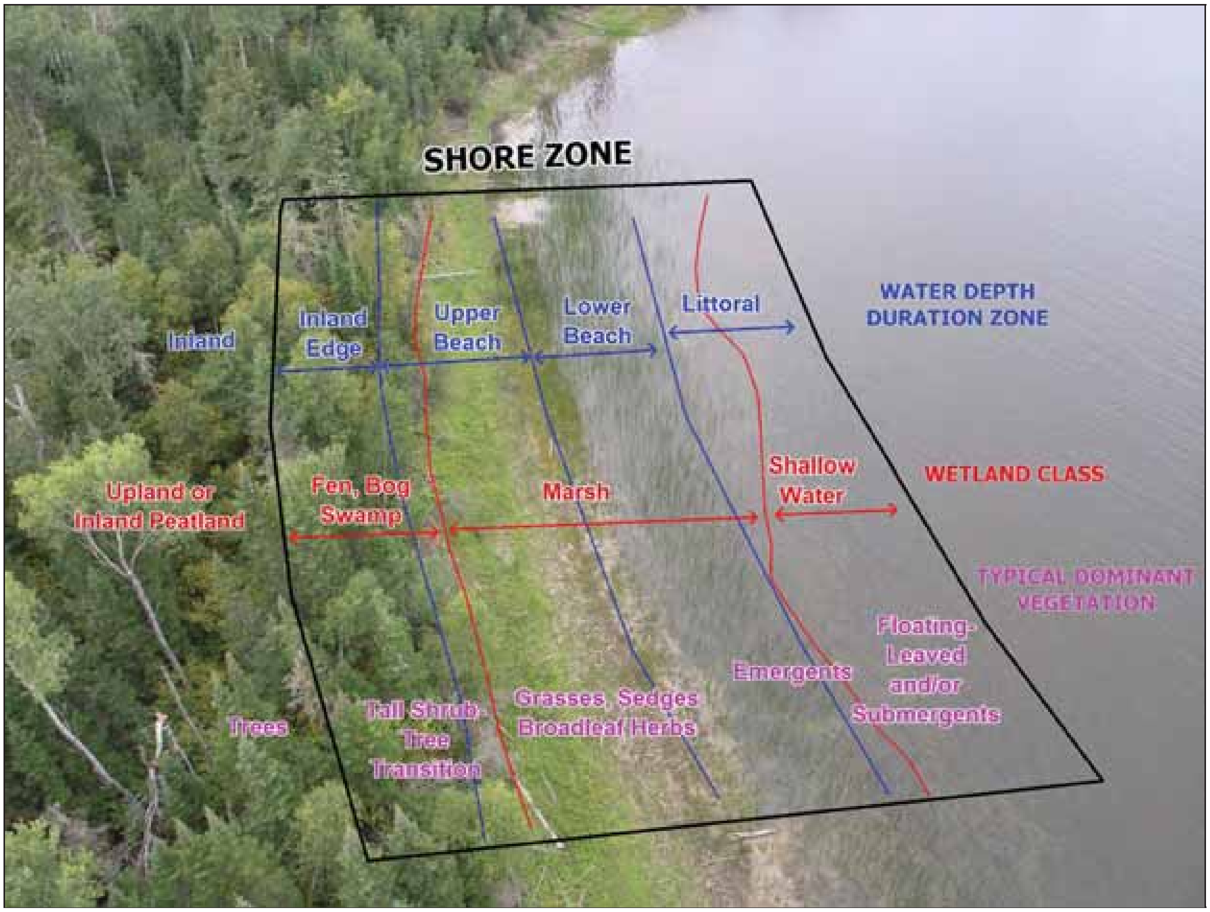


Photo 2-2: Photo Illustrating Shoreline Wetland Water Depth Duration Zones, Vegetation Bands and Wetland Classes in an Off-system Waterbody

2.2 APPROACH AND METHODS

2.2.1 Overview

The overall approach taken for the terrestrial habitat and ecosystems assessment was the same as that described in Section 1. An ecosystem-based assessment approach was used throughout the TE SV, as outlined in Section 1.1.

The environmental setting was described using available local **Aboriginal traditional knowledge (ATK)**, existing information, information from the Physical Environment Supporting Volume (PE SV) and Project studies conducted to fill information gaps.

Project studies were conducted between 2003 and 2011. Information from these studies, supplemented by associations and trends reported in the literature, were used to develop habitat and ecosystems relationships **model**s for use throughout the assessment.

Potential Project effects on the key topics were assessed by comparing the status of measurable indicators with and without the Project in place. Predictions of the future levels of the measurable indicators considered current conditions and trends in the indicators, future changes in **non-Project drivers** and the combined effects of the Project with past, existing and reasonably foreseeable future projects.

Residual Project effects, in combination with past and existing projects, after mitigation were assessed based on the nature of the effect, geographic extent, **magnitude**, duration, frequency and reversibility as defined in Table 1.4-1. **Residual effect**s likelihood and prediction uncertainty were evaluated using the approach described in Section 1.4.4. Current and future trends in the measured indicators and contextual driving factors were considered in the residual effects assessment..

2.2.2 Key Topics

Keeyask terrestrial habitat and ecosystems provide numerous benefits such as: food and shelter for all terrestrial animals; cultural, social, spiritual and economic benefits to people; and perform ecological functions such as cleaning the air and water for all people and animals. Some components of the terrestrial ecosystem are of particular interest because they are highly valued by people, are rare and are in danger of disappearing in some areas, are highly sensitive to disturbance or play a prominent role in ecosystem function. It is neither practical nor necessarily instructive to decision-making to investigate and assess the possible effects of the Project on every component of the terrestrial environment. For all of the above reasons, the terrestrial environment assessment addresses the key ecosystem health issues of concern, or the terrestrial key topics. That is, the ecosystem patterns, processes and functions that could experience substantial Project effects and are particularly important to maintaining overall ecosystem function and the long-term benefits that these functions provide to present and future generations. High importance to the **Keeyask Cree Nations** (KCNs) was one of the criteria used to select the key topics.

A stepwise screening process that focused on Project-related ecosystem health issues that were of relatively high ecological and social concern was used to select the key topics (see Section 1.3.1). There were many potential pathways for Project impacts to lead to effects on Keeyask terrestrial habitat and ecosystems. One of the main steps in this process was identifying generic issues of particular concern that could have **Project linkage**s. These linkages were identified using a number of tools such as conceptual diagrams (*e.g.*, Figure 1.1-1), pathway diagrams (*e.g.*, Figure 1.3-2) and network linkage diagrams (*e.g.*, Figure 1.3-3).

The ecosystem-based approach to assessing Project effects on ecosystem components considered direct and indirect effects in combination with other past, existing and reasonably foreseeable future developments and activities at multiple spatial and temporal scales. Anticipated Project effects on the habitat and ecosystems key topics would extend varying distances from the **Project Footprint** and for varying lengths of time, depending on the key topic, impact type and local conditions (see Section 1 for an overview).

The main potential indirect Project effects considered in the terrestrial habitat and ecosystems assessment were:

- Changes to soil drainage and moisture;
- Soil warming and permafrost melting;
- Changes to soil quantity and quality;
- Tree blowdown around clearings;
- Edge effects on vegetation and soils around clearings and compacted areas;
- Physical disturbance of plants, vegetation, soils and other environmental components of habitat;
- Habitat loss and alteration;
- Crowding out of native plants by non-native invasive species;
- Changes to ecosystem and plant diversity;
- Changes to primary productivity and carbon storage;
- Increased plant harvesting and woody material removal;
- Alterations to the fire regime; and
- Changes to wetland quantity and quality.

The three terrestrial habitat and ecosystems key topics elevated to VECs through the stepwise screening process were **ecosystem diversity**, **wetland function** and intactness (Table 1.3-1). The remaining three key topics evaluated as the supporting topics were fire regime, terrestrial habitat and soil quantity and quality.

2.2.3 Study Areas

As described in Section 1.3, each terrestrial VEC and key supporting topic had its own set of nested study areas referred to as the **Local Study Area**, **Regional Study Area** and **context area**. The Local Study

Area captured the potential zone of Project influence on individuals in the case of species and individual elements in the case of non-species topics. The Regional Study Area captured the area needed to assess how local effects were expected to affect population viability in the case of species or the regional manifestation of the attribute for non-species key topics. The context area provided control for conditions or factors that could confound the interpretation of information, such as animals moving into the Regional Study Area due to unusual conditions in the surrounding area. The Local Study Area, Regional Study Area and context area for each VEC and supporting topic were selected from the six nested study zones shown in Map 2-1 (see Section 1.3 for the rationale). Due to the manner in which it was derived, the Regional Study Area selected for a key topic was also used as its cumulative effects assessment area.

Proxy areas were other northern areas that provided examples of how the Project could affect terrestrial ecosystems because they have been affected by similar types of development. The four **proxy area**s used to indicate the likely effects of **flooding** and water regulation on terrestrial habitat and ecosystems were Stephens Lake (*i.e.*, the **reservoir** for the Kettle **generating station**), Notigi reservoir, Wuskwatim Lake and Long Spruce reservoir (Map 2-2). The terrestrial habitat and ecosystems assessment relied most heavily on Stephens Lake information because it was immediately downstream of the proposed Keeyask reservoir, was the most ecologically comparable proxy area and had the best time series of large-scale historical aerial photography.

Proxy areas for vegetation and soil recovery in cleared and excavated areas were selected from **borrow area**s developed for PR 280 and for the Kettle, Limestone and Long Spruce generating stations.

Benchmark areas, which were areas relatively unaffected by human development, were used to characterize patterns and dynamics in natural ecosystems. Benchmark areas for shoreline wetlands were **off-system** lakes and large rivers in the Study Zone 6 (Map 2-2). Benchmark areas were not required for uplands and **inland peatland**s since most of Study Zone 6 has been relatively unaffected by large-scale human activities other than **global change**.

2.2.4 Information Sources

The sources of information for the terrestrial habitat and ecosystems assessment were:

- Aboriginal traditional knowledge (ATK);
- existing published information; and,
- EIS studies designed and conducted to address identified data gaps.

Information from the Project Description Supporting Volume (PD SV) was used to determine which Project impacts are relevant to the terrestrial habitat and ecosystems assessment while the PE SV provided information on the status of and trends in physical factors with and without the Project. Additional and/or specific information sources are listed below.

2.2.4.1 Aboriginal Traditional Knowledge

Aboriginal traditional knowledge (ATK) played an important role in both technical data collection and describing the existing environment. The KCNs Partners provided ATK through their Environmental Evaluation Reports and community-based studies. The KCNs were involved in reviewing annual fieldwork plans through the Environmental Studies Working Groups and individual KCNs Members participated in field data collection. In addition, ATK of historic and current conditions as gathered through community-based research and workshops was incorporated into the detailed VEC and supporting topic descriptions that are presented below and in the TE SV (e.g., CNP Keeyask Environmental Evaluation Report; YFFN Evaluation Report (*Kipekiskwaywinan*); FLCN Traditional Knowledge Report 2010 Draft). FLCN's TK Report, as well as the KCNs Environmental Evaluation Reports, also document how the terrestrial ecosystem was impacted by past hydro development.

2.2.4.2 Existing Information

A limited amount of existing published information was available for the study areas prior to the commencement of EIS studies. Geotechnical data were provided from investigations conducted by Manitoba Hydro. Reviews of the effects of hydroelectric development on the Nelson River **aquatic environment** (*e.g.*, Split Lake post-project environmental review; Split Lake Cree 1996a-f) provided some information on historical shoreline conditions. Although some vegetation and soil mapping was available, its usefulness for EIS purposes was limited because the mapping scale was too small and/or coarse, the information was outdated and/or only a small portion of the study areas was captured. For example, although Forest Resource Inventory mapping for Forest Management Unit 86 provides coverage for the southern half of the Regional Study Area, it is older mapping that very coarsely classifies **ecosite type**s and many **broad habitat type**s. **Landscape**s and waterscapes of the **Split Lake RMA** are characterized in CNP Keeyask Environmental Evaluation Report Appendix 1. Existing plant and habitat studies were not available except with regard to peatland responses to past climate change.

Key data sources available for the EIS studies were large scale stereo air photos (taken in 1962, 1975, 1986, 1991, 1999, 2003 and 2006), Manitoba Conservation fire history mapping, National Topographic Survey (NTS) topographic maps, ecodistrict descriptions at a 1:1,000,000 scale (Smith *et al.* 1998), Manitoba Hydro digital ortho-rectified imagery developed from 1999, 2003 and 2006 stereo photography; and, the 1:1,000,000 scale Soil Landscapes of Canada map (Agriculture and Agri-Food Canada 1996).

2.2.4.3 Environmental Impact Assessment Studies

The majority of the information used for the terrestrial habitat and ecosystems assessment came from a wide range of EIS studies that included a large number of sample locations, which were initiated in 2001 and continued to 2011. Most field data were collected from 2003 to 2009. The majority of the studies completed for the terrestrial environment assessment were conducted within the Study Zone 5 (Map1.7-1). Data collection efforts were highest in Study Zone 3 (Map 2-1) and decreased with distance from it. Stephens Lake (*i.e.*, the Kettle generating station reservoir) was the proxy area most commonly included in field studies.

Habitat mapping and habitat relationships were the two major types of information developed by Project studies. Regardless of the terrestrial environment discipline, most effects predictions used models that require habitat maps as an input. Reliable predictions of potential Project effects on habitat and ecosystems depended on a detailed terrestrial habitat map for the existing environment and on an adequate understanding of local relationships between each of the major habitat components (*e.g.*, vegetation, soils, permafrost, groundwater) and the factors that could have a substantial influence on ecosystem composition, structure and dynamics (*e.g.*, water regime).

One of the practical implications of this for the habitat and ecosystems assessment was a hierarchical **ecological land classification** system that grouped sample locations and habitat map units into ecologically meaningful classes that could be linked to ecosystem drivers and potential pathways of Project effects. Consequently, plot and **stand** level **hierarchical habitat classification** systems were developed to reflect substantial differences in habitat composition and the factors that were thought to strongly influence ecosystem composition, structure and dynamics.

Sampling design, analytical methods and modeling techniques for the inland studies differed from those used for shoreline wetlands due to the dramatic differences in driving factors and Project linkages. For example, inland habitat data were collected in plots located in relatively homogenous portions of stands whereas shoreline wetland data were collected along **transect**s that spanned the entire water depth **gradient** in the shore zone.

Most of the key **habitat attribute**s for terrestrial plants and animals could be captured by mapping and describing the visible ecosystem attributes that were not mobile (*e.g.*, vegetation, soils, surface water, **topography**, most recent disturbance type) and the **disturbance regime** associated with the location. Mapped habitat was used as a proxy for stand level ecosystems because habitat includes most of the major ecosystem components, **biomass** and controlling factors.

Appendix 2B provides details regarding habitat mapping and habitat relationships study methods.

2.2.4.4 Habitat Mapping

Hierarchical habitat and ecological land classifications were developed for use throughout the terrestrial habitat and ecosystems assessment to provide a framework for characterizing terrestrial ecosystems and their interrelationships at multiple scales. Regardless of whether it was a wetland or upland, the attributes used to classify and map terrestrial habitat attributes were vegetation type, vegetation age class (where this could be determined), ecosite type, topographic position and either recent disturbance type (*e.g.*, large fires, ice scouring) or water depth duration zone. Ecosite type is a classification of soil, surficial material, surface water, groundwater and permafrost conditions that are associated with substantial differences in vegetation composition and / or structure.

Wetland habitat classes were derived from the Canadian Wetland Classification System (CWCS; National Wetlands Working Group 1997), with enhancements to reflect dramatic differences in marsh water regimes along the Nelson River and between the Nelson River and off-system waterbodies. Mitch and Gosselink (2000) point out that the CWCS and the US hydrogeomorphic approach (Smith *et al.* 1995) use the same factors to classify wetlands.

The CWCS broadly classifies wetlands into the following classes: **bog**, fen, swamp, marsh and **shallow open water**. Bogs, fens and some swamps are peatlands. Peatlands are wetlands where **organic** material has accumulated on the surface because dead plant material production exceeds decomposition (National Wetlands Working Group 1997). Compared with bogs, fens have higher nutrient availability in the plant rooting zone and tend to have a **water table** that is closer to the surface. Swamps are tall shrub and/or treed wetlands with nutrient rich water and a water table that is generally deeper than in fens. Wetlands from all five wetland classes (National Wetlands Working Group 1988) can occur in the shore zone in the Keeyask region (Photo 2-3).

Wetland classes were subdivided into wetland forms based on surface morphology, surface pattern, water type and underlying mineral **substrate** morphology. Because hydrology is a key driver for the development of these attributes, the type of hydrological connection is key to classifying wetland form. The two hydrological connection types in the CWCS are littogeneous and terrigenous which, as noted above, are referred to as shoreline and inland wetlands. Although all inland wetlands are peatlands or swamp, some peatland types were also found in shoreline wetlands.

Multivariate analyses of vegetation, soils and environmental data collected at the habitat plots and transects were used to develop ecologically relevant site and stand level habitat classifications. The site and stand level habitat classifications mirrored each other to the extent appropriate for the different spatial levels (see Appendix 2B for details). Cluster and ordination analyses were used to produce the site level habitat classification. The stand level habitat classification was developed from the site level habitat classification, the observed site level relationships between overstorey vegetation and site conditions and the observed range of vegetation and ecosite types in the preliminary habitat mapping.

From most general to most detailed, the hierarchical levels in the stand level habitat classification system were land cover type, **coarse habitat type**, broad habitat type and **fine habitat type** (Table 2-1). The categories within each classification level were combinations of vegetation type and ecosite type. Land cover was used to provide very general study area descriptions and habitat use relationships for species. Vegetation on **thin peatland**s and mineral ecosites were grouped together at the land cover level because, although the vegetation on these two types were substantially different, the vegetation on thin peatlands was more similar that found on mineral ecosite types than to the other peatland types.

The 11 land cover types, including permanent human features and water, were sub-divided into 23 coarse habitat types. Coarse habitat types were generally used to provide overview descriptions, characterize the general habitat requirements for the species of interest and/or to relate habitat mosaic information to field data.

The coarse habitat types were subdivided into 65 broad habitat types. Broad habitat types were generally used to characterize the habitat preferences for the species or species group of interest, to relate habitat mosaic information to field data and to describe certain areas of development from a wildlife perspective (*e.g.*, olive-sided flycatcher habitat in the south access road). The broad habitat classification level was also used to identify the **regionally rare habitat type**s.

The broad habitat types were subdivided into 114 fine habitat types. Fine habitat type was generally used to address the specialized needs of VECs and supporting topics. For example, some types of high quality wildlife habitat were identified at the fine habitat level.

Table 2-1: Hierarchical Habitat Classification and Examples of its Uses in the EIS

Classification Level (number of classes)	Example of a Habitat Type	Examples of Uses in EIS	
		Habitat and Ecosystems	**Plants and Animals**
Land Cover Type (11)	Needleleaf treed on peatlands	Very general description of the study areas	Very general description of habitat use by a species
Coarse Habitat Type (23)	Black spruce treed on **shallow peatland**	Overview description of the study areas	Characterize the habitat preferences for a **generalist** species. Develop mixture types to relate to mammal 500m field transects.
Broad Habitat Type (65)	Black spruce mixture on ground ice peatland	Identify the regionally rare and **uncommon habitat type**s	Characterize the general habitat preferences for a species
Fine Habitat Type (114)	Black spruce mixture/ Tall shrub on ground ice peatland	Distinguish the nature and degree of effects for different Project linkages (*e.g.*, groundwater versus vegetation clearing)	Identify patches satisfying specialized needs for some wildlife species (*e.g.*, feeding habitat)

A 1:15,000 scale terrestrial habitat map was created for Study Zone 4, the largest Local Study Area used for all but one of the terrestrial environment VECs and supporting topics. This habitat map was created by photo-interpreting stereo aerial photographs. Most of this photography consisted of 1:15,000 scale photos acquired in 2003 and 2006. Where there were photo gaps, the most recent and/or largest scale photography from 1962, 1975, 1986, 1991 and 1999 was used. The photo-interpreted habitat polygons were heads-up digitized from the traced photos onto digital ortho-images (DOIs) provided by Manitoba Hydro (created from 1999 stereo photography at a pixel size of 2 m). Preliminary mapping was validated using a combination of aerial and ground surveys. The initial mapping was updated to 2010 conditions by adding recent disturbances observed during aerial surveys conducted during the summers from 2009 to 2011.

For some key topics, the habitat composition of Study Zone 5 (Map 2-1) was estimated based on the existing proportions of each habitat type in Study Zone 4 since the Soil Landscapes of Canada map (Agriculture and Agri-Food Canada 1996) and coarse land cover mapping derived from classified satellite imagery suggested that the land cover composition of these two areas were similar. Different extrapolation factors were used for inland habitat and shoreline wetland habitat. Inland habitat factors were based on the Study Zone 5 to 4 total land area ratio whereas shoreline wetland factors were based Study Zone 5 to 4 total shoreline length ratio. Nelson River shoreline wetland habitat composition was not extrapolated from Study Zone 4 to 5 due to the large differences in the Nelson River water regimes along the river **reach**es. Human **infrastructure** area was considered when calculating the extrapolation factors.

More detailed shoreline wetland mapping was created for the Nelson River shoreline and selected off-system waterbodies. The selected off-system waterbodies were all of those within the proposed reservoir area and a sample of waterbodies elsewhere in Study Zone 6.

The first step in the shoreline wetland mapping was producing the **terrestrial habitat shoreline**, which was defined as the visible historical extent of water and **ice regime** effects. The 2006 Nelson River terrestrial habitat shoreline location was initially photo-interpreted from 1:15,000 stereo air photos taken on July 8, 2003. Changes in shoreline location that occurred between 2003 and 2006 were identified from 1:15,000 stereo air photos acquired in 2006. The photo-interpreted shoreline location was heads-up digitized from the traced photos onto digital ortho-images (DOIs) provided by Manitoba Hydro (created from 1999 stereo photography at a pixel size of 2 m).

The Nelson River terrestrial habitat shoreline was segmented where changes in one or more of the following attributes occurred: beach material type, bank material type, beach slope and bank height. The minimum shore segment length was 100 m. These attributes were generally mapped on a paper map of the shoreline while flying in a helicopter and then verified in the office using oblique still photos taken from a helicopter. Additional field data were collected during the summers of 2010 and 2011 to document the effects of very high flows and water levels that began in 2005.

In off-system waterbodies, the water surface edge was used to approximate the terrestrial habitat shoreline location because its position is often difficult to locate in air photos. The large peatlands in the flat terrain that often borders off-system water bodies show little evidence of where the high water mark occurs. As well, off-system waterbodies usually did not have visible water and ice regime effects, likely because most were too small for wave energy effects and water levels were thought to be considerably less variable than on the Nelson River.

Detailed shoreline wetland mapping was created for the Nelson River shoreline and most of the off-system lakes in Study Zone 4 (Map 2-1). Wetland mapping was conducted at three progressively more detailed levels:

- Stereo photography was used to classify wetlands for the entire Nelson River shoreline, and most of the off-system lakes in Zone 4;
- Oblique helicopter photography obtained during the summers of 2001 to 2011 was used to develop more detailed mapping of the Nelson River shoreline, and a subset of off-system lakes. This photography was also used to validate the stereo photo-interpretation; and,
- The most detailed shoreline mapping was obtained during boat-based shoreline surveys conducted in a subset of off-system lakes and waterways (51 km of shoreline). Boat surveys provided another level of validation for the stereo photo and oblique helicopter photo interpretations.

As of 2011, much of the Nelson River vegetation located on the upper beach and inland edge had disappeared due to the effects of very high flows and water levels from 2005 to that time. Shoreline vegetation is expected to recover over time after water levels decline. Because shoreline wetlands are highly dynamic, they are characterized based on the range of conditions observed from 2003 to 2011.

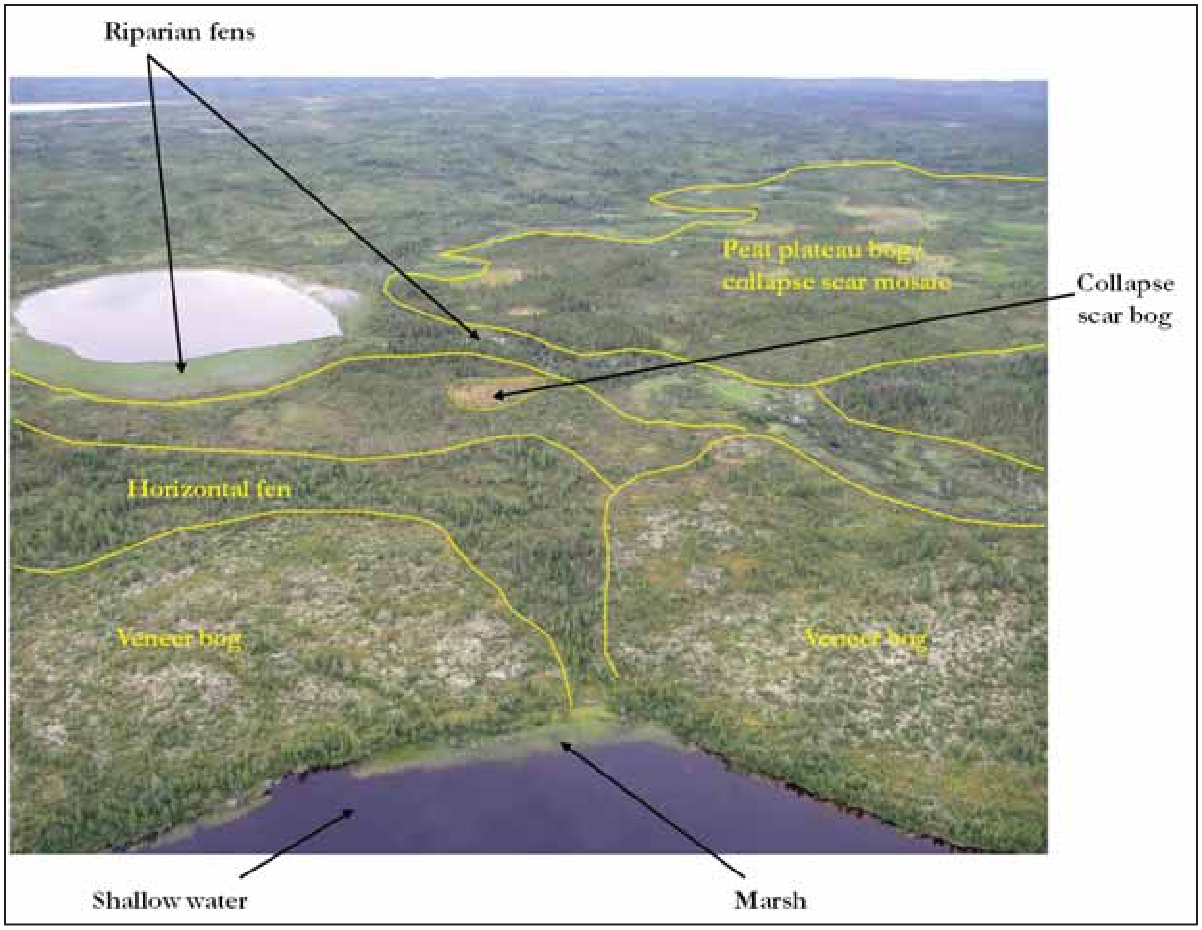


Photo 2-3: Photo from Study Zone 4 Showing Four of the Five Wetland Classes

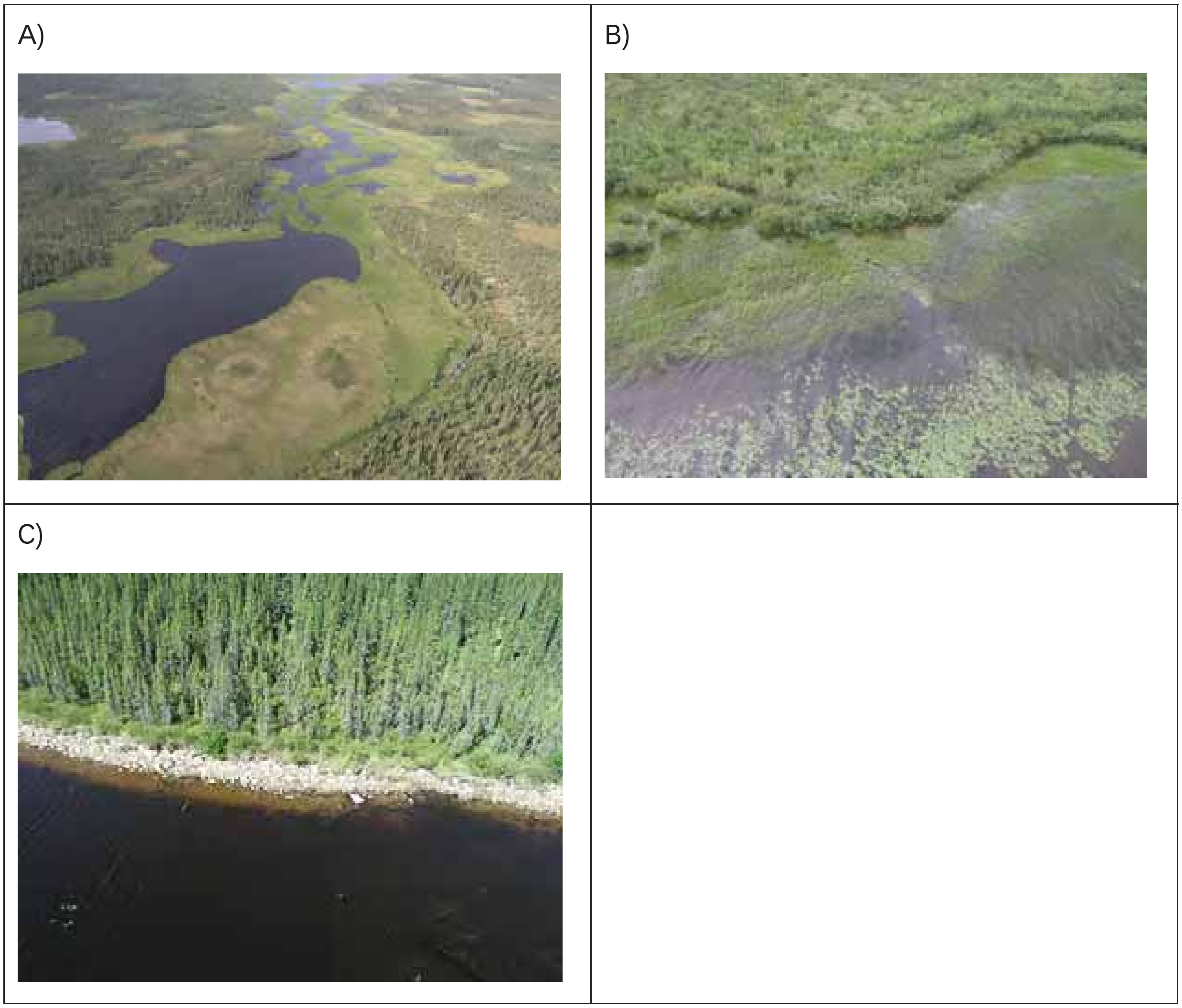


Figure 2-1: Photos from Off-System Waterbodies Showing: A) Riparian Fen and Bog; B) Marsh and Floating-Leaved Plants in Shallow Water; and, C) Shallow Water Wetlands

2.2.4.5 Habitat Relationships Studies

Since ecosystems are organized hierarchically (Section 1.1), many of the observed stand level patterns were the outcomes of site level processes. Site level data were the primary sources of information used to develop our understanding of local ecological relationships and to develop the site level habitat classifications. The habitat relationship studies that provided the majority of the data used to address the wide range of issues were:

- Inland habitat relationships;
- Shoreline wetland relationships;

- Peatland disintegration processes; and,
- Soil characteristics.

The following sections describe each of these studies.

2.2.4.5.1 Inland Habitat Relationships

Inland habitat sample locations were selected using a two-phased, two-staged sampling design. During the first phase, the more common inland habitat types were sampled using a representative design. In the second phase, stands representing **priority habitat type**s not adequately sampled to date were selected from those available, which generally meant most of the available stands due to the rarity of the habitat types.

The first phase of the inland habitat relationships sampling design employed a stratified, random cluster design. Since ecosite is typically the primary driver for spatial differences in vegetation composition on the Boreal Shield (Ehnes 1998), clusters of the most common ecosite types were located on a preliminary ecosite map. Each cluster included at least four of the following ecosite types: deep **mineral soil**, **veneer** bog, **blanket peatland**, **peat plateau bog**, collapse scar peatland or **horizontal peatland**. These ecosite types were thought to be the most common ones in the area based on reconnaissance soil surveys, helicopter surveys, air photos and existing maps. From the map of cluster locations, clusters were randomly selected from geographic zones (*i.e.*, the strata in the sampling design). Once the clusters were selected, additional less common ecosite types were added to the cluster if they occurred within a reasonable walking distance.

Data were collected from a total of 377 inland plots sampled during the growing seasons of 2003 to 2010 (Map 2-3). Each plot was generally 400 m^2 and established entirely within homogeneous habitat conditions, typically near the center of the **habitat patch** to minimize the variability introduced by edge effects. The plot was subdivided into several nested sub-plots, in which different habitat components were sampled. These habitat components included surface substrate percent cover, downed woody material density, trees, snags, shrubs, understorey vegetation, depth to groundwater, soil profile and site characteristics. Tree cores and ground moss samples were collected and taken back to the lab for processing.

Inland habitat data from plots sampled for non-Project studies being conducted along the Nelson River downstream of Study Zone 6 were also used in the assessment. These data were collected during the 2005 to 2010 growing seasons using the same sampling methods as above.

2.2.4.5.2 Shoreline Wetland Relationships

Detailed shore zone wetland habitat data were collected at 212 locations on the Nelson River and in off-system waterbodies sampled during the summers of 2003 to 2006 and 2011 (Map 2-4). At each location, habitat was sampled along two parallel transects positioned perpendicular to the shoreline. In general, sampling began in the inland edge zone and extended to the deep end of the upper sub-littoral zone. Data regarding plant species, surface substrate, soils and **tall shrub structure** was collected along the transects. Vegetation structure, plant species composition and soil **stratigraphy** data were collected at an inland plot adjacent to the transects.

Since several different shoreline wetland studies were conducted to address various questions, several different variations of the detailed sampling designs were employed. For example, transects at locations sampled in off-system lakes were similar to the Nelson River transects, but extended into the water five meters beyond any **emergent** vegetation.

2.2.4.5.3 Peatland Disintegration

Another of the terrestrial habitat studies was an in-depth study of peatland disintegration in existing northern reservoirs (*i.e.*, proxy areas) to support shoreline habitat and shoreline **erosion** predictions. This study developed two types of post hoc monitoring datasets. First, historical change in surface peatland area in three proxy areas was mapped using a time series of large scale historical stereo air photos. Second, **chronosequence** data were collected along transects in Stephens Lake.

The three proxy areas were Stephens Lake (*i.e.*, the Kettle GS reservoir), Notigi reservoir and Wuskwatim Lake (Notigi reservoir and Wuskwatim Lake water levels and flows are regulated as part of the **Churchill River Diversion**). Within each proxy area, case study areas were selected to represent different levels of factors thought to be potentially important in determining the nature and rate of peatland disintegration.

Chronosequence transects provided the second type of post hoc monitoring data. A chronosequence transect is a linear series of sample locations that pass through areas representing different times since peatland disintegration started. Chronosequence transects originated in existing peat islands and proceeded out into the open reservoir water passing through several peatland disintegration stages. Soil profile data were collected at intervals along each transect. Open water “soil profiles” provided data relevant for resurfacing, peat bank collapse, peat sinking and **sedimentation**. Chronosequence transects were sampled in Stephens Lake only since this is the proxy area that is most ecologically comparable to proposed reservoir area,

Peatland disintegration and shoreline habitat model development and **parameterization** relied most heavily on results from Stephens Lake because it is immediately downstream of the proposed Keeyask reservoir and is the most ecologically comparable proxy area. The Kettle reservoir also had the best time series of large scale historical aerial photography.

The large amount of proxy area data were supplemented with lab work that was conducted to better understand the physical properties of peat using peat samples collected in the proposed reservoir area.

PE SV Section 6 Appendix A provides further information regarding the shoreline peatland disintegration studies.

2.2.4.5.4 Soil Characteristics

Soil profile data were collected at all of the locations sampled for the inland habitat and peatland disintegration studies. Soil profiles were also sampled at 3,582 additional locations in the Regional Study Area during the 2002 to 2011 growing seasons (Map 2-5). Of the locations sampled, the 574 habitat plots and the 2002 soil reconnaissance survey provided a representative sample for most of Study Zone 4. The remaining soil profile locations were either systematically sampled or targeted specific areas for the purpose of validating specific study predictions and / or ecosite mapping.

Detailed soil profile data were collected at the habitat plots and most soil reconnaissance locations, by soil pit excavation and / or hand augering into the **parent material**, where feasible (ground ice was impenetrable at some locations). Soil horizons were identified and measured based on the Canadian System of Soil Classification (Soil Classification Working Group 1998). Also recorded were surface organic matter thickness, depth to permanent **mottling**, depth to **gleying**, depth to water table, depth to **bedrock**, depth to frost, **deposit type**, **drainage regime** and **moisture regime**. These data were used to classify each soil profile to a **site type**.

At the remaining soil profile locations, soil profile data collection was often less detailed, or did not extend as deep into the parent material. Sampling for peat disintegration, groundwater effects, fires and soil profiles generally extended only a short distance (20 - 30 cm) into the mineral horizon. The primary purpose of these studies was to establish organic material depth and the underlying mineral soil texture. Deposit type, site type, drainage regime and moisture regime were generally recorded as well.

2.2.4.5.5 Analysis Methods

Site level habitat data analysis was conducted using univariate and multivariate analytical techniques. The primary **multivariate techniques** were Ward's clustering, principal coordinates analysis, non-metric multi-dimensional scaling, logistic regression and decision tree analysis.

2.2.5 Assessment Methods

This section provides an overview of the assessment methods.

2.2.5.1 Historical Change

With the exception of flooding losses, the cumulative historical change in the size of the permanent human footprint in the Study Zone 5 was estimated as follows. The current human footprint was derived for Study Zone 4 from the "human infrastructure" land cover class in the stand level habitat map (see Section 2.2.4.4). NTS maps, developer datasets (*e.g.*, Manitoba Hydro **transmission line**s) and satellite imagery were used for the portion of Study Zone 5 outside of Study Zone 4. A further step needed to map historical land area was to indentify land areas that had been converted to aquatic areas by flooding and associated shoreline erosion. Flooding and erosion losses were estimated by comparing maps of current conditions with historical aerial photos, NTS maps, other maps and reports such as the Split Lake post-project environmental review (Split Lake Cree – Manitoba Hydro Joint Study Group 1996).

The habitat composition of historical terrestrial habitat loss and alteration from human causes could be easily determined in areas where there were pre-disturbance air photos or land cover maps. For locations outside of these areas, several assumptions were made. For linear features and smaller human footprints, it was expected that human feature had the same habitat composition as the adjacent undisturbed areas. For the remaining area, it was assumed that their historical habitat composition was similar to Study Zone 4 habitat composition.

Historical changes in peat plateau bog area in Study Zone 4 were documented by mapping changes between 1962 and 2006, as shown on large-scale stereo air photos (or between 1962 and 2003 where 2006 photography was not available). This is the longest time period where photography of a suitable scale was available for most of the reservoir area.

Historical changes in Nelson River peat shore segments were detected using large scale aerial stereo photos acquired in 1962, 2003 and 2006. Nelson River peat shoreline locations in 1962 and 2003 were compared to determine if and to what extent peat bank recession had occurred due to peatland disintegration. Photography from 2006 was used for cross-checks and to validate the mapped 2003 shoreline location. Horizontal differences in 1962 and 2003 shore locations that were less than 10 m were considered were considered to fall within the error margin related to photo-interpretation, differences in photo scales, geo-rectification and the horizontal positional accuracy of the DOIs.

2.2.5.2 Project Effects Predictions

Project effects on vegetation, soils, individual animals and key ecological flows were expected to generally decline with distance from the Project Footprint. To account for this pattern, the habitat and ecosystems effects assessment used different local zones of influence for each topic. These zones of influence were also used in the spatial scoping for each key topic (Section 1.3.5).

Most likely and worst case scenarios for the local **zone of influence** related to each key topic were developed. The most likely scenario identified the expected zone of Project effects on terrestrial habitat in areas surrounding the Project Footprint. A worst case scenario, based on extreme assumptions about indirect effects and Project-related disturbance, defined the maximum predicted extent of potential Project effects. The anticipated worst case scenario defined the Local Study Area for terrestrial habitat.

Using terrestrial habitat as an example, the Habitat Local Study Area was a 150 m wide **buffer** of the Project Footprint (Section 2.2.5.2). This buffer size was thought to be at least three times larger than the anticipated indirect Project effects on terrestrial habitat. Consequently, the Habitat Local Study Area should also be adequate to capture increased resource harvesting and the portions of undefined footprints that will be outside of the Project Footprint, if any.

To predict potential Project effects, habitat relationship models were applied to existing environment and Project Footprint maps. The types of models used depended on the key topic indicator, and included complex conceptual models, expert information models, simple empirical models and/or complex multivariate quantitative models (Section 1.4.2). In the case of edge and elevated groundwater effects on terrestrial habitat, Project effects predictions were based on several modeling approaches. Predictions from the regional groundwater model (PE SV Section 8) were used to identify inland areas where the water table will rise and where the predicted post-Project water table elevation would be within approximately 2 m of the surface. Secondly, physical limitation analysis was used to identify areas where it physical conditions likely prevent Project-related changes to elevate groundwater to within two meters of the surface. Third, a proxy area analysis was undertaken to develop an empirical groundwater effects on habitat model. This empirical model was developed from data collected on Kettle, Kelsey and Long Spruce reservoirs and the Keeyask reach of the Nelson River that found that the related habitat local zone of influence was typically less than 50 m but varied with habitat type at the edge. For reservoir-related shoreline edge and elevated groundwater effects, the width of zone of influence was a function of topography and ecosite conditions, which was implemented in a GIS using a DEM provided by Manitoba Hydro and the ecosite mapping. The complex multivariate quantitative habitat relationships model will also predict how vegetation, soils and habitat composition are expected to change in the **habitat zone of influence**.

The terrestrial habitat and ecosystems effects assessment assumed that all of the habitat and ecosystems inside of the local zone of influence would be lost when **construction** starts. This assumption was an overestimate because it was expected that: impacts will be phased in over the construction period; only a portion of the potential borrow area footprint will be used; clearing of the access road **ROW** will generally be less than the 100 m width; and, a large proportion of the potential disturbance areas are unlikely to be used.

The terrestrial habitat assessment used the same prediction periods for Project operation as the PE SV. That is, quantitative predictions for the operation periods spanning Year 1, Years 2 to 5, Years 6 to15 and Years 16 to 30 and qualitative predictions for the operation periods spanning Years 31 to 100. The assessment assumed that reservoir expansion will convert terrestrial habitat to water in the amounts predicted in the PE SV Shoreline Erosion Section (PE SV Section 6).

2.3 OVERVIEW OF HABITAT AND ECOSYSTEMS

This section provides an overview of terrestrial habitat and ecosystems, generally based on the largest study zone (Map 2-1) for which data were available. Study Zone 2 information is included for some ecosystem components since this was the Local Study Area for most of the VECs and supporting topics.

2.3.1 Ecological Context

Most of Study Zone 6 (Map 2-1) is located within the Boreal Shield **Ecozone** and the Hayes River Upland Ecoregion (Ecological Stratification Working Group 1996). There is some overlap with the Taiga Shield Ecozone and the Selwyn Lake Upland Ecoregion in the northeast and with the Churchill River Upland Ecoregion in the northwest. Study Zone 6 overlaps seven Ecodistricts. Most of Study Zone 2 is within the 2,300,000 ha Knee Lake Ecodistrict.

Land accounted for 91% of Study Zone 6 in 2010 (Table 2-2). The percentage of land area generally declined through the smaller nested study zones due to the influence of the Nelson River.

Table 2-2: Total Land and Water Areas (ha) in the Terrestrial Study Zones

Study Zone[1]	Total Area (ha)	Land Area[2]	Water Area[2]
Study Zone 6	3,050,000	2,700,000 (*89*)	350,000 (*11*)
Study Zone 5	1,420,000	1,240,000 (*87*)	180,000 (*13*)
Study Zone 4	221,509	167,255 (*76*)	54,254 (*24*)
Study Zone 3	41,966	33,339 (*79*)	8,627 (*21*)
Study Zone 2	18,689	13,043 (*70*)	5,646 (*30*)
Study Zone 1	13,010	7,592 (*58*)	5,418 (*42*)

1 Each Study Zone includes all of the study zones nested within it.
2 Areas for Study Zones 5 and 6 are rounded to the nearest 10,000 ha. Numbers in brackets are the percentage of total area.

The terrain is broadly similar throughout Study Zone 6, having been shaped by glaciation and subsequent inundation by glacial Lake Agassiz. Undulating morainal plains are punctuated by ridges and hills (Smith *et al.* 1998). Much of this morainal terrain is overlain by clayey **glaciolacustrine** deposits, which are more prominent and extensive in lower-laying areas and more continuous toward the south in the **basin** of former Lake Agassiz. **Glaciofluvial** and morainal deposits form ridges and hills throughout the area. Extensive areas of shallow to deep organic soils have developed on the glaciolacustrine deposits. See the Physiography Section of the PE SV (PE SV Section 5.3) for more detailed information.

Climate **parameter**s vary across Study Zone 6 with mean annual temperatures and total annual precipitation generally decreasing toward the northeast. Mean annual temperatures across Study Zone 6 range from about -2.4°C to -4.9°C, with growing seasons ranging from 124 days in the northeast extent, to 149 days in the southwest extent (Smith *et al.* 1998). The weather station at Gillam, which is approximately 30 km east of the proposed generating station site, was used to characterize climate for Study Zone 4 since it is the only weather station in that zone. The mean annual temperature at Gillam is approximately -4.2°C while mean daily temperatures in the coldest and warmest months are -25.8°C in January and 15.3°C in July. The total accumulated growing degree days are 969.6 with a 5°C **threshold** base temperature, and 428.6 using a 10°C threshold base temperature. The average number of frost-free days is 91.9. Average total annual precipitation is approximately 499.4 mm. Of the total annual precipitation, rainfall accounts for approximately 63% while snowfall accounts for 37%. Annual precipitation is highly variable throughout Study Zone 6. The highest mean annual precipitation is 530 mm in the northwestern extent of Study Zone 6 in the Pikwitonei Lake, Orr Lake and Waskaiowaka Lake Ecodistricts, (Smith *et al.* 1998). Mean annual precipitation decreases to approximately 480 mm at the northeastern extent. At Gillam, mean annual precipitation ranges from approximately 500 – 530 mm, most of which falls during the summer months. See the Climate section of the PE SV (PE SV Section 5) for more detailed information.

Study Zone 6 is sparsely populated. The City of Thompson, located near the southwestern limit of Study Zone 6, is the largest settlement in Northern Manitoba. Other settlements include Gillam and the A Kwis Ki Mahka Reserve, Ilford, York Landing (Kawechiwasik), and Tataskweyak (Split Lake). PR 280 passes through the center of Study Zone 6 in an east-west direction and is the only all weather road, providing access to other parts of Manitoba. One rail line provides passenger and cargo service.

2.3.2 Terrestrial Ecosystem Processes and Drivers

2.3.2.1 Overall

Approximately 90% of Study Zone 6 is wetland, and most of this area is peatland (Section 2.8.3). When flying at low elevations over northern areas, it becomes apparent that many peatland areas are a mosaic of various types of peatlands and other wetland types (Photo 2-3). **Lacustrine** wetland mosaics may include various combinations of **shallow open water**, marshes, open fens, shrub fens, treed fens, bogs and swamps. Lacustrine wetland mosaics generally have the same pattern of peatland types. From wettest to driest, these are open water, marsh, wet open fen, dry open fen, treed fen and bog (Figure 2-2; Photo 2-4). These types of peatland mosaics develop around small lakes that have little wave action (Mitsch and Gosselink 2000) and, therefore, may not be typical of all regions, but, nonetheless, serve to illustrate a succession in peatland types, with progressively increasing peatland age from centre toward the edge of the complex. Marshes are much less common in northern than in southern Canada (Glooschenko and Grondin 1988, Vitt *et al.* 2001).

Figure 2-2: Conceptual Diagram Illustrating the Distribution of Five Peatland Communities Surrounding Shallow Ponds of the Mid-Boreal Region of Alberta (from Whitehouse and Bayley 2005).

Photo 2-4: Wetland Mosaic Showing Sequence Similar to that in Figure 2-2

Each of the peatland types within the Photo 2-3 wetland mosaic represents substantially different ecological conditions and substantially different peat development and breakdown dynamics. Ecosystem patterns (*e.g.*, wetland mosaics) and ecosystem processes are strongly influenced by a number of factors. For example, Figure 2A-1 shows the linkages, or pathways of effects, between Project clearing and vegetation.

The primary ecosystem drivers depend on the ecosystem level (Section 1.1) of interest, which determines the relevant temporal and spatial scales. For the boreal biome to region ecosystem levels (the millennia and centuries temporal scales), the key drivers are climate, glaciation and soil formation (Bailey 2009) because they create the surface materials, topography, fire regime and peatlands.

Over millennia, peatlands have developed over extensive portions of the Keeyask area, covering some ponds and small lakes through **terrestrialization** and converting some mineral ecosites to bogs through **paludification**. Terrestrialization refers to the process whereby all or portions of a water body or waterway are filled in by the horizontal expansion of peat from the shore towards the center of the water body or waterway and by organic sediment deposition (Figure 2-3).

Paludification is the process whereby vegetation (primarily *Sphagnum* mosses) on mineral soils progressively creates a wetter moisture regime that eventually leads to the formation of a surface organic layer that expands laterally over time (Figure 2-3). Paludification can be initiated outside of lacustrine basins or riverine valleys in lower slope areas. In upland areas, paludification can occur in wet depressions or in areas with a moist to wet moisture regime. Paludification can progressively blanket an area in an upslope direction. An **aquatic peatland** that was initiated through terrestrialization often expands inland and paludifies adjacent mineral soils. Factors that currently promote paludification in new areas include climate change, geomorphological change, beaver dams or forestry practices (Mitsch and Gosselink 2000).

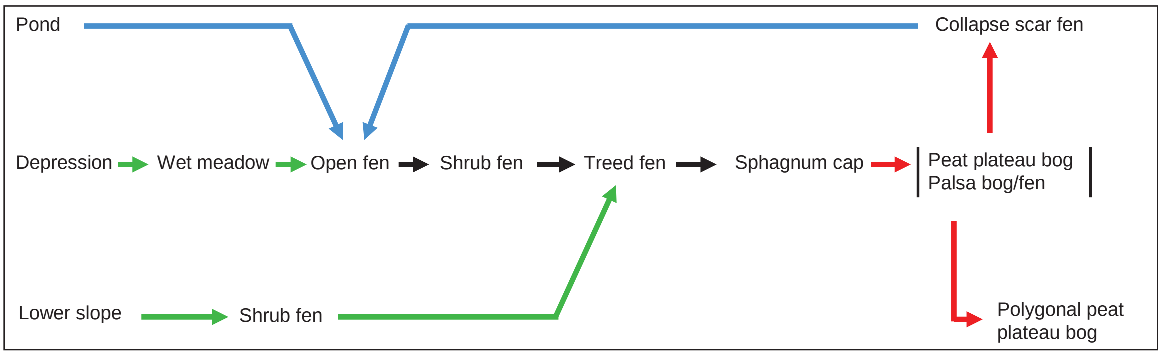


Figure 2-3: Pathways of Wetland Development in Northern Canada (after Zoltai et al. 1988a). Arrow legend: blue=terrestrialization; green=paludification; black=terrestrialization or paludification; red=permafrost dynamics.

Most inland peatland mosaics in the Keeyask area are thought to be derived from a combination of terrestrialization and paludification. Paludification may or may not have been initiated by riparian terrestrialization. In the north, paludification usually commences once *Sphagnum* spp. have established. As organic material accumulates, the water table of peatlands can slowly elevate over time, causing peatland encroachment onto upland areas. The elevated water table can lead to forest flooding and eventual stunting or killing of trees (Keddy 2010).

In some shoreline wetlands, surface water level fluctuations, water flows, waves and ice scouring retard the natural tendency for terrestrialization to expand peatlands into the water. In some Study Zone 4 shoreline locations (predominantly on the Nelson River), it appears that these counteracting factors were so strong that vegetation and peatlands were sparse or absent. For inland peatlands, the water table was typically below the surface and wildfire was a dominant driving factor.

Permafrost is an important factor in northern peatland development. Permafrost initially establishes in unfrozen peatlands in thin layers under small *Sphagnum* moss cushions (Zoltai and Tarnocai 1975) or under stands of black spruce (Zoltai 1972). As these pockets accumulate more permafrost, they eventually become small peat plateaus which may merge together to form peat plateau bogs (Zoltai 1972, Zoltai and Tarnocai 1975).

Typical successional pathways for peatlands in the discontinuous permafrost zone are shown in Figure 2-4. The pathways represented by connecting arrows A and C can be either a terrestrialization or paludification process. Pathway D is a permafrost aggradation process. Pathways E and G are natural permafrost degradation processes that follow climate warming or fire, respectively. Windthrow, which refers to a high wind event that blows down patches of trees, can also initiate pathway G. Pathways E and G generate thermokarst features known as collapse scars. Holocene peat plateau bog dynamics are viewed as cyclic in continental Canada (Zoltai and Tarnocai 1975, Chatwin 1981, Zoltai 1993, Englefield 1995) but this will probably end with climate warming (Camill 1999). Pathways F and I show a collapse scar redeveloping into a permafrost bog.

Typical successional pathways for peatlands in the discontinuous permafrost zone are shown in Figure 6. The pathways represented by connecting arrows A and C can be either a terrestrialization or paludification process. Pathway D is a permafrost aggradation process. Pathways E and G are natural permafrost degradation processes that follow climate warming or fire, respectively. Windthrow, which refers to a high wind event that blows down patches of trees, can also initiate pathway G. Pathways E and G generate thermokarst features known as collapse scars. Holocene peat plateau bog dynamics are viewed as cyclic in continental Canada (Zoltai and Tarnocai 1975, Chatwin 1981, Zoltai 1993, Englefield 1995) but this will probably end with climate warming (Camill 1999). Pathways F and I show a collapse scar redeveloping into a permafrost bog.

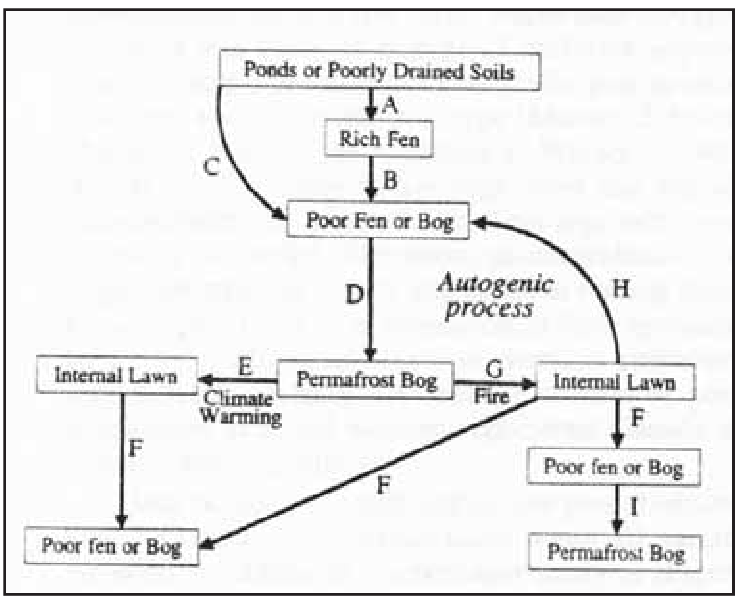


Figure 2-4: Historical Development of Peatlands in the Discontinuous Permafrost Zone of Boreal, Western Canada. (Source: Turetsky *et al.* 2000)

Climate is a key influence on permafrost distribution at the regional level. Wetlands began developing shortly after glacial Lake Agassiz drained. However, peatland development may have been delayed by up to 2000 years due to plant migration, unfavourable climatic conditions and/or other environmental factors (Zoltai *et al.* 1988a). It is thought that peat formation became possible in the northern part of the former Lake Agassiz basin between 4300 and 4800 years BP with the end of a warm and dry period, which had largely precluded prior peatland development (Zoltai *et al.* 1988b). Peatland initiation occurred later in the northern part of the former Lake Agassiz basin and much sooner in the Hudson Bay Lowlands.

Climate has an importance influence on the distribution and abundance of different peatland types. The southern edge of peat plateau bog distribution generally corresponds with the -1°C isotherm (Vitt *et al.* 1994). Permafrost may have reached its maximum spatial extent during the Little Ice Age (1550-1850 AD; Turetsky *et al.* 2000).

Several studies document a reduction in the total area of permafrost peatlands since the end of the Little Ice Age (~ 150 years ago) with no evidence of subsequent aggradation (Thie 1974, Vitt *et al.* 1994, Halsey *et al.* 1995, Vitt *et al.* 2000). From aerial photography, Thie (1974) studied permafrost in peatlands at the southern edge of the discontinuous permafrost zone in an area north of Lake Winnipeg in Manitoba. Thie (1974) estimates that about 75 % of the permafrost in peatlands in the study area degraded since the end of the Little Ice Age; many peat plateau bogs completely disappeared over a 20 year period (1947-1967). Over the same period, Vitt *et al.* (2000) estimate a net area loss of 9% of permafrost peatlands across boreal continental western Canada. Some locations across boreal continental Canada that once contained permafrost have had a complete melting of permafrost, moving the current southern limit of permafrost north by an average of 39 km, and in some locations, by as much as 200 km (Beilman *et al.* 2001).

Ongoing permafrost degradation and permafrost melting is thought to be a lagged response to the general warming trend that occurred at the end of the Little Ice Age (Vitt *et al.* 2000, Camill and Clark 1998). This climate change disequilibrium in permafrost melting may be attributed to the buffering capacity of local factors (*e.g.*, presence of insulating layer of *S. fuscum*) to mediate the effects of regional climate change (Camill and Clark 1998). Vitt *et al.* (2000) estimate that, of the permafrost that remains in boreal western Canada, 22 % is still in disequilibrium with the climate.

The mean annual decrease in permafrost area of peatlands from western Canada appears to be around 1% or greater, while rates of permafrost retreat measured at the plateau-collapse scar edge have ranged from 0 to 2.8 m yr-1 (Tarnocai 1972; Thie 1974; Reid 1977; Chatwin 1981; Englefield 1995; Camill and Clark 2000; Camill 2005). Camill and Clark (1998) show that the thaw rate increases linearly with mean annual temperature in Northern Manitoba, while Camill (2005) reports that thaw rates have significantly accelerated since 1950. "Current warming trends may eliminate most, if not all, peatland permafrost in the [sporadic and discontinuous permafrost] zones of Manitoba" (Camill 2005). However, it could still take centuries for permafrost peatlands to reach equilibrium with the current regional climate (Woo *et al.* 1992).

At the regional level, fire has been and remains the dominant natural driving factor shaping the habitat mosaic and ecosystem dynamics in Study Zone 6, which is why it is a key supporting topic (Section 2.5). Although other disturbances such as windthrow or insect and disease infestations can also affect large areas elsewhere in the boreal forest, there is no evidence that stand-replacing disturbances of these types occurred in Study Zone 6 based on photo-interpretation and field surveys. Human developments and human-induced global change are the dominant human driving factors in Study Zone 6.

At the landscape and stand levels, research indicates that the overriding influence on boreal vegetation composition is usually stand and site level ecosite type. Of the ecosite attributes, moisture regime appears to be the most influential factor on vegetation composition (Ehnes 1998). Nutrient availability and light intensity gradients become influential when the focus narrows to variability among sites with a similar moisture regime or to temporal changes on particular sites. In contrast with the very different vegetation types created by moisture and nutrient availability gradients, wildfire typically initiates a **succession** of vegetation types with similar species composition. That is, boreal post-fire vegetation dynamics generally involve immediate regeneration of the **vascular plant**s that were present prior to the fire, the rapid growth and demise of post-fire thrivers (*e.g.*, green-tongue liverwort (*Marchantia polymorpha*), Bicknell's geranium (*Geranium bicknellii*), fireweed (*Chamerion angustifolium*)) and gradual changes in the moss and lichen community (Ehnes 1998; Ehnes 2003). Most **herbaceous** post-fire pioneers disappear within about ten years of the fire leaving a group of plant species that is similar to what was there prior to fire.

Multivariate analysis of plot data from Project studies confirmed that the largest differences in vegetation types were associated with dramatic differences in soil moisture, depth to groundwater and soil type (soil type is strongly influenced by moisture regime). These relative degrees of influence are demonstrated in Figure 2-5, which was taken in the Study Zone 4. The habitats at the top of the hill are relatively dry. In contrast, the collapse scar bog in the lowest topographic location has no trees because there was too much water for trees to survive to maturity. Likewise, the habitat sequence in Photo 2-4 was created by large differences in depth to water table, groundwater flow and nutrient availability to plants.

Multivariate analysis of plot data also confirmed that spatial patterns in Study Zone 4 were consistent with those reported in the scientific literature regarding the central Canadian boreal forest:

- Habitat types included in the broadleaf mineral grouping:
    - Trembling aspen (*Populus tremuloides*) and jack pine (*Pinus banksiana*) mixes tended to occur on sites with shallower organic substrates, while balsam poplar (*Populus balsamifera*) types tended to have somewhat deeper organic substrates.
    - More mature and needleleaf mixedwoods tended to have more bryoid ground cover, while immature broadleaf dominated types had more low shrub cover.
- Habitat types included in the needleleaf on mineral and thin peatlands:
    - Jack pine dominated mixtures tended to occur on drier, shallower organic sites with coarser soil textures;
    - Black spruce (*Picea mariana*) dominated mixtures tended to occur on moister sites with deeper organic substrates and finer soil textures;
    - Pure black spruce types also had more bryoid-dominated (feathermoss) understories.
- Habitat types included in the thin to shallow peatlands grouping:
    - Habitat types on permafrost peatlands tended to have deeper fibric organic layers and lacked mineral soil in the profile due to massive ground ice.

- o Shallow to thin peatland habitat types had thicker mineral soil layers in the profile and were somewhat drier with a shallower fibric organic layer.
- Habitat types included in the deep, wet peatland grouping:
  - o Tall shrub habitat types often occurred on shallower organic substrates with deeper water tables,
  - o Fen types had a somewhat shallower water table, and thinner fibric layer than deep sphagnum bogs.

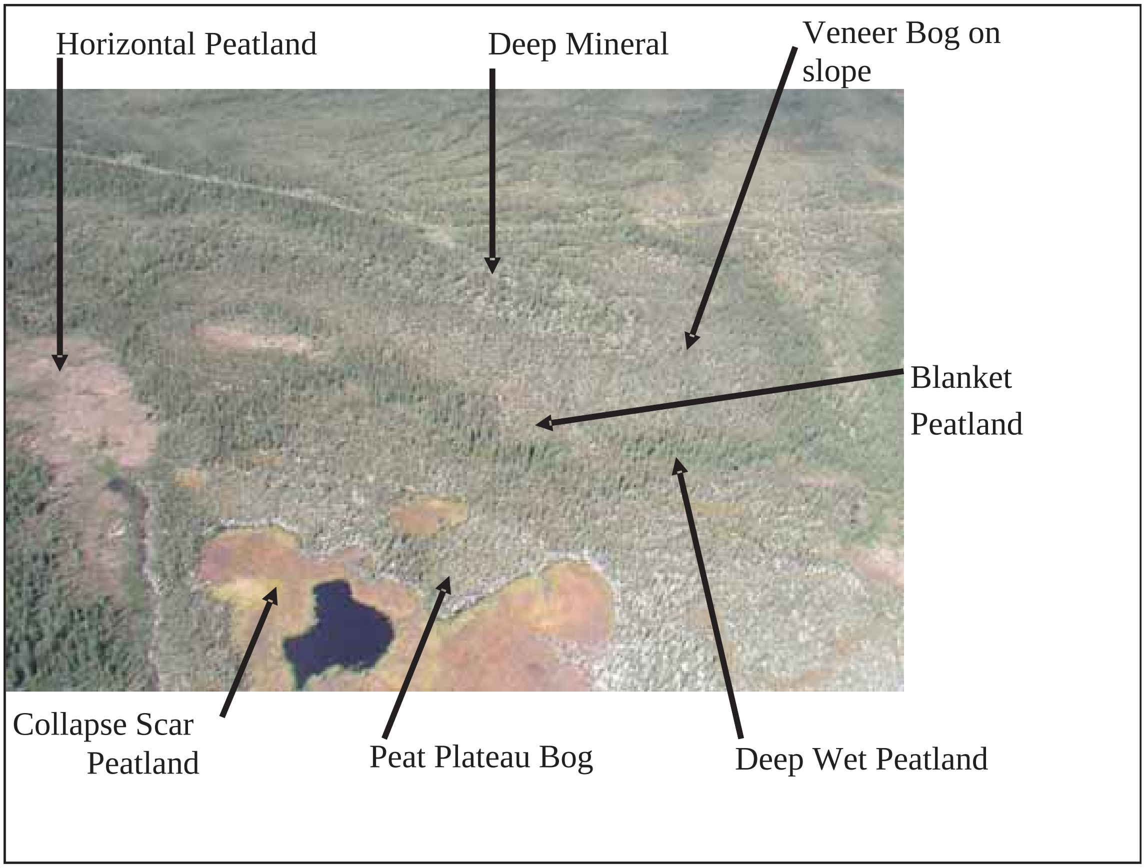


Figure 2-5: A Common Toposequence in the Regional Study Area, Showing the Sequence of Ecosite Types that Occur when Moving from a Hilltop (Deep Mineral in the Photo) to the Lowest Nearby Elevation (Forefront)

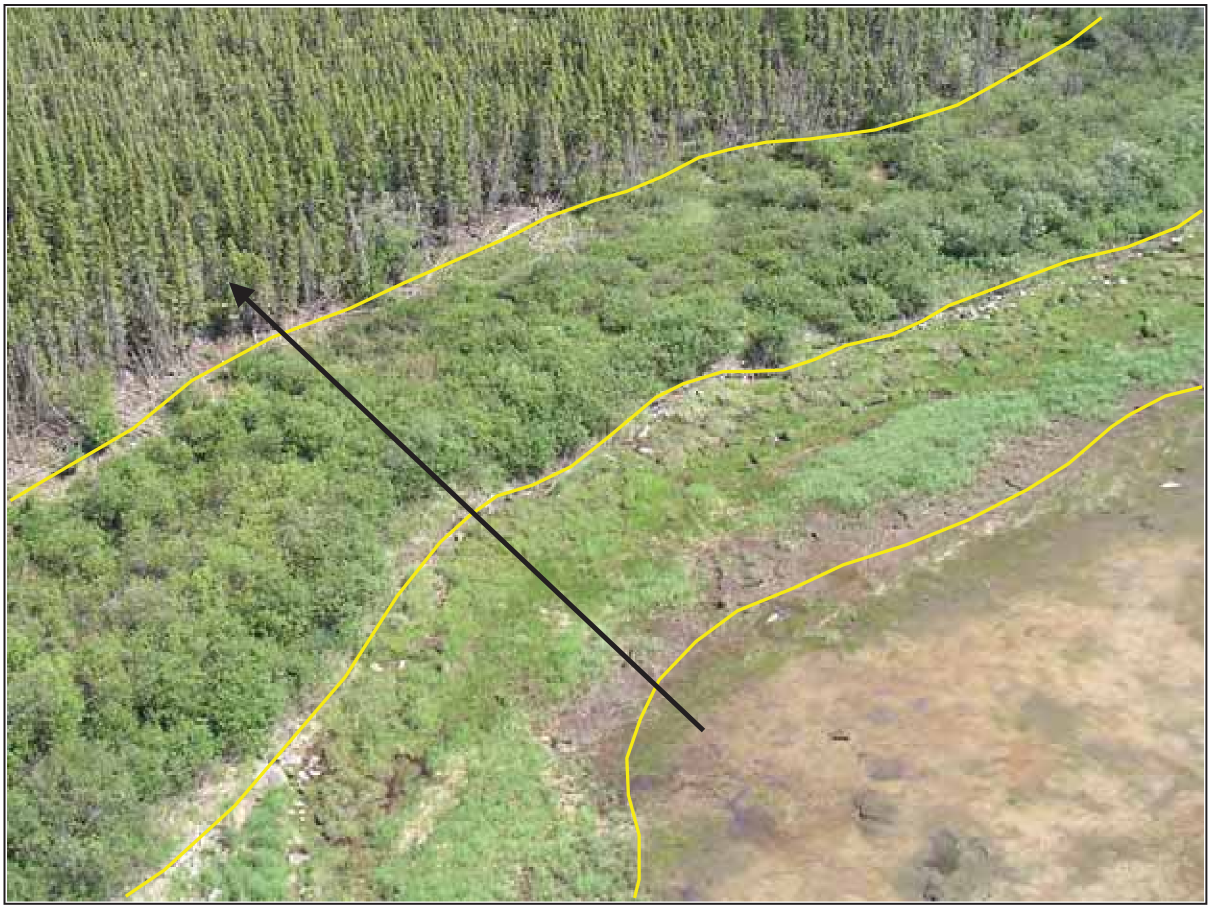


Photo 2-5: Photo Illustrating Shoreline Water Depth Duration Zones, Vegetation Bands and Wetland Classes in Back Bay on the Nelson River During Very Low Water

2.3.2.2 Shore Zone

At any given shoreline location, different plant species are typically arranged into bands that reflect a transition in typical growing season water depths (Photo 2-2). The dominant mechanism in creating these vegetation bands are different plant tolerances to flooding duration (Hellsten 2000; Keddy 2010). Species that can only survive under water for a relatively short period (*e.g.* tall shrubs) grow in the higher elevations of the shore zone because this area is rarely under water. Species that cannot survive out of the water for very long grow in the lower elevations of the shore zone (*e.g.* pondweed (*Potamogeton* spp.)). In other words, a sequence of vegetation bands forms because day to day water fluctuations constantly change water depths and the amount of beach that is exposed/flooded. Labelled photos show shore zone vegetation bands at a location on the Nelson River shoreline (Photo 2-5) and a location in an off-system lake (Photo 2-6).

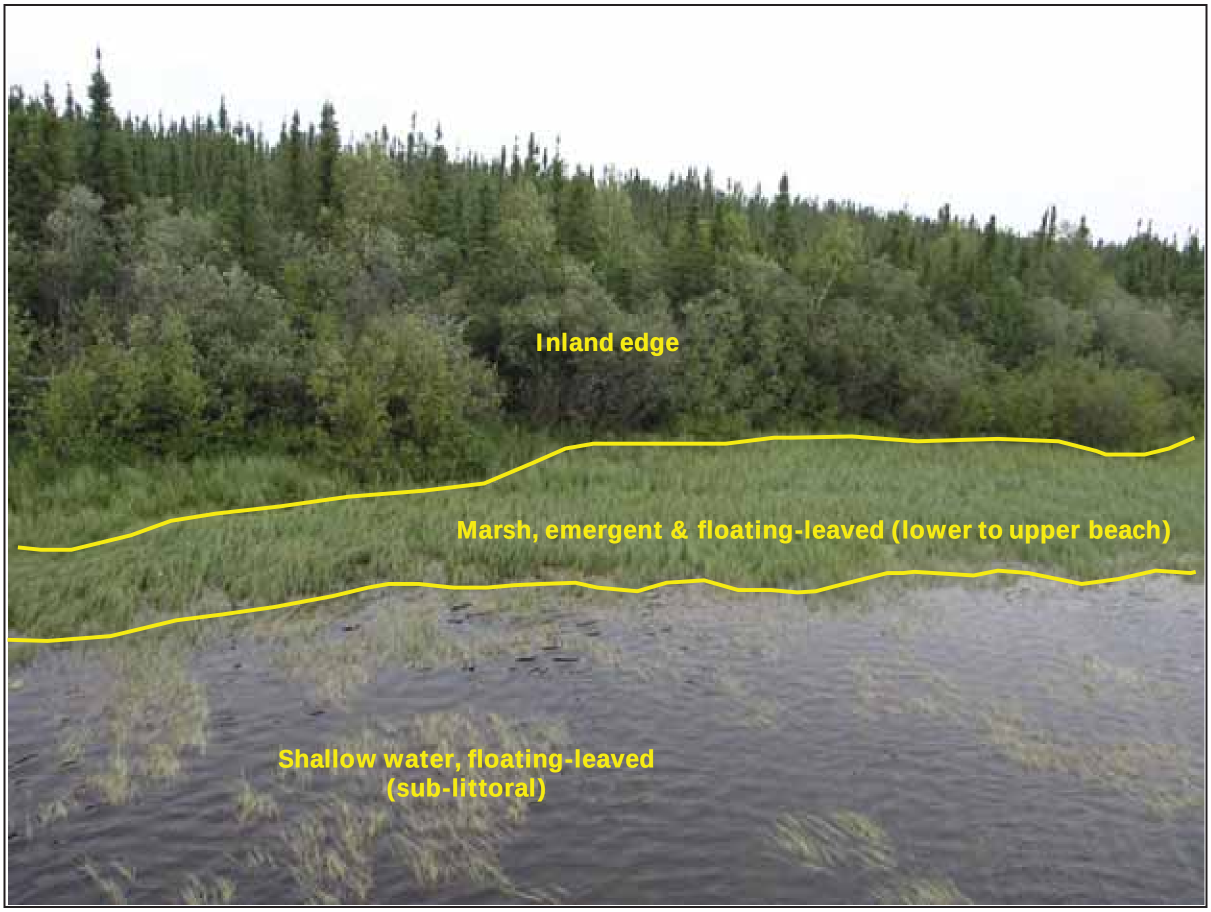


Photo 2-6: Typical Off-System Marsh Growing on the Lake Bottom

On a daily basis, the width of the beach (*i.e.* the exposed organic or mineral substrate that is the lake bottom on some days) varies with water levels. The beach is at its widest when water levels are at their lowest elevation. Also, on any given day, the width of the exposed beach is different at various places along the shoreline because the slope and shape of the lake bottom varies. A low slope area will have a much wider beach than a high slope area.

Plant species distributions along the shore zone water depth gradient are best understood when a plant's location within the shore zone is related to standardized growing season water depths rather than water depths on the day of sampling (Rorslett 1984; Wilcox and Meeker 1991; Hellsten 2000; Keddy 2010). A standardized water depth is the water elevation on a given day minus the median growing season water elevation calculated over the 3–5 years prior to shore zone sampling (Hellsten 2000). The frequency of standardized daily water depths is a key water regime parameter for plant species.

Standardized growing season water depths can be usefully grouped into standardized water depth duration zones (U.S. Army Corps of Engineers 1987; Hellsten 2000). Using Hellsten (2000) because it was specifically developed to address the effects of hydroelectric water regulation, the water depth duration zones going from driest to wettest are inland edge, supra-littoral, upper eu-littoral, middle eu-littoral, lower eu-littoral, upper sub-littoral and lower sub-littoral (Figure 2-6). Every day names used for this sequence were inland edge, upper beach / inland edge transition, upper beach, middle beach, lower beach, sub-littoral and deep water / aquatic. Table 2-3 describes the water duration zones and the types of species that typically grow in each zone.

Different water regimes produce water depth duration zones with different horizontal widths. Consequently, water regime can lead to shore zone vegetation zonation at two spatial levels: the site and the waterbody (or river reach). Site level zonation refers to the shore zone vegetation bands described above. Zonation at the waterbody level refers to reaches of a river or large segments of a lake. Even in a natural river, the elevation ranges of the duration zones will vary in reaches where the flow passes through more constricted areas. A given flow passing through a more constricted reach will have more variable water levels than the same flows passing through a less constricted reach. Consequently, different river reaches can have different water regimes.

When examining an entire waterbody or when different waterbodies are compared, shoreline wetlands with similarly sloped substrates, water regimes and ice regime can exhibit difference vegetation types due to the secondary factors that structure wetlands (Keddy 2010). Secondary factors influencing shore zone vegetation zonation at the site and waterbody levels include light regime, erosion, **sediment deposition**, depth to bottom freezing, ice pressure, bottom slope, bottom shape and soil type (Hellsten 2000; Keddy 2010). Broad differences in these factors were the primary basis for identifying zones at the waterbody level. Some proxies for these factors are wave energy, turbidity, bottom slope, bottom shape and type of surface materials. These broad differences provide the context for vegetation and soils at a particular location and constrain which types of shore zone vegetation sequences can develop.

The primary sub-division of a waterbody into zones is often based on water regime since this is generally the most important influence on the overall composition of shore zone vegetation sequence types in a study area. This was the primary reason why Nelson River and off-system waterbody shoreline wetlands were addressed differently, as well as for treating the Split Lake, Keeyask and Stephens Lake reaches as separate shoreline wetland zones. A secondary, sub-zonation was based on broad differences in other influential factors such as wave energy, current, sedimentation or surface materials, to the extent they were apparent within each waterbody zone. These latter factors were considered for the stratification component of field studies and when analyzing field data.

The preceding generalizations regarding shoreline wetland relationships and drivers have been confirmed for areas subjected water regulation (Keddy and Fraser 2000; Keddy 2010).

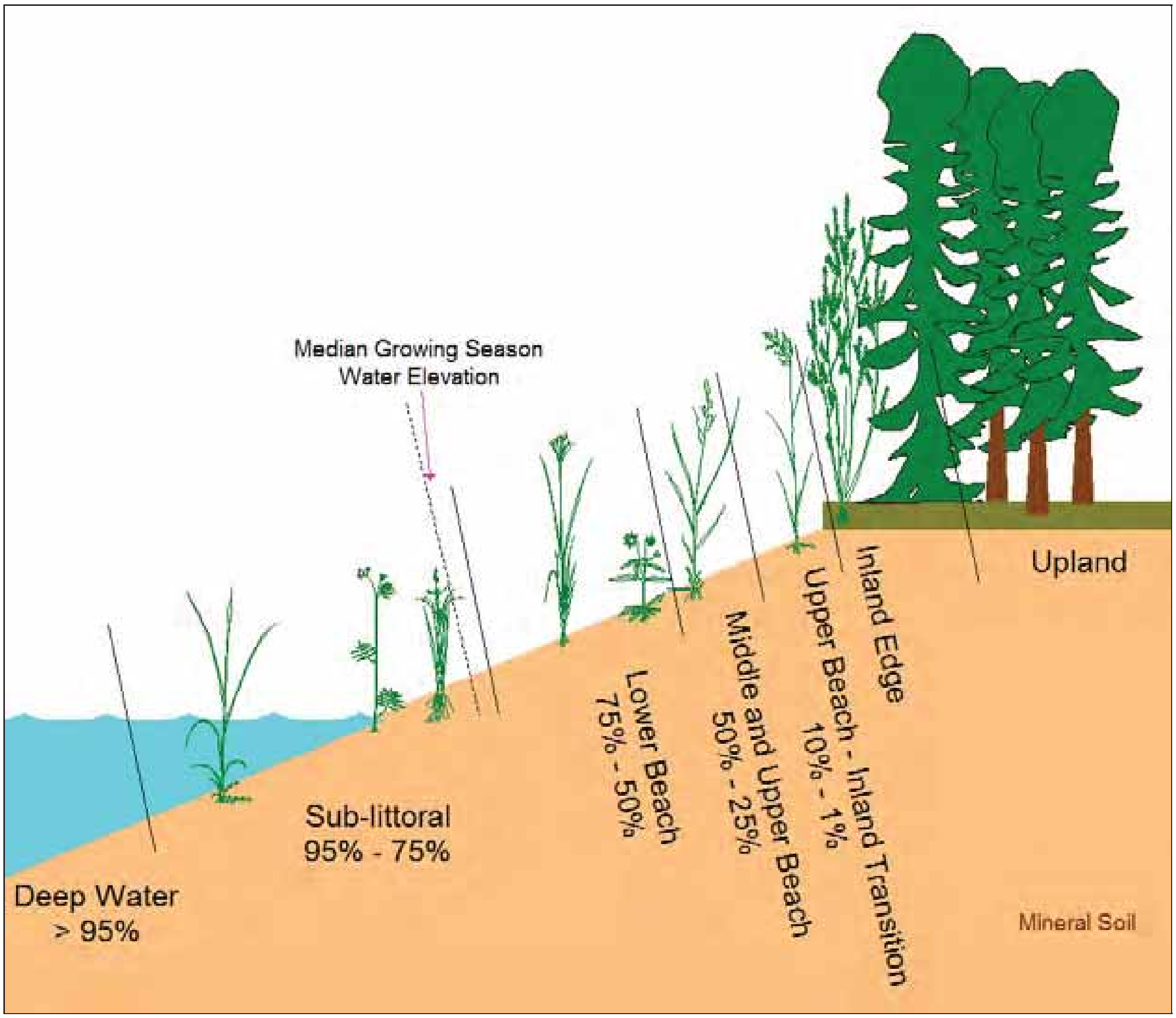


Figure 2-6: Water Depth Duration Zones and the Types of Plants Found in Each Zone

Table 2-3: Water duration zones, associated water conditions and types of species found in each zone.

Water Duration Zone	Water Conditions[1]	Typical Species[2]
Deep Water	Under water at least 95% of the time*.	Covered in aquatic section
Sub-littoral	Under water more than 75% but less than 95% of the time. Bottom freezing occurs in most or all of this zone.	Plants which cannot tolerate desiccation but which can tolerate bottom freezing and ice pressure. Hydrophytes ("true" **aquatic plants** according to some authors)
Lower Beach	Under water more than 50% but less than 75% of the time	Plants which can tolerate alternating periods of inundation and desiccation during a season between years where the condition may persist for more than about 45 days. Tall emergents. Most are monocots. These species also expand their distribution into the higher portion of the Very Shallow Water when water levels drop for a prolonged period.
Middle & Upper Beach	Under water more than 10% but less than 50% of the time	Plants which can tolerate alternating periods of inundation and desiccation during a season between years where the condition may persist for more than about 30 days. Tall to short emergents. Most are **graminoid**s and ruderal herbs.
Beach/Inland Edge Transition	Under water more than 1% but less than 10% of the time	Plants which grow poorly in wet soil but can survive periodic short-term flooding. Graminoids, ruderal herbs, shrubs.
Inland Edge- Mineral Ecosite	Under water less than 1% of the time & surface organic layer < 20 cm deep	Plants which will die if their roots are under water for extended periods during the growing season. Most woody plants, many herbs.
Inland Edge- Peatland Ecosite	Under water less than 1% of the time & surface organic layer >= 20 cm deep	Fen or bog plants. Substrate edge may be a floating or expandable mat which moves up and down with moderate water level fluctuations thereby protecting plant roots from submergence. Most woody plants, ericaceous plants, many herbs.

Notes: [1] Number of growing season days over past three to five years.
[2] References include Rorslett 1984, Mark and Johnson 1985, Wilcox and Meeker 1991, Hellsten 2000 and Keddy 2000

2.3.2.3 Resilience and Ecosystem Health

As described above, a boreal wildfire drastically changes habitat but generally only for the short-term. Boreal plant species are well adapted to regenerate from the individuals that were there when the fire occurred and this imparts inherent resistance and resilience to fire at the plant community level (Rowe 1983; Payette 1992; Ehnes 1998). An important function performed by fire is rejuvenating site conditions by arresting the successional decline in nutrient availability, pH and, in some cases, soil temperature and elevating these factors to levels that are more favourable for plant growth.

Boreal plant and animal adaptations to frequent disturbance by large wildfires impart some resistance and resilience to novel types of disturbance provided they are within the ranges of natural variability. Even beyond this, it is generally thought that ecosystem functions can be maintained with the loss of one or a few species due to ecological redundancies.

2.3.3 Historical Change

Human impacts, global change and fire regime changes have been the primary factors driving habitat and ecosystem changes in Study Zone 6 over the past few hundred years. Other widespread human alterations such as airborne deposition and spreading invasive plants have also contributed to change. This section provides an overview of how changes in these driving and contextual factors are thought to have changed terrestrial habitat and ecosystems.

2.3.3.1 Human Impacts

Aboriginal people have lived on the land for thousands of years. Although Europeans are thought to have first visited Study Zone 5 in the 1600s, most of the cumulative historical change in the Study Zone 5 human footprint was derived from the settlements, infrastructure and hydroelectric projects developed over the past 50 to 100 years. Human influences on the fire regime such as fire suppression and accidentally started fires have also indirectly affected habitat and ecosystems.

Settlements first appeared in Northern Manitoba along the Hudson’s Bay coastal and inland region in late 1600’s. York Factory was one of the first European settlements and was based around the Hudson Bay Company York Factory Fur Trade Post, which was built in 1684. Later, fur trade posts were established inland, creating a fur trade corridor to the south, with two documented posts along Split Lake. In 1886, a post was established at the north end of Split Lake. This was followed by the construction of a permanent Anglican Mission house in 1906 (Split Lake Cree Nation 1996a). York Factory First Nation was moved from York Factory at the coast, to a reserve at York Landing in 1957.

Ilford originated as a construction and service centre during the building of the Hudson Bay Railway and became one of the Bayline communities to service the route from The Pas to Churchill. War Lake First Nation Members (originally part of the Split Lake Band) had lived in the Ilford area to take advantage of railway employment and the fishery. In 1976, Cree leaders began efforts to obtain a reserve at Ilford and to form an independent First Nation; formal status was received in 1980.

The Fox Lake Cree have inhabited the camps around Gillam, Fox Lake, and Bird for many years. Prior to 1947, the FLCN Members were part of YFFN. FLCN was unofficially recognized as an independent Band from YFFN in 1947. FLCN’s reserve at Fox Lake (Bird), 53 km northeast of Gillam was formalized in 1985; however, FLCN Members and their families had been living in the Bird area for many years prior to that. The reserve community at Bird was renamed Fox Lake in 2010. In the same year, a small urban reserve was legally recognized at Kettle Crescent in Gillam.

Gillam became a formal settlement in the late 1960s associated with the development of the Kettle Generating Station; however, several families of Cree, Metis and others had lived in the vicinity of Gillam for several decades prior to the 1960s as it was a railway stop.

See Section 2 of the SE SV for further details on the history of the settlements in the area.

Terrestrial areas were flooded by water regulation related to Lake Winnipeg Regulation and the Churchill River Diversion, and by the reservoirs created for the Kelsey, Kettle and Long Spruce hydroelectric generating stations (for details regarding the history of hydroelectric development in Northern Manitoba see the PD SV Section 1.3).

Total historical terrestrial area loss to permanent human features was estimated to be approximately 39,200 ha, or 3.2%, of historical land area in Study Zone 5 (Table 2-4). The settlement and infrastructure component of this change was approximately 8,000 ha, or 0.6% of the land area. Gillam and Split Lake have the largest settlement footprints. Flooding, reservoir expansion and water regulation have made the largest contribution to habitat loss at approximately 31,350 ha, or 2.5% of historical land area. The Kelsey reservoir flooded approximately 5,700 ha of land area (Split Lake Cree – Manitoba Hydro Joint Study Group 1996). **LWR** and CRD decreased water levels on Split Lake by an average of 0.2 m during the summer and increased water levels by 0.8 m during winter, with no associated flooding of land (Split Lake Cree – Manitoba Hydro Joint Study Group 1996). LWR and CRD up to 2005 did not remove any inlands in Study Zone 2 (PE SV Section 6). The Kettle generating station reservoir (i.e., Stephens Lake), and its associated reservoir expansion area converted approximately 23,500 ha of uplands and peatlands to aquatic areas from the time of **impoundment** to 2003.

Using a 50 m buffer of the mapped areas of loss as an estimate of the spatial extent of the indirect effects of these permanent human footprints on terrestrial habitat (Section 2.2.5.2), it was estimated that an additional 22,000 ha, or 1.7%, of inland **habitat alteration** has occurred (Table 2-4). Approximately two-thirds of this total was associated with hydroelectric developments.

Human developments have affected higher proportions of Study Zones 2 to 4 than the larger study zones because most of the developments are concentrated within the smaller study zones. Approximately 20% of historical land area in Study Zone 4 has been converted to human features or water (Table 2-4). It was estimated that the indirect effects of these losses may have increased the amount of affected inland terrestrial habitat land loss to more than 30% of Study Zone 4 historical land area.

Table 2-4: Historical Terrestrial Loss and Alteration from Large-Scale Human Developments in the Regional Study Area

Human Footprint	Size in Study Zone 5 (ha)			Percentage of Study Zone 5 Historical Land Area			Percentage of Study Zone 4 Historical Land Area		
	Loss	Alteration[4]	Total Change	Loss	Alteration[4]	Total Change	Loss	Alteration[4]	Total Change
PR 280 and connected borrow areas[1]	2,169	3,000	5,169	0.2	0.2	0.4	1.1	1.5	2.6
Other roads and "permanent" clearing (*e.g.*, borrow areas)[1]	1,419	2,100	3,519	0.1	0.2	0.3	0.7	1.1	1.8
Settlements: Gillam, Split Lake, York Landing, Ilford[1]	951	956	1,907	0.1	0.1	0.2	0.5	0.5	1.0
Generating stations and **dyke**s[1]	208	U	208	0.0	U	0.0	0.1	U	0.1
Transmission lines and **converter station**s[1]	3,070	6,383	9,453	0.2	0.5	0.7	1.6	3.2	4.8
Keeyask early infrastructure- unique borrow area[1]	771	302	28	0.1	0.0	0.0	0.4	0.2	0.5
Kelsey reservoir and Split Lake flooding[2]	5,700	5,400	11,100	0.4	0.4	0.9	2.9	2.7	5.6
Kettle flooding and reservoir expansion[3]	23,479	3,500	26,979	1.8	0.3	2.1	11.9	1.8	13.6
Long Spruce flooding and reservoir expansion[3]	1,400	300	1,700	0.1	0.0	0.0	0.7	0.2	0.9
Total	39,167	21,941	61,108	3.1	1.7	4.8	19.8	11.1	30.9

Notes: U = no estimate available. Column totals may not equal sum of rows due to rounding.
Data sources: [1] Terrestrial habitat mapping; [2] Split Lake Cree – Manitoba Hydro Joint Study Group 1996 (based on proportion of total area that is in Study Zone 5); [3] Historical terrestrial habitat mapping; [4] 50 m buffer of mapped area of loss.

2.3.3.2 Global Change

Global change refers to global-scale, human induced changes in environmental attributes such as climate warming, ground level ultra-violet radiation and ozone layer thickness. Global change has important direct and indirect influences on habitat and ecosystems. This section deals with climate change since this was the only attribute that had adequate historical information for the Study Zone 5.

Over the 50-year period from 1967 to 2006, an overall trend in increasing temperature was observed in the study zones (Manitoba Hydro 2009c). Mean temperature increases in Gillam were the highest in winter (3.11°C increase) and in September (1.54°C increase). There were no statistically significant changes in precipitation at Gillam over this period. There was a significant downward trend in precipitation at Thompson, near the southwest extent of the study zones, with October mean precipitation decreasing 33.88 mm.

Climate has an importance influence on the distribution and abundance of different vegetation, soil and habitat types. For example, Bigelow *et al.* (2003) estimated that the northern treeline did not extend further north than 55°N following the last glacial maximum (18,000 yr BP). In the Keewatin area of central Canada, studies estimated that the northern treeline shifted approximately 240 km south since the end of the Mid-Holocene Warm Period (5,000 – 4,000 yr BP; Nichols 1976; Bigelow *et al.* (2003). Likewise, the southern limit of permafrost-affected peat landforms has shifted southward and then northward over the past 500 years (Tarnocai 2009).

Peatlands cover most of Study Zone 5. Climate warming that occurred at the end of the Little Ice Age approximately 150 years ago has had a major effect on northern peatlands (Halsey *et al.* 1995), including those in Study Zone 5 (see Section 2.3.2). Several studies relevant to Study Zone 5 report a reduction in the total area of permafrost peatlands since the end of the Little Ice Age (~150 years ago) with no evidence of subsequent aggradation (Thie 1974, Vitt *et al.* 1994, Halsey *et al.* 1995, Vitt *et al.* 2000). Ongoing permafrost melting is thought to be a lagged response to the climate warming that began at the end of the Little Ice Age.

Thie (1974) estimated that about 75% of the permafrost in peatlands in an area north of Lake Winnipeg in Manitoba has degraded since the end of the Little Ice Age. Many peat plateau bogs completely disappeared between 1947 and 1967. Over the same period, Vitt *et al.* (2000) estimate a net area loss of 9% of permafrost peatlands across boreal continental western Canada. Complete melting of permafrost has occurred in some of the continental boreal locations that once contained permafrost, moving the current southern limit of permafrost north by an average of 39 km, and in some locations, by as much as 200 km (Beilman *et al.* 2001). The mean annual decrease in permafrost area of peatlands in western Canada appears to be at least 1%, while rates of permafrost retreat measured at the plateau-collapse scar edge have ranged from 0.0 to 2.8 m yr^{-1} (Tarnocai 1972; Thie 1974; Camill and Clark 2000; Camill 2005).

A study undertaken in Study Zone 4 confirmed these trends. Historical rates of permafrost peatland change were estimated using historical air photos from 1962, 2003 and 2006. Over the 44-year study period, peat plateau bog area declined by approximately 20%, or at a mean annual rate of loss of 0.5% per year. This mean annual rate was within the range reported in the scientific literature for northern Canada. Area losses for individual peat plateau bogs ranged widely from a minimum of 1% to a maximum of 48%. Recently burned peat plateau bogs shrank faster than unburned ones. Over 90% of the shrinking area became other peatland types; the rest became open water.

2.3.3.3 Fire Regime

Fire is the keystone ecosystem process in the boreal forest (Rowe and Scotter 1973; Weber and Flannigan 1997), which is why fire regime is a key supporting topic. Section 2.5.3 describes the past and current fire regimes. In brief, the fire regime is highly dependent on climate. Climate change that increases **evapotranspiration** rates has been associated with higher fire frequency and total area burned (Girardin et al. 2009). Humans have altered the fire regime in several ways. Fire suppression and possibly roads have reduced the total area burned by natural and human caused fires. In contrast, the human contribution to fire starts and total burned area has likely increased.

2.3.4 Current Conditions

2.3.4.1 Habitat Composition

The habitat classes in the hierarchical habitat classifications (Table 2-1) are combinations of vegetation and ecosite types. Because ecosite conditions are the primary influence on spatial vegetation patterns (Section 2.3.2), this section begins with a description of Study Zone 4 ecosite composition.

2.3.4.1.1 Ecosite Abundance and Distribution

From most general to most detailed, the ecosite levels in the hierarchical habitat classification were land type, coarse ecosite type, broad ecosite type and fine ecosite type. In 2010, the land type composition of the Study Zone 4 was approximately 12% mineral, 39% thin peatland, 45% other peatland, 3% shore zone peatland, and less than 1% other shore zone wetlands combined (Table 2-5).

Table 2-5: Land Type Composition of Study Zones 4 and 2, as a Percentage of Land Area

Land Type	Study Zone 4	Study Zone 2
Mineral	11.7	18.7
Thin peatland	38.8	39.7
Other peatlands	45.5	34.3
Shore zone peatland	3.1	4.0
Nelson River shore zone	0.8	3.2
Off-system shore zone	0.1	0.1
Total land area (ha)	*167,255*	*13,043*

Note: Reported areas are land area only.

Thin peatland was the most common coarse ecosite type (Table 2-6), covering approximately 39% of the area. Most of the remaining area was covered by shallow peatland (25%), ground ice peatland (16%) and mineral ecosites (12%).

Table 2-6: Coarse Ecosite Composition of Study Zones 4 and 2, as a Percentage of Land Area

Land Type	Coarse Ecosite Type	Study Zone 4	Study Zone 2
Mineral	Mineral	11.7	18.7
Thin peatland	Thin peatland	38.8	39.7
Other Peatlands	Shallow peatland	24.7	20.0
	Ground ice peatland	15.9	11.8
	Permafrost peatland- other	0.4	0.3
	Deep peatland	4.4	2.3
	Wet deep peatland	0.0	-
Shore Zone Peatland	Riparian Peatland	3.1	4.0
Nelson River Shore Zone	Ice-Scoured Upland	0.1	1.0
	Nelson River Shoreline Wetland	0.8	2.2
Off-System Shore Zone	Off-System Shoreline Wetland	0.1	0.1
Total land area (ha)		*167,255*	*13,043*

Note: Reported areas are land area only.
Cells with "0.0" values are areas that round to 0, while "-" indicates that the type is absent.

Vegetation on the thin peatland coarse ecosite type was more similar to that found on mineral soils than the other peatland types. Thin peatlands typically formed the transition zone between mineral ecosites at higher elevations and other peatland types at lower elevations. Mineral ecosites occurred more frequently along the Nelson River including its islands and the elevated portions of **esker**s and **moraine**s (Map 2-6). Thin peatlands are **veneer bog**s that occurred on slopes or **crest**s. Bedrock outcrop patches that were large enough to map were found near the Nelson River to the north and south of Gull Lake.

Included in the other peatlands land type were the shallow and ground ice peatland coarse ecosite types. Shallow peatlands are well distributed on flat terrain throughout Study Zone 4 (Map 2-6). Most shallow peatlands were comprised of the blanket bog fine ecosite type, with a small amount of veneer bog and **slope bog** (Table 2-6). Ground ice peatland was most prevalent in the inland portions of Study Zone 4 (Map 2-1). Ground ice peatlands, which covered 16% of the total land area, were mostly composed of peat plateau bog and collapse scar mosaics and the transitional stages of peat plateau bog formation or breakdown.

The other peatlands land type also included the other permafrost peatland, deep peatland and wet deep peatland coarse ecosite types. Deep peatlands were the most common, and were almost entirely comprised of the horizontal fen fine ecosite type which was scattered in flat terrain and depressions throughout the Study Zone 4. Large patches of deep peatlands occurred south of Stephens Lake, north of the Long Spruce reservoir and on the south side of PR 280 in the west of Study Zone 4 (Map 2-1). Collapse scar peatlands were more abundant than suggested by Table 2-6 because many collapse scars were very small so they were mapped as peat plateau bog and collapse scar mosaics.

The shore zone peatland land type was comprised of riparian peatlands, and dominated by the riparian fen fine ecosite type (Table 2-6). Riparian peatlands tended to occur along small waterways and **runnel**s, and were more frequent nearer the Nelson River.

Surface water was generally present throughout the growing season in riparian peatlands and many collapse scars. Small patches of open water occurred in many horizontal peatlands. Depth to groundwater generally increased with the following sequence of ecosite types: riparian and collapse scar peatland, horizontal peatland and wet deep peat. The remaining peatland ecosite types may have groundwater before mineral contact but the depth to occurrence was highly variable and somewhat dependent on slope position, season, and other conditions.

The Nelson River shore zone land type included the ice-scoured upland and Nelson River shoreline wetland types. Ice scoured upland ecosites occurred on sloping topography only along the Nelson River shoreline. This ecosite is located within the portion of the shore zone that is above the zone of fluctuating water levels. Nelson River shoreline wetland fine ecosite types included the upper beach, upper beach on sunken, disintegrated peatland and lower beach fine ecosite types, which reflected the shore zone water depth duration zones (Section 2.2.4.5). Sunken peat is the margin of a peatland whose surface has sunk below the water surface but is often suspended above the bottom. Emergent vegetation may occur on the coarse ecosite type. Because of Nelson River water level regulation and hydrodynamics, Nelson River shoreline wetlands are dramatically different than those found in the off-system shoreline wetlands.

In Study Zone 4, upper beach was the most common Nelson River shoreline wetland land type (0.6%), followed by the upper beach on sunken, disintegrated peatland and ice scoured upland broad ecosite types (Table 2-6). Upper beach occurred in narrow bands within the fluctuating water zone on sloping topography along the Nelson River, while upper beach on sunken, disintegrated peatland were mostly scattered in Stephens Lake.

The off-system shoreline wetland land type was mostly comprised of the littoral island and upper beach fine ecosite types. Littoral island refers to off-shore areas with patches of emergent and/or floating-leaved vegetation, which was taken as an indicator that water depths were shallower may be shallower than adjacent areas. Off-system shoreline wetlands were scattered throughout Study Zone 4 but each made up less than 0.1% of the land area. Detailed discussion of shoreline wetlands are provided in Section 2.8, Wetland Function.

Three quarters of the land in Study Zone 4 occurred on gentle slopes and horizontal topography (Map 2-7). Most of the remaining topography was comprised of networks of ridges, depressions and runnels.

Most of the sloping topography was associated with the thin peatland ecosite and mosaics of Organic Cryosols and Gray Luvisols (see PE SV Physiography Section). Most of the horizontal topography was associated with shallow and ground ice peatland ecosites. Ridges tended to be associated with mineral ecosites and **Eutric** Brunisolic soils that have developed on coarse **till**s and fluvioglacial deposits. Riparian and deep wet peatland ecosites were generally associated with runnels, depressions and flat topography.

Topography plays an important role in ecosite development. Virtually all of the minerals and thin peatlands in the study area occurred on crests or the upper portions of slopes because good water drainage has prevented thick peat development in these locations (see Appendix 2C). Thicker peatlands develop in most other locations due to factors that reduce decomposition rates such as poorer drainage, permafrost and a longer period with **impermeable** shallow seasonal frost.

Most low-lying areas contained either ground ice peatlands or wet peatlands (88% of the area; see Appendix 2C). Wet peatlands and riparian peatlands were generally associated with areas where water collects and/or drains such as depressions, runnels and flat topography. Peat thickness in runnels tended to decrease with increasing runnel slope.

The coarse and fine ecosite composition of Study Zone 2 was very similar to that of Study Zone 4. Study Zone 2 had a slightly higher proportion of mineral ecosites due to the proximity to the Nelson River and the esker and the higher proportion of ridges and crests there (see Appendix 2C).

2.3.4.1.2 Ecosite Type Descriptions

The most common coarse ecosite types (Table 2-6) are characterized in the fact sheets presented in Figure 2-7 to Figure 2-14. The fact sheets are ordered from the driest upland type to the wettest wetland type.

Mineral Coarse Ecosite Type Sites with surface organic layers less than 20 cm thick.	
Deep Dry Mineral Fine Ecosite Type: Very fresh to dry sites with mineral soil greater than 100 cm thick	

Figure 2-7: Example and Description of the Mineral Soil Coarse Ecosite Type

Thin Peatland Coarse Ecosite Type Sites with surface organic layers less than 20 cm thick.	
Veneer Bog On Slope Fine Ecosite Type: Moist, sloping sites with thin organic soils, usually less than 50 cm thick, and occasional ground ice may be present.	

Figure 2-8: Example and Description of the Thin Peatland Coarse Ecosite Type

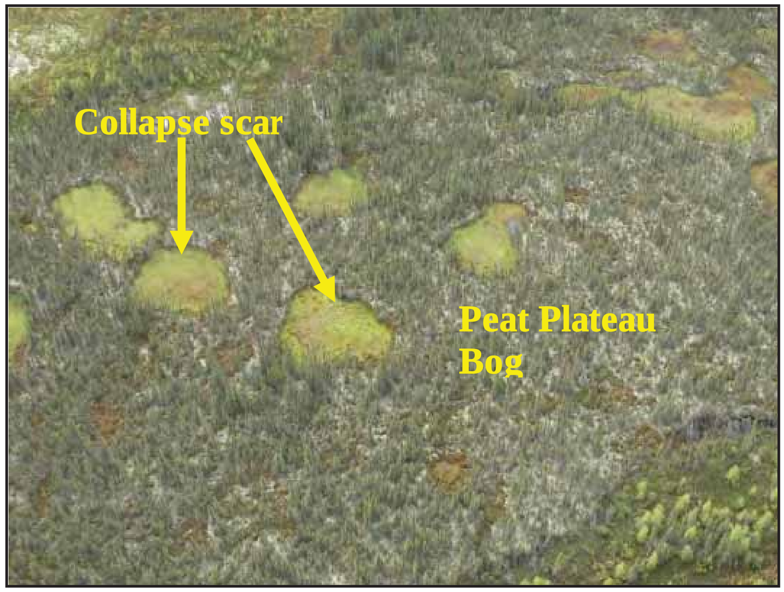
<table>
<tr><td colspan="2">Shallow Peatland Coarse Ecosite Type
Sites with a surface organic layer greater than 20 cm and less than 200 cm thick.</td></tr>
<tr><td>Blanket Bog Fine Ecosite Type:

Peatlands with a surface organic layer between 100 cm and 200 cm thick. Discontinuous ground ice permafrost present. Occurring on flat topography.</td><td></td></tr>
</table>

Figure 2-9: Example and Description of the Shallow Peatland Coarse Ecosite Type

<table>
<tr><th colspan="2">Ground Ice Peatland Coarse Ecosite Type
Sites with organic layers greater than 20 cm thick and either continuous or patchy ground ice at least one meter thick.</th></tr>
<tr><td>Peat Plateau Bog/Collapse Scar Mosaic Fine Ecosite Type:

A mixture of peat plateau bogs and small collapse scar peatlands. Peat plateaus are elevated relative to collapse scars and have distinct banks formed by continuous ground ice cores.

Collapse scar bogs or fens are depressed features formed when ground ice melts and the surface peat collapses. Larger features (>500m^2) are classified under the Wet Peatland Coarse Type.</td><td>


</td></tr>
<tr><td>Side view of a peat plateau bog</td><td>

</td></tr>
</table>

Figure 2-10: Example and Description of the Peat Plateau Bog/Collapse Scar Mosaic Fine Ecosite Type Included in the Ground Ice Peatland Coarse Ecosite Type

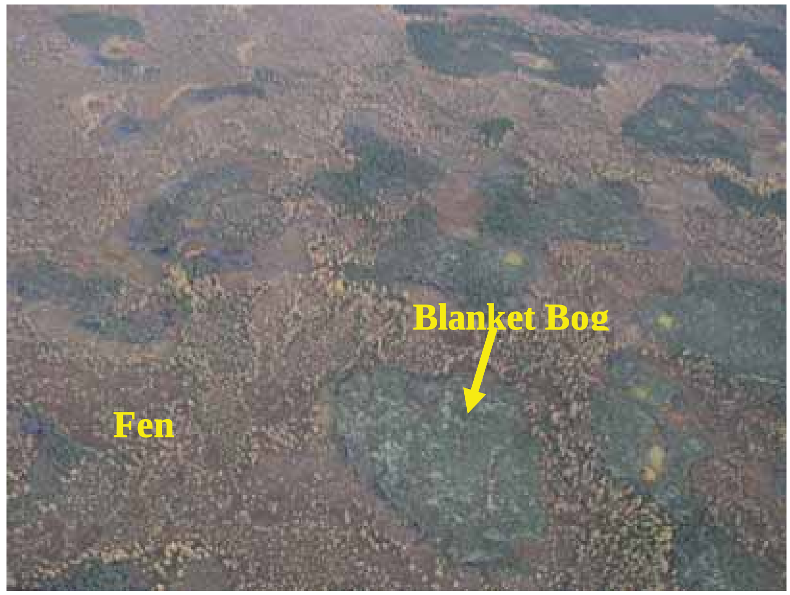
Ground Ice Peatland Coarse Ecosite Type Sites with organic layers greater than 20 cm thick and either continuous or patchy ground ice at least one meter thick.	
Peat Plateau Bog Transitional Fine Ecosite Type: Peatlands where thick ground ice is obviously either forming or melting.	

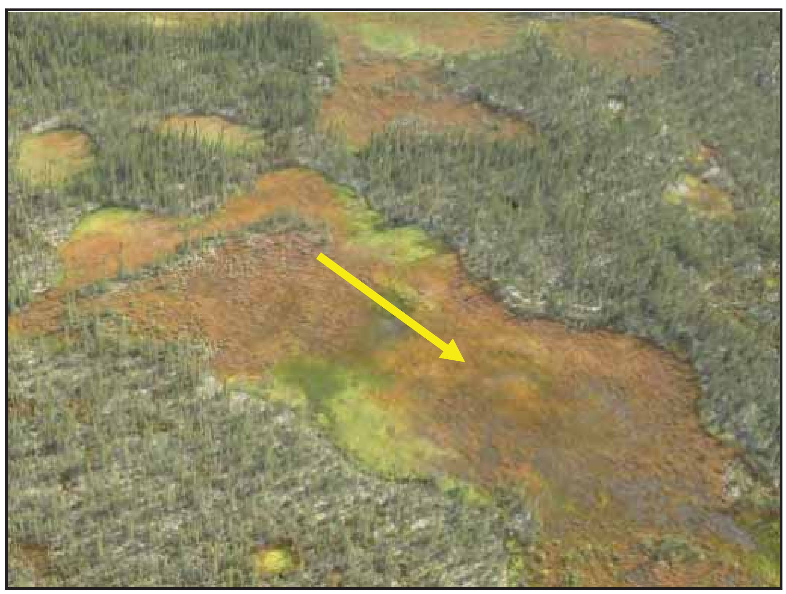
Figure 2-11: Example and Description of the Peat Plateau Bog Transitional Fine Ecosite Type Included in the Ground Ice Peatland Coarse Ecosite Type

<table>
<tr><th colspan="2">Wet Peatland Coarse Ecosite Type</th></tr>
<tr><td colspan="2"><u>Other Permafrost Peatland Broad Ecosite Types:</u>

Sites with organic layer ≥ 20 cm with evidence of excess ice actively forming or melting. Hummocky surface due to patchy excess ice.</td></tr>
<tr><td>Other Permafrost Peatland Broad Ecosite Type:

Horizontal Fen/Blanket Bog Mosaic Fine Ecosite Type:

A mixture of horizontal fens and blanket bogs.</td><td>
</td></tr>
<tr><td>Collapse Scar Bog or Fen Fine Ecosite Type.

Depressed features formed in peat plateau bogs when ground ice melts and the surface peat collapses</td><td></td></tr>
<tr><td colspan="2"><u>Deep Peatlands Broad Ecosite Type:</u>

Sites in depressional areas with sparse tree cover. Surface organic layer is greater than 20 cm thick.</td></tr>
</table>

Horizontal Fen Fine Ecosite Type: Sites typically have buried water layers, occasionally with small **pool**s at the surface. Sparse tree cover is primarily tamarack.	
Wet Deep Peatlands Broad Ecosite Types: Sites with organic layers greater than 200 cm. The surface is level and featureless, and the peatland is not confined and isolated by mineral or bedrock terrain.	
String Fen Fine Ecosite Type: Sites with a pattern of peat ridges and water-filled depressions. Direction of water flow is perpendicular to the peat ridges.	

Figure 2-12: Example and Description of the Wet Peatland Coarse Ecosite Type

<table>
<tr><th colspan="2">Riparian Peatlands Coarse Ecosite Types</th></tr>
<tr><td colspan="2">Peatlands occurring along lakes or waterways, with open water present. Edge of peatland along water is usually floating.</td></tr>
<tr><td>Riparian Fen Fine Ecosite Type:

These riparian peatlands are not landlocked. The water is nutrient-enriched by runoff from adjacent land areas and/or the stream flow.</td><td></td></tr>
</table>

Figure 2-13: Example and Description of the Riparian Peatland Coarse Ecosite Type

<table>
<tr><td colspan="2">Nelson River Shoreline Wetland Coarse Ecosite Types:

Wetlands occurring either along the shorelines of the Nelson River where the water is less than 1.5 m deep.</td></tr>
<tr><td colspan="2"><u>Nelson River Upper Beach, Sunken Peat and Lower Beach Broad Ecosite Types</u></td></tr>
<tr><td>Upper Beach Fine Ecosite Type:

Shore zone wet meadows occurring along the main body of lakes and the Nelson River. Gentle to steep slopes. Under water less than half of the growing season days over the past five years.</td><td></td></tr>
<tr><td>Upper Beach on Sunken, Disintegrated Peatland Fine Ecosite Type:

Shore zone wet meadows occurring on sunken, disintegrated peatlands, such as disintegrating peat plateau bogs. Usually associated with recently flooded and expanding zones of Stephens Lake. Under water less than half of the growing season days over the past five years.</td><td></td></tr>
</table>

<table>
<tr><th colspan="2">Nelson River Shoreline Wetland Coarse Ecosite Types:

Wetlands occurring either along the shorelines of the Nelson River where the water is less than 1.5 m deep.</th></tr>
<tr><td>Lower Beach Fine Ecosite Type:

Portions of shore zone wet meadows that are under water for more than half of the growing season days over the past five years. Usually occurring in sheltered bays along Nelson River. May support emergent vegetation, but not native marsh due to water regulation.</td><td></td></tr>
</table>

Figure 2-14: Examples and Descriptions of the Nelson River Shoreline Wetland Coarse and Fine Ecosite Types

<table>
<tr><td colspan="2">Off-System Shoreline Wetland Coarse Ecosite Types:

Wetlands occurring either along the shorelines of lakes or waterways or as offshore islands where the water is less than 2.0 m deep.</td></tr>
<tr><td colspan="2"><u>Off-System Upper Beach, Lower Beach and Littoral Broad Ecosite Types</u></td></tr>
<tr><td>Upper Beach on Sunken Peat Fine Ecosite Type:

Sunken margins of floating peatlands along waterways and lake shores that are under water less than half of the growing season days over the past five years.</td><td></td></tr>
<tr><td><u>Lower Beach Fine Ecosite Type</u>:

Portions of shore zone wet meadows that are under water for more than half of the growing season days over the past five years.</td><td></td></tr>
</table>

Off-System Shoreline Wetland Coarse Ecosite Types:

Wetlands occurring either along the shorelines of lakes or waterways or as offshore islands where the water is less than 2.0 m deep.

Littoral Fine Ecosite Type:

Rarely exposed sites in the shallow water zone of water bodies sometimes supporting emergent and floating-leaved vegetation.

Figure 2-15: Examples and Descriptions of the Off-System Shoreline Wetland Coarse and Fine Ecosite Types

2.3.4.1.3 Habitat Abundance and Distribution

Study Zone 4

Land accounted for 76% of total Study Zone 4 area in 2010 (Table 2-2). The Nelson River comprised 47,655 ha of the 54,254 ha of water area with the remaining area distributed amongst waterways, ponds and 185 waterbodies larger than five ha.

Land Cover

Land cover in Study Zone 4 was dominated by open to dense needleleaf treed vegetation on uplands and inland peatlands (Table 2-7; Map 2-8). The needleleaf treed vegetation on mineral or thin peatlands and on other peatlands land cover types accounted for 43% and 36% of Study Zone 4 land area, respectively (Table 2-7). Broadleaf treed land cover comprised 1% of the land area. Tall shrub and low vegetation on uplands and peatlands covered approximately 16% of the land area. Shore zone, which only includes vegetated coarse habitat types, covered less than 1% of the land area. Human infrastructure accounted for 2% of the land area. Approximately 0.5% of the land area was not classified to a land cover or habitat type because there was insufficient information to classify vegetation type.

Coarse Habitat Abundance and Distribution

The needleleaf treed vegetation on mineral or thin peatlands land cover type included several black spruce and jack pine treed or mixedwood coarse habitat types (Table 2-8). Black spruce treed on thin peatland, the most abundant of these coarse habitat types, was also the most abundant coarse habitat type overall. Jack pine treed and jack pine mixedwood covered only 2% of land area. Although needleleaf treed vegetation was widely distributed, the mineral ecosite coarse habitat types tended to be more abundant near the Nelson River and along the north esker, as well as around Ferris Bay (Map 2-9).

Included in the needleleaf treed vegetation on other peatlands land cover type was a variety of black spruce, jack pine and tamarack (*Larix laricina*) coarse habitat types (Table 2-8). Black spruce treed on shallow peatland was the most abundant shallow peatland type by far, covering nearly an equal area as on thin peatland. Jack pine treed on shallow peatland was rare (0.1% of land area), and concentrated in areas that were recently burned. Black spruce and tamarack coarse habitat types made up most of the remaining area, of which black spruce treed on wet peatland was the most abundant at 2.1% of land area. Shallow peatland habitat was widely distributed throughout Study Zone 4, but wet peatlands were scattered in smaller patches in depressions and low flat areas (Map 2-9).

Broadleaf treed land cover captured a relatively even mixture of broadleaf dominant and broadleaf mixedwood coarse habitats. Trembling aspen was the most abundant vegetation type, followed by white birch (*Betula papyrifera*) (Note that white birch was somewhat more abundant than the habitat mapping suggests, as it frequently occurred as scattered individuals too sparse to map in upland stands). Broadleaf treed habitat generally occurred in the infrequent areas where conditions are favourable, such as mineral and thin peatland ecosite types and, infrequently, in richer riparian areas such as on slope fens (Map 2-6). As a result, broadleaf treed land cover tended to be more abundant near the Nelson River and along the north esker (Map 2-9). The higher proportion of mineral surface materials in Study Zone 2 compared with Study Zone 4 (Table 2-5), was associated with a higher proportion of broadleaf treed cover.

Tall shrub vegetation on mineral or thin peatland land cover consisted of only one coarse habitat type, comprising only 0.2% of Study Zone 4 land area (Table 2-7). This coarse habitat type most often occurred as early regenerating vegetation on recently burned thin peatlands. Subsequently, the largest areas were distributed in the recent burns north of Gull Lake (Map 2-9).

Tall shrub on other peatlands land cover was a mixture of tall shrub on shallow peatland and tall shrub on wet peatland, making up only 0.5% of the Study Zone 4 land area combined (Table 2-7). The more common tall shrub on shallow peatland type was usually associated with either recently burned shallow peatlands as early regeneration, or slope bogs in runnels and disintegrating peat plateau bogs. Due to the former case, many of the larger areas were located in the recently burned area north of Gull Lake (Map 2-9). Tall shrub on wet peatlands were scattered throughout Study Zone 4, usually in horizontal fens.

Low vegetation on mineral or thin peatlands consisted of only one habitat type, comprising 4.5% of the Study Zone 4 land area (Table 2-7). Most of this area is associated with poorly regenerating burns on thin peatlands, while most of the remaining area is associated with cutlines, and other human features. As a result, this coarse habitat type tends to be distributed in large concentrated areas that correspond with more recent burns (see Map 2-9 and Map 2-16 for a comparison of poorly regenerating burned areas).

Low vegetation on other peatlands covered 8.4% of Study Zone 4 land area, and was mostly comprised of the low vegetation on shallow peatland coarse habitat type (6.8%), with low vegetation on wet peatland making up the remaining area (Table 2-7). As with tall shrub on shallow peatlands, most of the low vegetation on shallow peatlands was associated with poorly regenerating recently burned areas, with much of the remaining area in disintegrating peat plateau bogs. The distribution of this habitat is similar to that of low vegetation on mineral or thin peatland (Map 2-9). Low vegetation on wet peatland was scattered throughout Study Zone 4 in horizontal fens and collapse scar peatlands.

Shrub and low vegetation on riparian peatland land cover comprised 2.4% of the Study Zone 4 land area (Table 2-7). Low vegetation was the more common vegetation type (1.8%). These coarse habitat types occurred in riparian fens along lake shores and waterways throughout Study Zone 4 (Map 2-1). They are also scattered in sheltered bays and at stream outlets along the Nelson River. Low vegetation on riparian peatland frequently forms wide areas along waterways and lakes surrounded by floating peatlands.

Human infrastructure such as PR 280, other roads, borrow areas, rail lines, transmission line rights-of way, towns and communities accounted for 2% of the land area. These features were concentrated around Stephens Lake, particularly within and surrounding the town of Gillam and on the esker north of Gull **Rapids** (Map 2-9).

Shore zone land cover included shrub and/or low vegetation on ice scoured upland, on upper beach and on sunken peat, as well as Nelson River and off-system marsh wetland coarse habitat types. Shoreline wetlands with vegetation patches large enough to map were rare in Study Zone 4 (0.9% of land area; Table 2-7). Although Nelson River shrub and/or low vegetation on upper beach was the most abundant shore zone coarse habitat type, it only covered 0.6% of land area.

The nature of shore zone habitat in the Nelson River off-system waterbodies was considerably different, presumably due to the substantial differences in water and ice regimes (see PE SV Section 4 for Nelson River water and ice regimes). During the study period, the vegetated upper beach and vegetated ice scour upland habitat types were only observed on the Nelson River while virtually all of the littoral and lower beach marsh was in off-system waterbodies (Map 2-9). Additionally, the Nelson River upper beach peatlands were periodically flooded while those in off-system waterbodies appeared to float up and down with water fluctuations.

On the Nelson River, shrub and/or low vegetation on upper beach was the most abundant of the shore zone coarse types (0.6% of the land area). Nelson River marsh was virtually absent, comprising 15 ha of the 1,585 ha of Nelson River vegetated shore zone habitat. Vegetation in the Nelson River shrub/low vegetation on upper beach coarse habitat type was dominated either by tall shrubs or low vegetation mixed in with graminoids, with the characteristic plant species being different in the Keeyask and Stephens Lake reaches of the Nelson River. For the tall shrub vegetation types, flat-leaved willow (*Salix planifolia*) and marsh reed-grass (*Calamagrostis canadensis*) occurred throughout the Nelson River, while bog billberry (*Vaccinium uliginosum*) and sweet gale (*Myrica gale*) cover occurred only in the Stephens Reach. For the low vegetation types, the vegetation cover commonly consisted of silverweed (*Argentina anserina*) and marsh reed grass in the Keeyask reach, while common horsetail (*Equisetum arvense*), marsh -five-finger (*Comarum palustre*) and sedges (*Carex* spp.) were more common in the Stephens Lake reach.

Shoreline wetlands in off-system waterbodies were predominantly marshes occurring within shallow lacustrine environments and along the sunken margins of floating peatlands. Off-system littoral or lower beach marsh on mineral substrates tended to be dominated by either viscid great-bulrush (*Schoenoplectus tabernaemontani*) or creeping spike-rush (*Eleocharis palustris*) and spiked water-milfoil (*Myriophyllum sibiricum*). Water horsetail (Equisetum fluviatile) occurred in shallower water on organic and mineral substrates, while floating-leaved species such as small yellow pond-lily (*Nuphar variegata*) and narrow-leaved bur-reed (*Sparganium angustifolium*) often occurred in deeper water. Nelson River littoral or lower beach marsh was dominated by water horsetail.

The terrestrial plants section (Section 3) lists species that typically grow in each water depth duration zone.

Wetlands and shore zone habitat are further described in the wetland function section (Section 2.8).

Nearly one quarter of the land cover in Zone 4 has burned at least once in the past 50 years. Approximately 7% of Study Zone 4 burned recently (between the beginning of 2002 and end of 2011), and is currently composed of young regenerating vegetation. Habitat has regenerated in most of the areas burned prior to 2002. Some of the habitat that burned prior to 2002 was regenerating slowly, and had not yet recovered mappable tree cover remaining as low vegetation or tall shrub cover in some areas. Poorly regenerating areas were usually found on thin, shallow, and ground ice peatland. Much of the poorly regenerating habitat corresponded to the 1999 and 2001 fires north of Gull Lake, and to older fires that occurred east of Split Lake, south of Stephens Lake, and adjacent to PR 280 near the proposed north access road.

Because of frequent large fires (Section 2.5.3.2), approximately one-quarter of the inland terrestrial habitat in the Study Zone 4 was less than 30 years old in 2010. Most of the mature forest in Study Zone 2 was approximately 70 years old.

Study Zone 2

Land accounted for 70% of Study Zone 2 total area in 2010 (Table 2-2). The Nelson River comprised 5,143 ha of the 5,418 ha of water area with the remaining area distributed amongst waterways, ponds and 19 waterbodies larger than five ha.

Compared with Study Zone 4, Study Zone 2 had higher proportions of broadleaf treed vegetation on all ecosites, jack pine treed on mineral or thin peatland and tall shrub vegetation on riparian peatlands (Table 2-7; Map 2-8). Conversely, there was a lower proportion of needleleaf treed on other peatlands, especially on shallow peatland. Broadleaf treed vegetation was concentrated adjacent and near to the Nelson River and regenerating in the recent burns on the esker, as were tall shrub on other peatlands.

Less common coarse habitat types that were more abundant in Study Zone 2 included broadleaf treed and broadleaf mixedwood on all ecosites, jack pine treed on mineral or thin peatland and tall shrub on wet peatlands. Nevertheless, they still comprised a small percentage of the coarse habitat types. Black spruce treed on shallow peatland was more abundant outside of Study Zone 2, but this was primarily due to the impact of the fires occurring in the past 12 years north and south of Gull Lake.

Due to the presence of the Nelson River, shore zone habitat types were proportionately more abundant in Study Zone 2, increasing to a total of 3.1%. The proportion of shrub/ low vegetation on ice scour and on upper beach coarse habitat types were higher in Study Zone 2, nearly 1% and 1.4%, respectively. This was primarily because of the higher relative proportion of Nelson River shoreline in this area. Overall, the wetland habitat composition is similar to that of Zone 4 (Table 2-8).

Table 2-7: Land Cover Composition of the Study Areas, as a Percentage of Land Area

Land Cover Type	**Study Zone 4**	**Study Zone 2**
Mineral and Thin Peatland Land Types		
Broadleaf Treed on All Ecosites	1.1	2.6
Needleleaf Treed on Mineral or Thin Peatland	43.2	47.3
Tall Shrub on Mineral or Thin Peatland	0.2	0.6
Low Vegetation on Mineral or Thin Peatland	4.5	3.6
Other Peatlands Land Type		
Needleleaf Treed on Other Peatlands	36.5	26.1
Shrub/Low Vegetation on Riparian Peatland	2.4	3.5
Tall Shrub on Other Peatlands	0.5	0.5
Low Vegetation on Other Peatlands	8.4	6.6
Shore Zone Land Types		
Nelson River Shore Zone	0.8	3.1
Off-system Shore Zone	0.1	0.1
Other Land Types		
Human Infrastructure	2.0	6.1
Unclassified	0.5	0.0
All	100.0	100.0
Total Land Area (ha)	*167,255*	*13,043*

Note: Cells with 0 values are values that round to 0, while “-“ cells indicate a value of 0. Reported areas are land area only.

Table 2-8: Coarse Habitat Composition of Study Zones 4 and 2, as a Percentage of Total Land Area

Land Cover	Coarse Habitat Type	Study Zone 4	Study Zone 2
Mineral and Thin Peatland Types			
Broadleaf Treed on All Ecosites	Broadleaf treed on all ecosites	0.6	1.4
	Broadleaf mixedwood on all ecosites	0.5	1.2
Needleleaf Treed on Mineral or Thin Peatland	Black spruce mixedwood on mineral or thin peatland	0.3	0.3
	Jack pine mixedwood on mineral or thin peatland	0.3	0.5
	Jack pine treed on mineral or thin peatland	1.8	3.1
	Black spruce treed on mineral soil	8.2	12.0
	Black spruce treed on thin peatland	32.6	31.3
Tall Shrub on Mineral or Thin Peatland	Tall Shrub on Mineral or Thin Peatland	0.2	0.6
Low Vegetation on Mineral or Thin Peatland	Low Vegetation on Mineral or Thin Peatland	4.5	3.6
Other Peatland Types			
Needleleaf Treed on Other Peatlands	Jack pine treed on shallow peatland	0.1	0.2
	Black spruce mixedwood on shallow peatland	0.0	0.0
	Black spruce treed on shallow peatland	32.2	23.6
	Black spruce treed on wet peatland	2.1	0.9
	Tamarack- black spruce mixture on wet peatland	0.9	0.3
	Tamarack treed on shallow peatland	0.4	0.7
	Tamarack treed on wet peatland	0.2	0.0
	Black spruce treed on riparian peatland	0.7	0.4
	Tamarack- black spruce mixture on riparian peatland	0.0	0.0
	Tamarack treed on riparian peatland	0.0	-
Tall Shrub on Other Peatlands	Tall Shrub on Shallow Peatland	0.3	0.3
	Tall Shrub on Wet Peatland	0.1	0.3
Low Vegetation on Other	Low Vegetation on Shallow Peatland	6.8	5.4

Table 2-8: Coarse Habitat Composition of Study Zones 4 and 2, as a Percentage of Total Land Area

Land Cover	**Coarse Habitat Type**	**Study Zone 4**	**Study Zone 2**
Peatlands	Low Vegetation on Wet Peatland	1.5	1.1
Shrub/Low Vegetation on Riparian Peatland	Tall shrub on riparian peatland	0.6	1.8
	Low vegetation on riparian peatland	1.8	1.7
Shore Zone Types			
Nelson River Shore Zone	Nelson River shrub and/or low vegetation on ice scoured upland	0.1	0.9
	Nelson River shrub and/or low vegetation on upper beach	0.6	1.4
	Nelson River shrub and/or low vegetation on sunken peat	0.1	0.6
	Nelson River marsh	0.0	0.1
Off-system Shore Zone	Off-system marsh	0.1	0.1
Other Land Cover Types			
Human Infrastructure		2.0	6.1
Unclassified		0.5	0.0
All		100.0	100.0
Total Land Area (ha)		*167,255*	*13,043*

Note: Cells with 0 values are values that round to 0, while "-" cells indicate a value of 0. Reported areas are land area only.

2.3.4.2 Coarse Habitat Type Descriptions

This section provides brief characterizations of the most common coarse habitat types occurring in the Study Zone 4 (Map 2-9 includes aerial photo examples of selected coarse habitat types). These characterizations are followed by a fact sheet for each of the coarse habitat types (Figure 2-16 to Figure 2-35). The fact sheets are ordered from structurally diverse upland to structurally simple wetland. It should be noted that some stands may have a very different composition than described in the fact sheets because the descriptions represent typical conditions. Between stand variability within a habitat type results from natural variability, and small sample size for a few habitat types.

The black spruce on mineral soil or thin peatland coarse habitat types typically occurred on sloped or elevated well drained mineral deposits. The surface organic layer thickness was 23 cm on average but highly variable, and was derived from peat mosses (*Sphagnum* spp.) and feathermosses. The vegetation was characterized by a black spruce dominated overstorey with occasional tamarack on moister sites and occasional jack pine, white birch and/or trembling aspen on drier sites. Green alder (*Alnus viridis* ssp. *crispa*) usually occurred in the tall shrub layer, often accompanied by willows (*Salix* spp.). Typical species in the lower understorey were Labrador tea (*Rhododendron groenlandicum*), rock cranberry (*Vaccinium vitis-idaea*), Schreber's moss (*Pleurozium schreberi*), stair-step moss (*Hylocomium splendens*), knight's plume moss (*Ptilium crista-castrensis*), reindeer lichens (*Cladina* spp.) and cup lichens (*Cladonia* spp.). Reindeer lichen cover was more abundant in the northern portion of the Study Zone 5 where the tree canopy was more open (CNP Keeyask Environmental Evaluation Report).

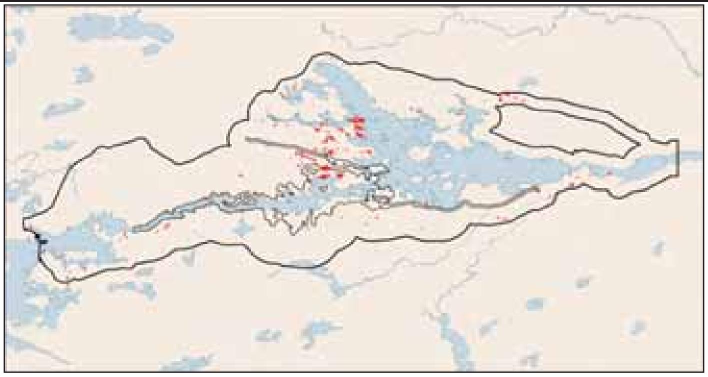
The black spruce on shallow peatlands coarse habitat type typically occurred on flat to gently sloping areas with very moist or poorly drained peatlands. The surface organic layer thickness was highly variable, averaging 71 cm, and was derived from peat mosses. Compared with black spruce on mineral soil or thin peatlands habitat type, the vegetation generally had a shorter, more open overstorey and tall shrubs were scarce. The lower understorey layer had more small cranberry (*Vaccinium oxycoccos*), reindeer lichen, peat mosses and feathermosses.

As noted in Section 2.3.2.2, shoreline wetlands types are related to water depth zones. Based on the 212 shoreline wetland transect locations that were sampled, water horsetail and viscid great bulrush were the most common broad habitat types in the littoral water depth zone of off-system waterbodies, followed by small yellow pond-lily and creeping spike-rush. Water horsetail was the only shallow water broad habitat type found in the Nelson River and most of its area was located in the Keeyask reach. The water horsetail and viscid great bulrush habitat types were emergent, or marsh, habitat types. The water horsetail habitat type usually occurred on mineral substrates with bottle sedge (*Carex utriculata*) and water smartweed (*Persicaria amphibia*) in the Nelson River and on organic substrates with narrow-leaved bur-reed and small yellow pond-lily in the off-system waterbodies. The viscid great bulrush habitat type, which included viscid great bulrush as its sole characteristic species, was associated with fine mineral substrates.

In the lower beach water depth zone, small bedstraw (*Galium trifidum*)/creeping spike-rush/water smartweed was the most common habitat type, followed by the bottle sedge/bladderwort type (*Utricularia* spp.). The small bedstraw/creeping spike-rush/water smartweed habitat type was the most common lower to middle beach habitat type in the Nelson River but was not found in the off-system lakes. It primarily occurred on organic substrates and often included water parsnip (*Sium suave*), smooth beggar-ticks (*Bidens cernua*) and water sedge (*Carex aquatilis*). In contrast, the bottle sedge/bladderwort (*Utricularia* spp.) habitat type was one of the most common in the off-system lakes but was not found in the Nelson River. It typically occurred on organic substrates and often included marsh reed-grass and water horsetail.

In the upper beach and inland edge water depth zone, flat-leaved willow/marsh reed-grass was the most common habitat type, followed by the water sedge/marsh reed grass and silverweed/narrow reed-grass (*Calamagrostis stricta* ssp. *stricta*) types. The former two habitat types were encountered in both the Nelson River and off-system waterbodies, while the latter was only found in the Nelson River. The flat-leaved willow/marsh reed-grass habitat type typically occurred on organic substrates and often included peat moss, common horsetail, three-leaved Solomon's-seal (*Maianthemum trifolium*), dewberry (*Rubus pubescens*) and water sedge. Bog bilberry also occurred in the Nelson River occurrences of this habitat type.

The Nelson River vegetated ice scoured upland coarse habitat type supported a mixture of shrub and low vegetation that was scoured by moving ice in areas of strong current along the Nelson River banks (PE SV Section 4.3.1.3).



Zone 4 Distribution

A regionally rare coarse habitat type (0.6% of land area).

Scattered stands, more frequent nearer the Nelson River banks and along eskers.

Characteristic Site Conditions

Upland flat terrain, ridges and upper slopes with moderately well drained mineral sites.

Thin organic substrate averages six cm, mostly derived from **LFH**.

Mineral soil varied in texture from **sand**y to clayey, and formed on a range of deposit types. Range of pH, neutral to ~5.
Total B-horizon organic carbon ~0.6%
Total B-horizon combustible nitrogen ~0.06%
Available B-horizon phosphorus/potassium ~ 148/<10 mg/kg

Aerial View

Characteristic Vegetation Composition

Structure: Forest and woodland stand types, often closed canopies 13 m – 18 m tall.

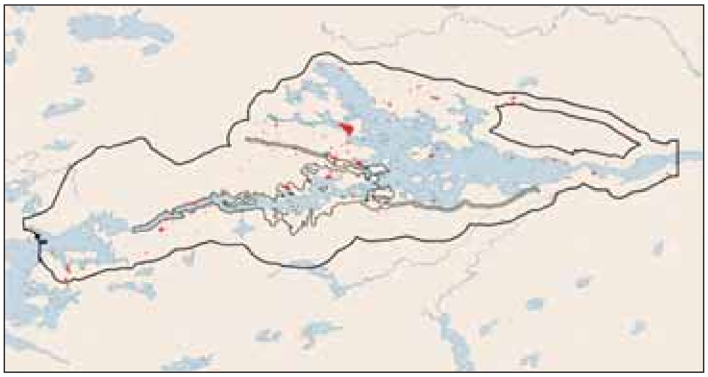
Canopy composition: Trembling aspen or white birch dominated, some black spruce or jack pine may occur. Understorey trees and seedlings dominated by black spruce.

Tall shrubs: Usually dense, dominated by green alder.

Understorey: Often rich with low shrubs including prickly rose, rock cranberry, and Labrador tea; herbs including bunchberry and twinflower, and mosses.

Ground View

Figure 2-16: Broadleaf Treed on All Ecosites Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally rare coarse habitat type (0.5% of land area).

Scattered stands, more frequent nearer the Nelson River banks and along eskers.

Characteristic Site Conditions

Upland flat terrain, ridges and slopes.

Moderately well to well drained mineral sites.

Thin organic layer averages five cm, mostly derived from LFH.

Mineral soils with a range of textures developed on glaciofluvial and glaciolacustrine mineral deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Forest and woodland stand types, often closed canopies 14 m – 19 m tall.

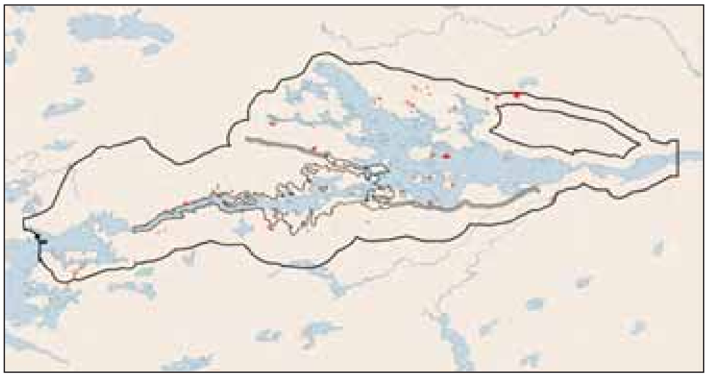
Canopy composition: White birch or trembling aspen mixed with jack pine or black spruce. Understorey trees are often a mixture of black spruce, white birch or trembling aspen.

Tall shrubs: Green alder, denser on fresh sites, sparser on drier sites.

Understorey: Often rich with low shrubs including prickly rose and rock cranberry; herbs including bunchberry and twinflower; and mosses with feather-mosses more widespread on drier sites.

Ground View

Figure 2-17: Broadleaf Mixedwood on All Ecosites Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally rare coarse habitat type (0.3% of land area).

Scattered stands, more frequent nearer the Nelson River banks and on islands in the south of Stephens Lake.

Characteristic Site Conditions

Upland flat terrain, ridges and slopes.

Mineral ecosites and some thin peatlands.

Variable organic substrate thickness, 14 cm deep on average.

Range of mineral textures, silty to clayey, derived from glaciofluvial and lacustrine deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Forest and woodland stand types, often closed canopies 8 m – 14 m tall.

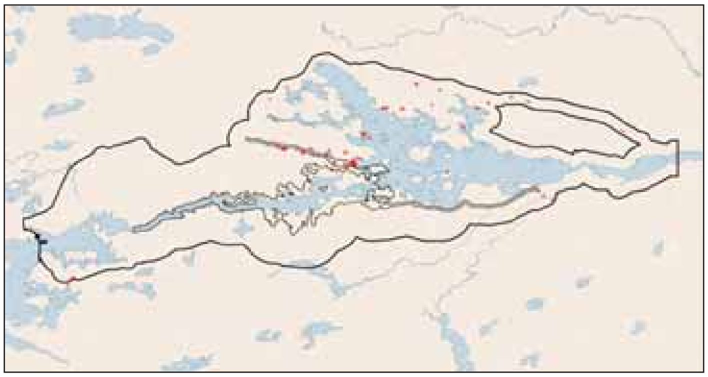
Canopy composition: Black spruce mixed with trembling aspen, sometimes with tamarack. Occasionally white spruce may be present. Understorey trees mostly black spruce, occasionally with hardwoods and tamarack.

Tall shrubs: Often dense green alder, some speckled alder, willow, buffaloberry and or bog birch may be present.

Understorey: Often rich in species, composed primarily of low shrubs including rock cranberry and Labrador tea, herbs including palmate-leaved coltsfoot and twinflower, and feathermosses.

Ground View

Figure 2-18: Black Spruce Mixedwood on Mineral or Thin Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally rare coarse habitat type (0.3% of land area).

Scattered stands, more frequent along eskers and nearer the Nelson River banks.

Characteristic Site Conditions

Upland flat terrain, ridges and upper slopes.

Fresh, moderately well drained mineral sites.

Thin organic layer averages seven cm mostly derived from mosses, including a thin LFH layer.

Mineral soil textures vary, but are often sandy, derived from glaciofluvial and glaciolacustrine mineral deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Sparsely treed to forest stand types, with open to closed canopies 13 m – 18 m tall.

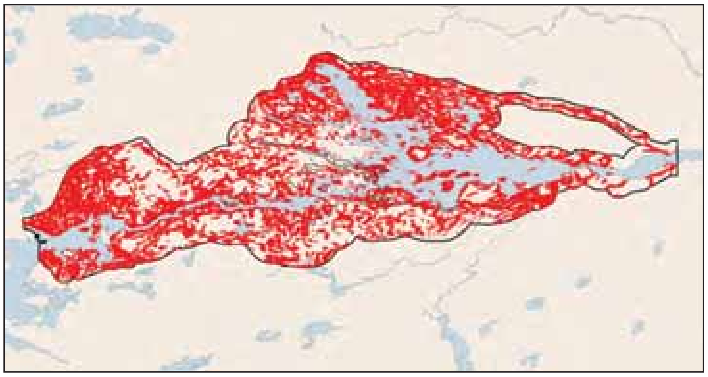
Canopy composition: Jack pine mixed with trembling aspen or white birch and black spruce. Understorey trees are usually black spruce.

Tall shrubs: Usually dense, dominated by green alder.

Understorey: Abundant low shrubs including rock cranberry, Labrador tea and velvet-leaf blueberry; herbs including bunchberry, twinflower and fireweed; and abundant feather-mosses.

Ground View

Figure 2-19: Jack Pine Mixedwood on Mineral or Thin Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

The most common coarse habitat types (41.6% of land area).

Widespread throughout the Study Zone 4.

Characteristic Site Conditions

Upland flat and sloping terrain, with moderately moist, imperfectly drained thin peatlands and fresher, well drained mineral sites.

Organic layer varies in thickness averaging 23 cm (lower on mineral, and higher on thin peatland), and is derived from mosses.

Organic deposits are derived from sphagnum or forest peat. Mineral soils vary in texture and are derived from a range of glacial deposit types. Upper horizon (A and B) soils average: 64% sand, 21% silt, 15% clay.
pH range from 5.4 – 7.3
Total organic carbon ~0.9%
Total combustible nitrogen ~0.06%
Available phosphorus/potassium ~ 62/<10 mg/kg

Aerial View

Characteristic Vegetation Composition

Structure: Sparsely treed to woodland stand types, with open to partially closed canopies 7 m – 12 m tall.

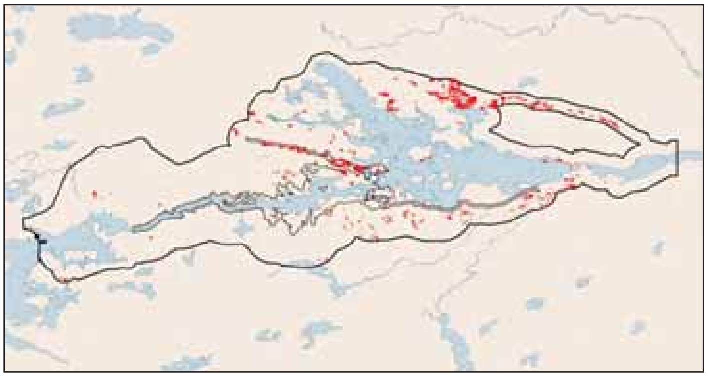
Canopy composition: Black spruce dominated, with occasional tamarack (moister) or jack pine and broadleaf (drier). Understorey trees are predominantly black spruce.

Tall shrubs: Green alder in varying densities, often with some willow. Occasionally bog birch.

Understorey: Occasionally rich, dominated by low shrubs including Labrador tea and rock cranberry; and abundant lichens and feather-mosses.

Ground View

Figure 2-20: Black Spruce Treed on Mineral Soil or on Thin Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally rare coarse habitat type (1.8% of land area).

Scattered primarily in north-central and eastern Study Zone 4. Large stands occur along north-central esker and north of Stephens Lake.

Characteristic Site Conditions

Slopes, ridges and upland flat terrain, usually with fresh, well drained mineral sites.

Thin organic layer nine cm thick on average, mostly derived from mosses, thin LFH layer may be present.

Mineral soils vary in texture but silty to sandy soils are more common with this habitat. Soils are derived from a range of glacial deposit types. Upper horizon (B) soils average:
66% sand, 24% silt, 10% clay.
pH range from 5.4 – 7.7
Total organic carbon ~2.1%
Total combustible nitrogen ~0.11%
Available phosphorus/potassium ~ 52/<10 mg/kg

Aerial View

Characteristic Vegetation Composition

Structure: Forest to sparsely treed stand types, with open to closed canopies 5 m – 16 m tall.

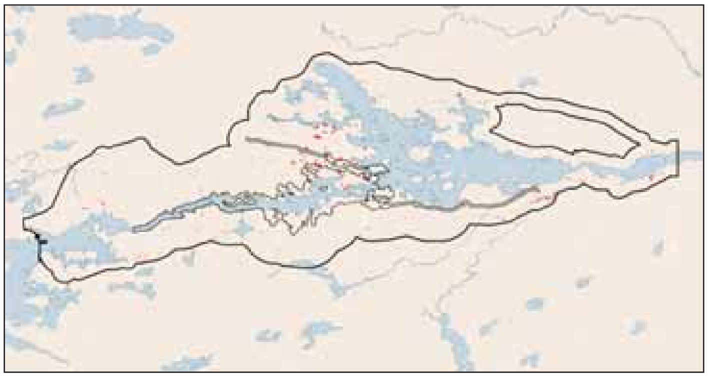
Canopy composition: Jack pine dominated, sometimes with some black spruce. Understorey trees are predominantly black spruce.

Tall shrubs: Dominated by green alder at highly variable densities.

Understorey: Often rich, dominated by low shrubs including rock cranberry, Labrador tea and prickly rose; herbs include bunchberry, twinflower and fireweed; and feather-mosses are common.

Ground View

Figure 2-21: Jack Pine Treed on Mineral or Thin Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally rare coarse habitat type (0.2% of land area).

Most widespread along the Nelson River shoreline, also scattered along inland riparian areas.

Characteristic Site Conditions

Slopes, ridges, upland flat topography adjacent to waterways, and ravines.

Occurring on thin peatlands to swampy mineral sites with very fresh, imperfectly drained regimes on average.

The organic layer is variable, 27 cm on average, usually with an LFH layer.

Mineral soils are usually silty clays, and derived primarily from lacustrine or fluvial deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed or very sparsely treed areas with dense tall shrub layer.

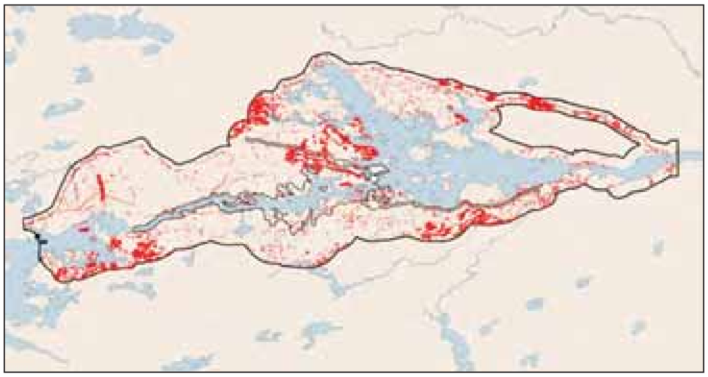
Canopy composition: Scattered stems of black spruce or white birch may be present.

Tall shrubs: Dense willow, often mixed with bog birch and speckled alder of varying densities.

Understorey: Rich in species, dominated by herbs including marsh reed grass, common horsetail and stemless raspberry. Labrador tea is widespread.=, and various moss species usually are present.

Ground View

Figure 2-22: Tall Shrub on Mineral or Thin Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally uncommon coarse habitat type (4.6% of land area).

Distributed throughout the Study Zone 4, associated with old poorly regenerating burns and cutlines.

Characteristic Site Conditions

Slopes, ridges and upland flat terrain, and river banks.

Usually on thin peatlands, occasionally on mineral sites. Variable moisture and drainage regimes.

Highly variable organic layer thickness, 30 cm on average, derived from mosses.

Mineral soil textures vary and are derived from a range of deposit types.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed areas, scattered tree stems may be present.

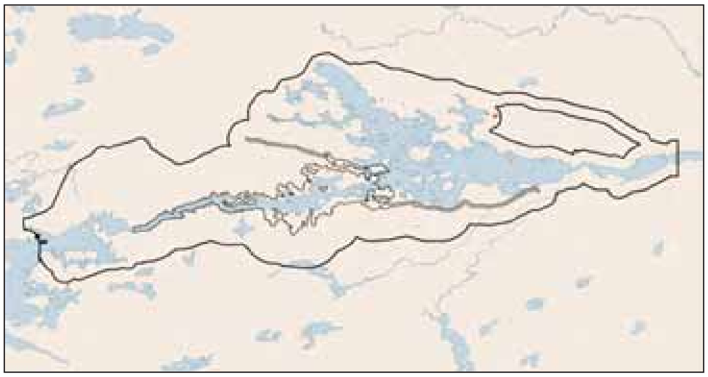
Canopy composition: Scattered seedlings or small black spruce or white birch up to three metres tall may be present.

Tall shrubs: Scarce, often may be scattered willow.

Understorey: Dominated by low shrubs such as Labrador tea; Lichens and mosses are also widespread.

Ground View

Figure 2-23: Low Vegetation on Mineral or Thin Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A rare coarse habitat type (<0.1% of land area).

A few scattered locations in the Study Zone 4 with suitable microsite conditions.

Characteristic Site Conditions

Most often located in runnels, gently sloping or flat topography on slope bog and veneer bog peatlands.

Associated with very moist, poorly drained sites on average.

The organic layer is 36 cm thick on average, mostly derived from mosses; usually with an LFH layer.

Ground ice is occasionally present at varying depths. Soils are primarily derived forest peat deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Woodland to sparsely treed areas, open to partially closed canopies, 8 m. – 11 m. tall.

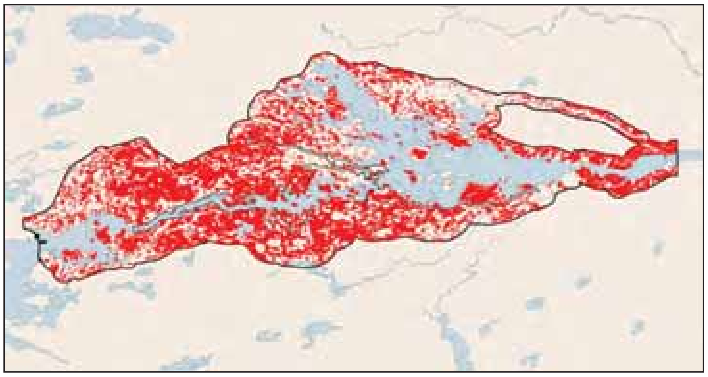
Canopy composition: Black spruce, mixed with white birch or balsam poplar. Understories dominated by black spruce, often mixed with white birch.

Tall shrubs: Often dense, with speckled alder or green alder. Usually mixed with willow, and occasionally bog birch.

Understorey: Usually rich, with widespread low shrubs including Labrador tea and rock cranberry; herbs including wood horsetail and bishop's cap; and stair-step moss.

Ground View

Figure 2-24: Black Spruce Mixedwood on Shallow Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A common coarse habitat type (32.8% of land area).

Widespread throughout the Study Zone 4.

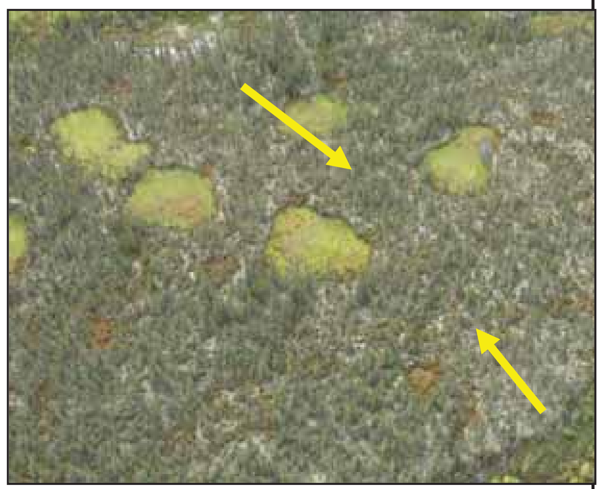
Characteristic Site Conditions

Flat to gently sloping terrain.

Very moist, poorly drained peatlands, including blanket and veneer bogs, and peat plateau bogs.

The organic layer is variable, averaging 71 cm thick, and ground ice is often present.

The organic substrate is primarily composed of fibric and **mesic** sphagnum deposits.



Aerial View

Characteristic Vegetation Composition

Structure: Sparsely treed to woodland areas, with open canopies up to eight m tall.

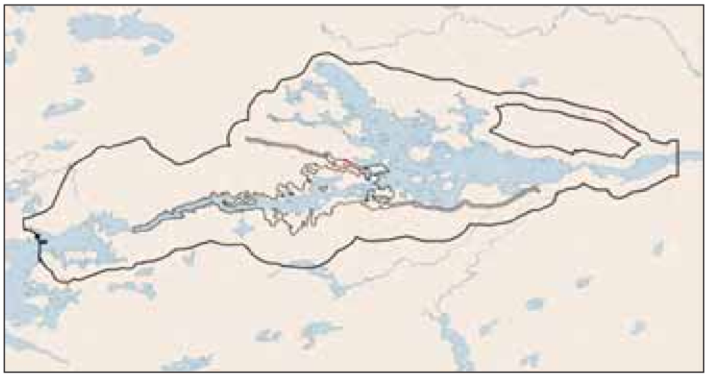
Canopy composition: Black spruce dominated. Understorey trees also black spruce.

Tall shrubs: Scarce.

Understorey: Dominated by low shrubs, including Labrador tea, rock and small cranberry; cloudberry and reindeer lichens are widespread, and sphagnum and feather-mosses comprise the remaining ground cover.

Ground View

Figure 2-25: Black Spruce Treed on Shallow Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A rare coarse habitat type (0.1% of land area).

A few scattered locations in the Study Zone 4.

Characteristic Site Conditions

Most often located on horizontal or gently sloping terrain, often adjacent to upland areas.

Moderately wet, very poorly drained peatlands, including blanket bogs.

The organic layer is greater than 20 cm, averaging 24 cm thick; primarily composed of fibric and mesic feathermoss over lacustrine deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Sparsely treed areas with short, open canopies 3 m. tall on average.

Canopy composition: Jack pine in mixture with black spruce, and occasionally tamarack. Understorey dominated by dense black spruce regeneration.

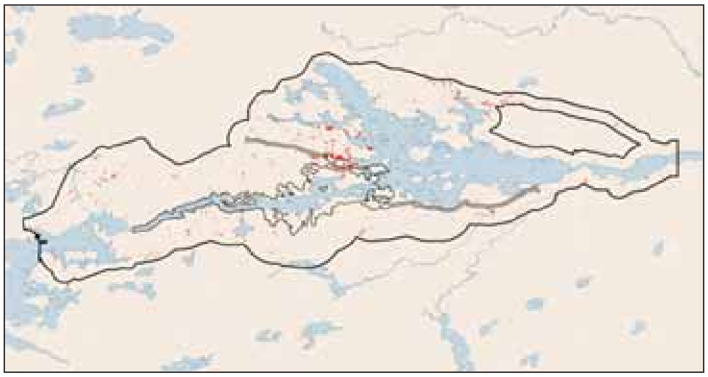
Tall shrubs: Predominantly willow and/or bog birch.

Understorey: Rich, with widespread low shrubs, including Labrador tea, bog bilberry and rock cranberry; herbs including alpine bearberry, dwarf scouring rush and sedges, as well as feather-mosses and lichens.

Ground View

* Habitat type has low plot representation. Understorey and microsite characteristics are estimated.

Figure 2-26: Jack Pine Treed on Shallow Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally rare coarse habitat type (0.3% of land area).

Distributed throughout the Study Zone 4. Often regenerating in recent burns.

Characteristic Site Conditions

Along runnels and on horizontal and depressed topography usually near waterways.

Wet, very poorly drained peatlands, including slope fens, blanket and veneer bogs.

The organic layer is variable, averaging 90 cm thick, and the water table is near the surface.

The organic substrate is composed of fibric, mesic and **humic** fen peat deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed, or very sparsely treed areas.

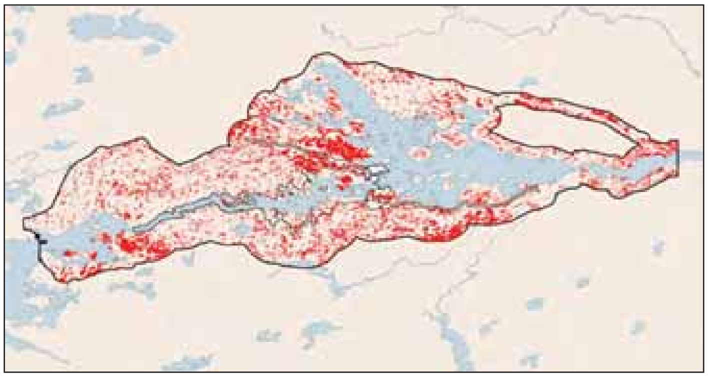
Canopy composition: Scattered tamarack, white birch or black spruce may occur.

Tall shrubs: Dense willow, speckled alder and bog birch.

Understorey: Rich, dominated by sphagnum and other mosses. Low shrubs include Labrador tea and leatherleaf; herbs include three-leaved false Solomon's-seal, sedges, swamp horsetail and marsh five-finger.

Ground View

Figure 2-27: Tall Shrub on Shallow Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally uncommon coarse habitat type (7% of land area).

Distributed throughout the Study Zone 4, often in cutlines, and forming some extensive areas corresponding to old, poorly regenerating burns.

Characteristic Site Conditions

Horizontal topography and depressions.

Wet, very poorly drained peatlands, including blanket bogs and permafrost peatlands.

The organic layer is variable, averaging 122 cm thick, often with ground ice, or a water table at variable depths.

The organic substrate is primarily composed of fibric and mesic fen peat deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed, or very sparsely treed areas.

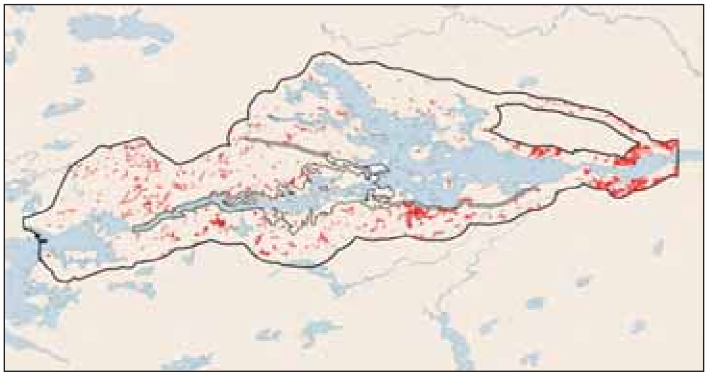
Canopy composition: Scattered black spruce may occur.

Tall shrubs: Sparse willow and bog birch.

Understorey: Low shrubs including Labrador tea; herbs including cloudberry and three-leaved false Solomon's-seal; and widespread sphagnum mosses and club lichens.

Ground View

Figure 2-28: Low Vegetation on Shallow Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally uncommon coarse habitat type (2.1% of land area).

Distributed throughout the Study Zone 4, extensive areas occur at the eastern extent and south of Stephens Lake.

Characteristic Site Conditions

Horizontal and depressed terrain and runnels.

Very moist to wet, very poorly drained horizontal and riparian fens and flat bogs.

The organic layer is variable but deep, more than 1.3 m thick on average, and the water table is often near the surface.

The organic substrate is primarily composed of fibric-dominated sphagnum, feathermoss or fen deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Sparsely treed to woodland areas, with open to partly closed, short, complex canopies; trees heights range from 3 m on poor, up to 13 m on richer sites.

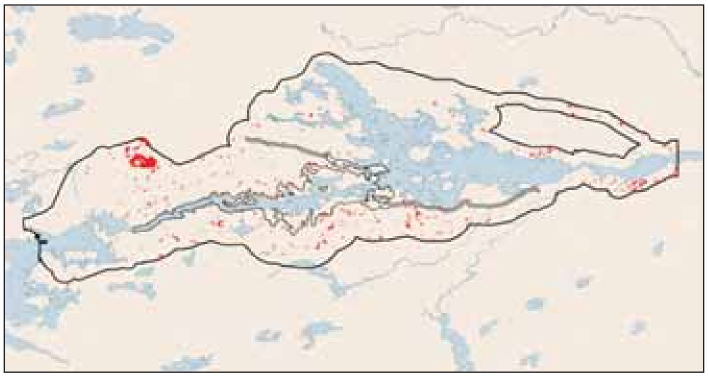
Canopy composition: Small diameter black spruce, scattered tamarack often present.

Tall shrubs: Composed of bog birch and willow in varying densities.

Understorey: Rich; low shrubs including leather-leaf, small bog cranberry, Labrador tea, rock cranberry and bog bilberry; herbs including sedges, three-leaved false Solomon's-seal, cloudberry and wood horsetail; ground cover dominated by sphagnum and other moss species.

Ground View

Figure 2-29: Black Spruce Treed on Wet Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally rare coarse habitat type (09% of land area).

Scattered throughout the Study Zone 4, one extensive area occurs near the northwest extent adjacent to PR 280.

Aerial View

Characteristic Site Conditions

Horizontal and depressed terrain.

Wet, very poorly drained horizontal and riparian fens, and flat bogs.

The organic layer is deep, 78 cm on average, water table depth is variable, often near the surface.

The organic substrate is primarily composed of fibric and mesic dominated sphagnum deposits.

Ground View

Characteristic Vegetation Composition

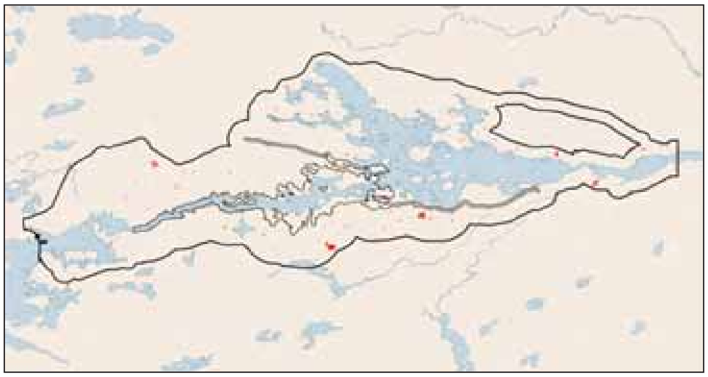
Structure: Sparsely treed areas, with open, short complex canopies and trees up to 7 m tall.

Canopy composition: Small diameter black spruce and tamarack.

Tall shrubs: Usually dense, comprised of bog birch and willow.

Understorey: Ground cover dominated by sphagnum mosses; low shrubs including leather-leaf, small bog cranberry and Labrador tea; herbs including swamp horsetail, three-leaved false Solomon's-seal and marsh-five-finger.

Figure 2-30: Tamarack- Black Spruce Mixture on Wet Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally rare coarse habitat type (0.2% of land area).

Scattered stands and a few large areas in the Study Zone 4, more common south of the Nelson River.

Characteristic Site Conditions

Flat and depressed terrain.

Wet, very poorly drained horizontal and riparian fens.

The organic layer is deep, 1.3 m thick on average, and the water table is near or at the surface.

The organic substrate is primarily composed of fibric dominated fen peat deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Sparsely treed to woodland areas, with short complex canopies and trees up to five m tall.

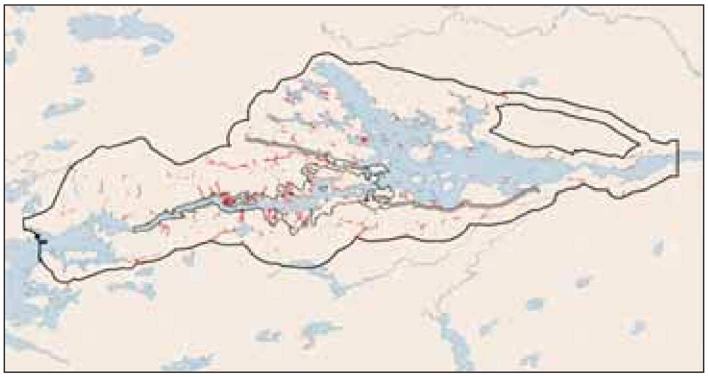
Canopy composition: Small diameter tamarack, often with scattered black spruce.

Tall shrubs: Often dense, comprised mostly of bog birch.

Understorey: Ground cover dominated by sphagnum mosses; low shrubs including leather-leaf and small bog cranberry; herbs include bogbean, bog rosemary, three-leaved false Solomon's-seal, water horsetail, marsh-five-finger and round-leaved sundew.

Ground View

Figure 2-31: Tamarack Treed on Wet Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

Regionally rare coarse habitat types (0.7% of land area).

Scattered areas throughout the Study Zone 4 along waterways and lake shores, less frequent northeast of Stephens Lake.

Characteristic Site Conditions

Usually in runnels, as well as flat and depressed terrain.

Very moist, poorly drained riparian and horizontal fens.

The organic layer is quite variable, 78 cm thick on average, often with a shallow water table.

The organic substrate is primarily composed of humic dominated fen peat deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed or very sparsely treed areas.

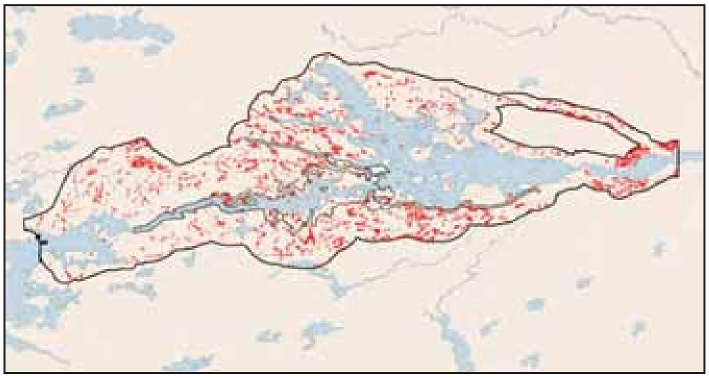
Canopy composition: Occasionally scattered short black spruce or white birch.

Tall shrubs: Dense, dominated by willow, sometimes with speckled alder or bog birch.

Understorey: Primarily moss species; Other scattered species include leather-leaf, sedges, three-leaved false Solomon's-seal and marsh-five-finger.

Ground View

Figure 2-32: Tall Shrub on Riparian or Wet Peatlands Coarse Habitat Fact Sheet



Zone 4 Distribution

Regionally uncommon coarse habitat types (3.3% of land area).

Distributed throughout the Study Zone 4 in very small to extensive areas.

Characteristic Site Conditions

Flat and depressed terrain.

Wet, very poorly drained collapse scars, horizontal fens and transitional peat plateau bogs, and riparian peatlands.

The organic layer is variable but deep, often more than 2 m thick with a shallow water table.

The organic substrate is composed of fibric dominated fen and sphagnum peat deposits.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed or very sparsely treed areas.

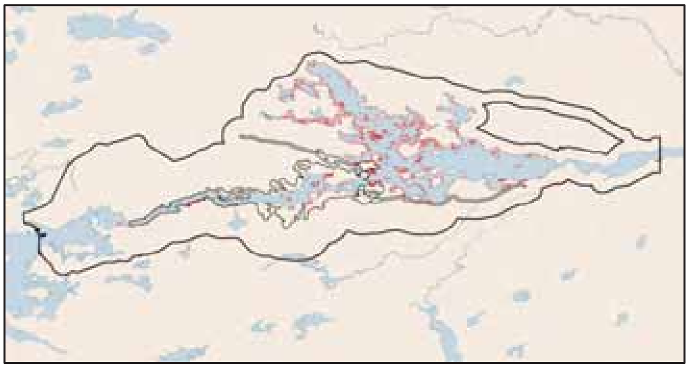
Canopy composition: Occasionally small scattered black spruce or tamarack usually less than two m tall.

Tall shrubs: Occasionally sparse willow.

Understorey: Primarily sphagnum mosses; low shrubs including leather-leaf and small bog cranberry; herbs include three-leaved false Solomon's-seal.

Ground View

Figure 2-33: Low Vegetation on Riparian or Wet Peatland Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally rare coarse habitat type (0.7% of land area).

Primarily distributed along the regulated Nelson River Shoreline.

Characteristic Site Conditions

Sloping topography.

Within the intermittently flooded shore zone.

Occurring on thin organic, and fine to coarse mineral substrates.

Aerial View

Characteristic Vegetation Composition

Structure: Untreed, tall shrub and / or low vegetation.

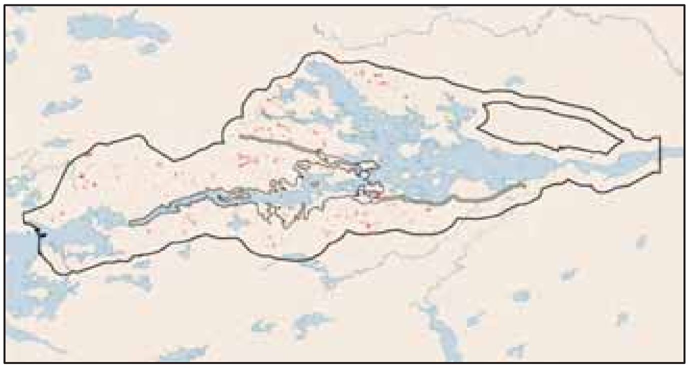
Canopy composition: Untreed.

Shrubs: Often dense flat-leaved willow when present, bog bilberry and sweet gale frequent in the Stephens reach.

Low vegetation: Silverweed and narrow reed grass and water sedge frequent in the Keeyask reach, and common horsetail, marsh-five-finger and sedge species more common in the Stephens reach.

Ground View

Figure 2-34: Shrub / Low Vegetation on Upper Beach Coarse Habitat Fact Sheet



Zone 4 Distribution

A regionally rare coarse habitat type (0.1% of land area).

Scattered along shorelines of off-system lakes and waterways, rarely in sheltered bays of Nelson River.

Aerial View

Characteristic Site Conditions

Shallow water, depths usually ranging up to 1.7m.

Submerged margins of floating peatlands and lake bottoms.

Substrates include submerged, floating **fibric peat**, and mineral, organic and littoral lake bottoms.

Ground View

Characteristic Vegetation Composition

Structure: Emergent, floating-leaved and submerged low vegetation.

Canopy composition: Untreed.

Shrubs: None.

Emergent & vegetation: Water horsetail and needle spike-rush, with creeping spike-rush on mineral substrates.

Floating-leaved vegetation: Various-leaved pondweed and yellow pond-lily, narrow-leaved bur-reed, large-leaved white water-crowfoot and arum-leaved arrowhead.

Submerged vegetation: Pondweeds, spiked water-milfoil and common bladderwort.

Figure 2-35: Off-System Marsh Coarse Habitat Fact Sheet

2.3.4.3 Landscape Elements

Some habitat types occur in repeating sequences referred to as **landscape element**s. Landscape elements can be especially important for animal species or ecosystem functions that depend on several different coarse habitat types in close proximity.

Landscape elements in Study Zone 6 reflected strong changes in soil moisture, nutrient availability, depth to water table and groundwater flow through an area (referred to as gradients in ecology). A **toposequence** is a type of landscape element that occurs on slopes. The toposequence shown in Figure 2-5 demonstrates how vegetation and soils change from the top to the bottom of the hill. Starting at the top of the hill and then moving down, the habitat sequence is Black Spruce Treed On Mineral Soil, Black Spruce Treed On Thin Peatland, Black Spruce Treed On Shallow Peatland, Black Spruce Treed On Ground Ice Peatland and, finally, Low Vegetation On Wet Peatland.

Hydrosequences are another common type of landscape element in Study Zone 5. The water depth duration zones shown in Photo 2-2 are an example of a hydrosequence that is predominantly driven by a gradient in the duration that the substrate is typically submerged. Photo 2-3 A shows another type of hydrosequence that is driven by gradients in nutrient availability in the plant rooting zone.

2.3.5 Current Trends (no future climate change)

Terrestrial habitat and ecosystems will change in Study Zone 6 even if the Project does not proceed. This section describes current trends (*i.e.*, future without the Project conditions) in terrestrial habitat. Ongoing, or lagged, ecosystem responses to past and existing human impacts and to past climate change are expected to be the primary drivers for future habitat changes. Reasonably foreseeable future projects are addressed in Section 0 while Section 2.11 considers the potential effects of future climate change on predicted residual Project effects.

2.3.5.1 Past and Existing Human Impacts

Ongoing erosion of Nelson River shorelines due to water regulation and the creation of reservoirs (Section 2.3.3.1) was expected to be the only substantial ongoing source of habitat loss and alteration from past and existing human developments in Study Zone 6. Other than the risk of a human started fire, recent upgrades to PR 280 use are not expected to have substantial additional effects on habitat composition into the future since this highway has been in use since 1971 for the segments from Thompson to Split Lake and Long Spruce to Gillam, and since 1985 for the segment from Split Lake to Long Spruce, which includes the construction periods of two generating stations (SE SV Section 2).

Regarding shoreline erosion, it was estimated that from 2006 until 2047 (equivalent to 30 years post-Project; PE SV Section 6), approximately 91 ha of land would be lost to ongoing mineral bank erosion along the Nelson River approximately between Birthday Rapids and Gull Rapids (PE SV Section 6). Habitat losses were predicted to be most extensive along the Nelson River in Gull Lake and upstream of Gull Rapids, with most of this area being the needleleaf treed on uplands (primarily black spruce) land cover type, followed by needleleaf treed on shallow peatlands (see Appendix 2C for details). It is predicted that the upland tall shrub and low vegetation land cover types would lose a higher proportion of their areas to ongoing mineral bank erosion because these types are more commonly found along the Nelson River shoreline. Estimates of the size of shoreline erosion losses in the remaining Study Zone 4 reaches of the Nelson River were not available.

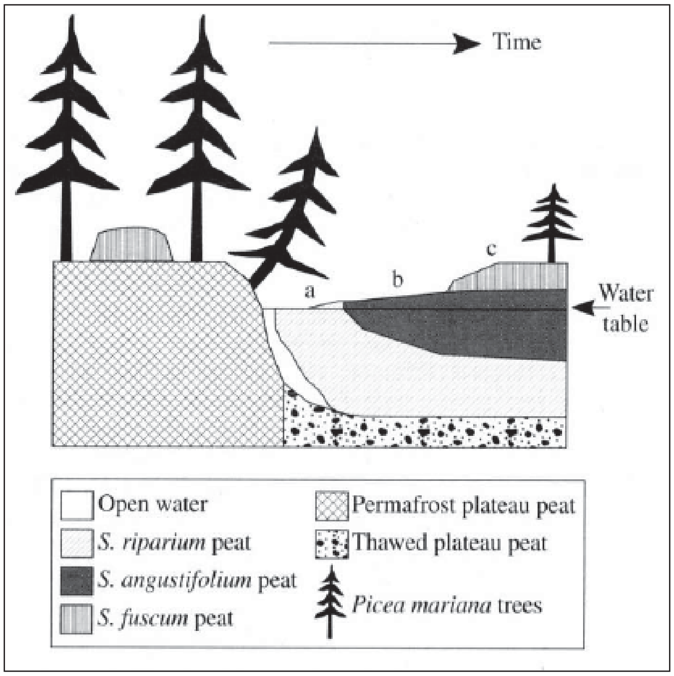
Project studies indicated that extremely high water levels and flows on the Nelson River from 2005 to 2011 temporarily increased shoreline erosion during the latter portion of this period, which would increase the anticipated amount of terrestrial habitat loss along the Nelson River.

2.3.5.2 Lagged Responses to Past Climate Change

As described above, climate and site conditions have important influences on the distribution and abundance of different habitat types, especially in areas with permafrost peatlands. Vitt *et al.* (2000) estimated that 22% of the remaining permafrost in boreal western Canada was still in disequilibrium with the climate, meaning that permafrost peatlands are expected to change in the future in response to past climate change. Camill (2005) subsequently reported that thaw rates have significantly accelerated since 1950.

Approximately 87% of Study Zone 5 land area was peatland in 2010 (Section 2.3.4.1.1). Permafrost was widespread, generally occurring in all peatland types except for horizontal and riparian peatlands. The types of permafrost ranged from cold soil temperatures only to ice crystals, ice lenses and ground ice. Ground ice permafrost makes important contributions to peatland composition and soil stratigraphy in the Study Zone 5.

Projecting historical trends for ground ice peatland distribution that were measured in Study Zone 4 (see Section 2.3.2), suggests that at least 20% of the area in peat plateau bogs in the Study Zone 4 will disappear over the 41 years from 2006 to 2047 (equivalent to 30 years post-Project). Over 90% of the peat plateau bog area that is lost is expected to convert to wet peatland types and the rest to open water based on typical ground ice permafrost dynamics (Figure 2-36) and observations from the Keeyask region. Collapse scars are the first main stage in this disintegration pathway. Subsequent stages depend on a variety of site specific conditions. Until 2047, the majority of the collapse scar area is expected to become various wet peatland habitat types and the rest to open water.



Note: Massive ground ice not depicted in this illustration. See Figure 2-11 for a photo of the ice that typically occupies the portion of the peat plateau bog identified as "permafrost plateau peat".

Figure 2-36: Hypothetical Succession of Collapse Scar Communities as a Function of Peat Accumulation: (a) Aquatic Sphagnum Communities, (b) Lawn Sphagnum Communities, and (c) Hummock Sphagnum Communities (From Camill 1999).

2.3.6 Project Effects

2.3.6.1 Introduction

TE SV Section 1.5 summarized the Project impacts during construction and operation that are relevant for the terrestrial assessment. This section outlines the potential direct and indirect effects of these impacts on terrestrial land cover and coarse habitat. A focused assessment of the implications of habitat changes for the terrestrial habitat and ecosystems issues of concern is provided by the ecosystem diversity and wetland function VECs (Sections 2.7 and 2.8) and by the terrestrial habitat and soil quantity and quality supporting topics (Sections 2.6 and 2.9).

Direct Project effects will include loss, alteration and disturbance of habitat and ecosystems in the Project Footprint as well any undefined footprints that may ultimately occur outside of the Project Footprint, if any (see Section 1.5 for Project Footprint details). Habitat loss in Section 2.0 refers to the conversion of terrestrial habitat into human features or an aquatic area, either temporarily or permanently. Habitat alteration refers to changes in one or more habitat attributes that are large enough to convert a habitat patch to a different fine habitat type. Lesser changes in one or more habitat attributes are classified as **habitat disturbance**. Examples of habitat disturbance are selective tree removal for firewood or narrow machine trails through a habitat patch.

Direct Project effects will create indirect effects, both within the Project Footprint and in some surrounding areas. That is, a Project impact will have a zone of influence surrounding its physical footprint. A particular indirect effect may be several stages removed from the direct Project effect. For example, clearing trees on permafrost soils will generally lead to higher soil temperatures, both within the cleared area and in adjacent areas. Vegetation clearing that creates large openings on treed peatlands with thick ground ice will generally lead to permafrost melting, followed by collapse of the soil surface to form craters, and then by the development of very wet peatland habitat and/or open water in the craters (Figure 1.3-1 illustrates this pathway of effects). In this situation, the direct effect on habitat is vegetation clearing, an initial indirect effect is soil warming which leads to the secondary indirect effect, permafrost melting, followed by the tertiary indirect effect, peatland surface collapse, and finally the ultimate indirect **habitat effect** which is conversion to very wet peatland habitat and/or open water.

The size and nature of the indirect zone of influence will be determined by how the particular Project impact interacts with the ecosystem component of interest and local conditions. For example, tree clearing in dense, mature forest on permafrost soils will have a much larger habitat zone of influence than tree clearing on a bedrock outcrop. The nature and spatial extent of indirect habitat effects will range from not measurable to conversion to aquatic areas.

Indirect Project effects on vegetation, soils, animals and key ecological flows were expected to generally decline with distance from the Project Footprint. As described in Section 2.2.5, the habitat and ecosystems effects assessment accounted for this pattern by using different zones of influence for stand and **landscape level** ecosystem attributes.

It should be noted that the term habitat zone of influence refers either to the concept of indirect effects on habitat or to the expected (*i.e.*, most likely) spatial extent of indirect effects on terrestrial habitat. The Local Study Area, or Study Zone 2, encompasses the predicted maximum potential (*i.e.*, worst case scenario) habitat zone of influence.

Improved access is another potentially important pathway for indirect Project effects since this will bring more equipment, material and/or people into an area, which could lead to increased resource harvesting or human-caused fires, among other things.

The remainder of this section summarizes potential Project effects on terrestrial habitat during construction and operation (more detailed information is provided in Appendix 2C).

2.3.6.2 Construction Period

2.3.6.2.1 Potential Construction Effects

Overview

During construction, the Project Footprint could directly affect up to 6,872 ha of terrestrial habitat (Table 2-9), but this could increase to 6,952 ha if borrow area E-1 is used. These estimates of habitat loss in the Project Footprint are cautious for several reasons. It is estimated that substantial portions of the potential disturbance and borrow areas will not be used (PD SV Section 2.2). Clearing within the south access road right-of-way (ROW) will be minimized to the extent possible, which could further reduce the total area affected. It is also likely that portions of the remaining potential disturbance areas will not be used. In addition, the **environmental protection plan**s (EnvPPs) include measures intended to minimize clearing and disturbance outside of the permanent **Project component**s (*e.g.*, in the potential disturbance areas). Finally, it is highly unlikely that borrow area E-1 will be used.

Indirect Project effects on habitat were generally expected to diminish below measurable levels within 50 m from the Project Footprint. Studies in forests have documented edge effects that range from 15 m to 50 m, depending on the ecosystem component of interest, the type of human disturbance and local conditions (Euskirchen *et al.* 2001; Harper and Macdonald 2002; Rheault *et al.* 2003; Gignac and Dale 2005, 2007). An edge effects study conducted along more than 900 km of transmission line rights-of-way in north-western Manitoba (the study area overlapped Study Zone 5) found that effects on overstorey vegetation extended less than 10 m from the cleared opening (Ehnes and ECOSTEM 2006). This narrow zone of overstorey edge effects was attributed to the very low proportion of area that is dense forest so that habitat attributes are more strongly influenced by factors other than those related to canopy closure. Of the treed areas more than 50 years old in Study Zone 4, only approximately 21% had canopy closure greater than 60%.

Indirect Project effects on habitat could extend further than 50 m from the Project Footprint in localized areas. These exceptions could occur in wetlands, physically disturbed areas and/or areas affected by a low probability event (*e.g.*, a human caused fire). To the extent these effects occur, they were expected to alter only a small portion of the peripheral 100 m of the 150 m buffer and likely be captured by the extent which the 50 m buffer was an overestimate of the general distance of indirect effects.

Table 2-9: Estimated Maximum Potential Amount (ha) of Terrestrial Habitat Affected During Construction by Source

Effect Source	Habitat Affected (ha)
Project Footprint	
Non-reservoir	3,458
Reservoir clearing	3,414
Sub-total	**6,872**
Indirect Project effects on habitat	2,055
Total	**8,927**

Note: Reported areas are terrestrial habitat areas only (*i.e.*, areas do not include human infrastructure or deep water). Addition of the Human Infrastructure habitat class increases the sub-total to the 7,591 ha reported in Table 1-5.

Project-related use of PR 280 for Project construction is expected to have negligible additional effects on habitat composition since upgrades are not part of the Project and this highway has been in use since 1971 (SE SV Section 2).

The Project is predicted to directly and indirectly affect 8,927 ha of terrestrial habitat (Table 2-9), assuming that all of the terrestrial habitat within 50 m of the Project Footprint (*i.e.*, the habitat zone of influence) is lost or altered during construction. In the unlikely event that borrow area E-1 is used, Project construction could directly and indirectly affect approximately 9,070 ha of terrestrial habitat.

Most of the land cover in the Project Footprint and predicted habitat zone of influence is needleleaf treed on mineral, thin and other peatlands (approximately 77%; Table 2-10). The dominant coarse habitat types within these land cover types are black spruce treed on thin peatland, black spruce treed on shallow peatland and black spruce treed on mineral soil, respectively (see Appendix 2C). Most of the remaining terrestrial habitat would be directly or indirectly affected is low vegetation on mineral and thin peatlands, low vegetation on other peatlands, and shrub and/or low vegetation on riparian peatland and on shore zone.

Compared with the Project Footprint, the habitat zone of influence is predicted to include a substantially lower proportion of each land cover type (Table 2-11).

Table 2-10: Land Cover Composition of the Habitat Local Study Area and Project Footprint During Construction, as a Percentage of Land Area

Land Cover Type	Project Footprint	Habitat Zone of Influence	All
Mineral and Thin Peatland			
Broadleaf treed on all ecosites	2.8	3.2	2.9
Needleleaf treed on mineral or thin peatland	44.9	58.0	47.9
Tall shrub on mineral or thin peatland	0.7	0.7	0.7
Low vegetation on mineral or thin peatland	3.6	3.9	3.7
Other Peatlands			
Needleleaf treed on other peatlands	30.0	24.1	28.6
Shrub/ low vegetation on riparian peatland	5.6	1.2	4.6
Tall shrub on other peatlands	0.6	0.6	0.6
Low vegetation on other peatlands	7.6	5.5	7.1
Shore Zone			
Nelson River shore zone	4.1	2.8	3.7
Off-system shore zone	0.1	0.0	0.2
Total	100.0	100.0	100.0
Land Area (ha)	*6,872*	*2,055*	*8,927*

Note: Reported areas are terrestrial habitat areas only (*i.e.*, areas do not include human infrastructure or deep water).

Table 2-11: Percentage Distribution of Land Cover Types Between the Project Footprint and Habitat Zone of Influence During Construction

Land Cover Type	Total Area Affected (ha)	Project Footprint (% of Area Affected)	Habitat Zone Of Influence (% of Area Affected)
Mineral and Thin Peatland			
Broadleaf treed on all ecosites	255	74.3	25.7
Needleleaf treed on mineral or thin peatland	4,276	72.1	27.9
Tall shrub on mineral or thin peatland	63	77.9	22.1
Low vegetation on mineral or thin peatland	326	75.7	24.3
Other Peatlands			
Needleleaf treed on other peatlands	2,556	80.7	19.3
Shrub/ low vegetation on riparian peatland	411	94.0	6.0
Tall shrub on other peatlands	52	77.6	22.4
Low vegetation on other peatlands	636	82.2	17.8
Shore Zone			
Nelson River shore zone	341	82.9	17.1
Off-system shore zone	9	89.4	10.6

Note: Reported areas are terrestrial habitat areas only (*i.e.*, areas do not include human infrastructure or deep water).

Habitat Changes

Map 2-25 to Map 2-27 show the coarse habitat composition of land areas potentially affected by the Project before considering mitigation.

Upstream

Habitat Loss

It was assumed that all of the terrestrial habitat within the Project Footprint would be lost during construction and that all of the habitat within the terrestrial habitat zone of influence would be affected by a combination of habitat loss, alteration and disturbance.

Generating Station and Dykes

Approximately 246 ha of the infrastructure footprint (see Section 1.5.1 for components) overlaps terrestrial habitat (Table 2-12; Map 2-25). Coarse habitat is primarily a mixture of black spruce treed on thin peatland, mineral soil and shallow peatland, and low vegetation on mineral and thin peatland (Appendix 2C). Most of the remaining habitat in the infrastructure footprint is low vegetation on shallow peatland. Shrub and/or low vegetation on ice scoured upland makes up almost all of the shore zone habitat within the infrastructure footprint, comprising just under six percent of the likely affected habitat.

The north and south dykes components of the infrastructure footprint , and associated disturbed areas, would affect the widest range of habitat types since they span the longest distance. These footprint components account for nearly 78% of the total infrastructure habitat area affected. The habitat composition within the remaining infrastructure components is similar, except that they contain most of the shore zone habitat as well. Some of the spillway footprints have no upland or inland peatland habitat since they are entirely within the Nelson River.

Roads

More than half of the 405 ha of the terrestrial habitat in the roads and road corridors (Map 2-25 to Map 2.13-3) would be black spruce treed on thin peatland and shallow peatland (Appendix 2C). Much of the remaining area occurs on low vegetation on mineral and thin peatland and shallow peatlands, and black spruce treed on mineral. A portion of the road footprint coincides with existing human features, including the Butnau Road, north access road and cutlines. Almost no shoreline wetlands would be affected by the road and road corridor footprints, except for a small amount of shrub and/or low vegetation on sunken peat (three ha) within the road footprint.

The north and south access roads and the Butnau Road upgrade constitute the largest proportion of the road footprints (Appendix 2C). Even though the north access road already exists, it is included because borrow material could be procured from the road right-of-way (ROW) and because there are construction effects that need to be captured (*e.g.*, traffic, disturbance, undefined footprints and indirect effects). Since the north access road and Butnau Road already exist at construction initiation, the south access road would affect the highest area (81% of road footprint) and range of native habitat of the road and road corridor footprint. The habitat composition affected by the remaining haul roads and corridors closely reflects the composition of the footprint as a whole.

Camp and Work Areas

Nearly all of the **camp** and work area footprint is within pre-existing human footprints, mostly related to the Keeyask Infrastructure Project, which was previously assessed and licensed. The remaining five hectares of habitat (Map 2-25 to Map 2.13-3) is primarily jack pine treed and jack pine mixedwood on mineral or thin peatland, black spruce treed on shallow peatland and low vegetation on shallow peatland (Table 2-12; Appendix 2C). No shore zone habitat occurs within the camp and work areas.

Of the five remaining hectares of native habitat likely to be affected all are located within the work areas (Appendix 2C; Map 2-25 to Map 2-27).

Borrow Areas

The 1,466 ha of terrestrial habitat in borrow areas (Map 2-25 to Map 2-27) contain the second largest amount and proportion of mineral soil and thin peatland habitat, primarily black spruce treed, jack pine and low vegetation habitat (Table 2-12). Most of the remaining area is black spruce treed and low vegetation on shallow peatland. Shore zone habitat are rare in the borrow areas footprint (1.4%), with shrub and/or low vegetation on shore zone being the types that would be most affected.

The impervious materials borrow areas are likely to affect the highest proportion of habitat (71%) in the footprint (Appendix 2C). This component is reflective of the overall borrow areas footprint, except that it contains almost all of the broadleaf treed habitat types and most of the low vegetation on shallow peatland. The **granular** materials borrow areas would likely affect the highest proportion of jack pine habitat within the overall footprint.

Although unlikely, one additional borrow area may be used. The 80 ha potential but unlikely E-1 borrow area and access road footprint primarily consists of black spruce treed on mineral soil, followed by black spruce treed on shallow peatland and black spruce treed on thin peatland (Table 2-13). The black spruce treed on mineral soil was primarily in the borrow area footprint, while the latter two types were mostly within the road footprint (Appendix 2C). The 63 ha habitat zone of influence and road corridor had similar composition to the footprint, except a lower proportion of black spruce treed on mineral soil, and a higher proportion of low vegetation on mineral, thin peatland and shallow peatland.

Reservoir

Of the various Project Footprint components, reservoir clearing affects the largest habitat area (3,414 ha). Woody vegetation 1.5 m and taller, and fallen trees 1.5 m or longer, or with a diameter at least 15 cm, will be cleared in these areas (PD SV Section 3.5).

Reservoir clearing contains the largest proportion and amount of peatland habitat (Table 2-12). This Project component contains the widest range of habitat types, but most of the habitat likely to be affected is comprised of black spruce treed on thin peatland and on shallow peatland, black spruce treed on mineral soil, and low vegetation on shallow peatlands.

Shoreline wetlands comprise less than two percent of the reservoir clearing land area combined. Shrub and/or low vegetation on ice scoured upland and on upper beach would have the most area impacted. The reservoir clearing area contains the highest proportion of off-system marsh habitat likely to be affected.

Excavated Material Placement Areas

The 262 ha of terrestrial habitat likely to be affected by the excavated material placement area footprint would primarily be black spruce treed on thin peatland, and low vegetation on mineral, thin and shallow peatland (Table 2-12). Shore zone habitat makes up approximately six percent of the habitat in the excavated material placement areas, with most of the area being shrub and/or low vegetation on ice-scoured upland and on sunken peat.

Construction Flooding and River Management

It is predicted that Stage 1 and 2A **cofferdam** flooding would be contained within the existing river banks or other Project Footprint components (PE SV Section 4.4.1). Although Stage 2B considerably increases flooding from Stage 2A, it is addressed in the operation phase since it occurs during the final month or two of construction.

The 14 ha of habitat affected by the land portions of the river management footprint (Table 2-12; Map 2-25 to Map 2-28) are mostly the black spruce treed on thin peatland, black spruce treed on shallow peatland and black spruce treed on mineral soil coarse habitat types (Appendix 2C). Almost all of this area is associated with the channel improvement area footprint component. Shore zone habitat comprises under 11% of the habitat likely affected by river management footprint, most of which is shrub and/or low vegetation on ice scoured upland located within the central dam excavation area.

Approximately 41% of the 277 ha of land area that would likely be affected by flooding during construction is shrub and/or low vegetation on riparian peatland, with an additional 34% in shoreline wetlands (Table 2-12). All of this area is associated with the ice boom and coffer dam diversion. Most of the shoreline habitat affected would be vegetated upper beach (Appendix 2C). Much of the affected marsh would also occur within this footprint component. Similarly, more than half of the habitat potentially affected by altered water levels is shrub and low vegetation on shore zone, as well as tall shrub on riparian peatland.

Potential Disturbance Areas

Potential disturbance areas (PDAs) identify areas that may be disturbed while constructing Project infrastructure or during reservoir clearing.

Most of the 631 ha of terrestrial habitat in the potential disturbance areas is black spruce treed on thin peatland, shallow peatland, and mineral (60% combined; Table 2-12). Low vegetation types, tall shrub on riparian peatland and shrub and/or low vegetation in shore zones make up most of the remaining habitat.

Reservoir clearing and dyke buffers make up the majority of potential disturbance areas (48% and 46% of the footprint, respectively; Appendix 2C). The habitat composition of these two footprint components are very similar, except the reservoir areas have a somewhat higher proportion of tall shrub on riparian peatland and shrub and/or low vegetation on upper beach.

Mitigation Area

The mitigation area is a borrow site that may be used to develop fish habitat in the Nelson River. Most of the 138 ha of habitat likely to be affected is black spruce treed on thin peatland, mineral soil and shallow peatland (86%; Appendix 2C). Jack pine treed on mineral or thin peatland, broadleaf treed habitat and low vegetation on wet peatland make up most of the remaining area. Less than one percent of the areas is in shore zone wetlands.

Habitat Alteration

As described above, it was assumed that all of the terrestrial habitat in the habitat zone of influence (*i.e.*, a 50 m buffer of the Project Footprint) would be affected during construction.

The coarse habitat composition of the predicted habitat zone of influence is very similar to that of the overall Project Footprint. Black spruce treed on thin peatland makes up the largest proportion of the habitat likely to be altered (35%), followed by black spruce treed on shallow peatland (22%) and on mineral soil (17%; Appendix 2C). Compared to the Project Footprint, there is a higher proportion of black spruce treed on thin peatland and jack pine treed on mineral or thin peatland habitat affected, but there is also a much lower proportion of existing human features.

Table 2-12: Predicted Coarse Habitat Composition of the Project Footprint Components Before Mitigation

Land Cover Type	Coarse Habitat Type	Project Footprint											Project Footprint Total	ZOI Construction	All
		Infra-structure	Road	Camp & Work Area	Borrow Areas	Reservoir	EMPA	River Management	Flooding	PDA	Mitigation Area	Altered Water Levels			
Broadleaf treed on all ecosites	Broadleaf treed on all ecosites	6.1	2.2	1.0	3.0	0.6	6.1	-	0.1	2.5	1.4	-	1.8	1.6	1.7
	Broadleaf mixedwood on all ecosites	-	0.1	-	2.8	0.6	0.0	-	0.2	0.5	1.5	-	1.0	1.6	1.1
Needleleaf treed on mineral or thin peatland	Black spruce mixedwood on mineral or thin peatland	0.1	0.8	-	0.1	0.1	0.1	-	0.1	0.3	0.8	-	0.2	0.5	0.3
	Jack pine mixedwood on mineral or thin peatland	1.3	0.0	35.7	1.2	0.0	-	-	-	0.7	-	-	0.4	0.9	0.5
	Jack pine treed on mineral or thin peatland	4.7	2.3	9.3	7.6	0.2	4.5	-	-	2.2	4.4	-	2.5	4.5	2.9
	Black spruce treed on mineral soil	15.6	8.6	-	20.6	6.8	7.6	18.2	2.9	11.8	30.3	16.7	11.0	16.6	12.3
	Black spruce treed on thin peatland	30.8	50.2	1.1	39.2	28.7	21.8	42.2	3.9	24.7	38.0	5.6	30.8	35.4	31.9
Tall shrub on mineral or thin peatland	Tall shrub on mineral or thin peatland	0.3	1.6	-	0.5	0.3	5.3	-	1.1	1.0	0.0	-	0.7	0.7	0.7
Low vegetation on mineral or thin peatland	Low vegetation on mineral or thin peatland	11.7	6.9	0.1	5.1	1.1	12.4	3.5	1.3	6.3	0.6	0.0	3.6	3.9	3.7
Needleleaf treed on other peatlands	Jack pine treed on shallow peatland	-	0.0	-	0.0	-	-	-	-	-	-	-	0.0	0.3	0.1
	Black spruce mixedwood on shallow peatland	-	0.0	-	-	0.0	0.1	-	-	0.1	-	-	0.0	0.1	0.0
	Black spruce treed on shallow peatland	13.4	15.3	27.1	14.2	38.7	20.2	24.1	9.3	23.3	18.1	-	27.4	21.7	26.1
	Black spruce treed on wet peatland	0.2	2.3	-	0.4	1.6	0.0	-	0.4	0.4	0.0	-	1.1	0.7	1.0
	Tamarack- black spruce mixture on wet peatland	0.0	0.3	-	-	0.6	-	-	-	0.2	-	-	0.3	0.2	0.3
	Tamarack treed on shallow peatland	0.2	2.2	-	0.2	1.1	0.0	-	0.1	0.2	0.1	-	0.8	0.7	0.7
	Tamarack treed on wet peatland	-	-	-	-	0.0	-	-	-	0.0	-	-	0.0	0.0	0.0
	Black spruce treed on riparian peatland	0.0	0.3	-	0.0	0.6	0.1	-	0.5	0.5	-	-	0.4	0.3	0.4
	Tamarack- black spruce mixture on riparian peatland		0.0	-	-	0.0	-	-	-	0.0	-	-	0.0	0.0	0.0
Tall shrub on other peatlands	Tall shrub on shallow peatland	0.3	0.1	-	-	0.3	0.0	-	0.8	0.4	0.0	-	0.2	0.4	0.3
	Tall shrub on wet peatland	-	-	-	-	0.7	-	-	0.4	0.2	-	-	0.4	0.2	0.3
Low vegetation on other peatlands	Low vegetation on shallow peatland	9.2	3.3	25.8	3.7	7.2	15.0	0.6	3.7	5.8	0.8	-	6.2	4.8	5.9
	Low vegetation on wet peatland	0.3	1.3	-	-	2.5	0.0	0.6	0.6	0.4	2.1	-	1.4	0.7	1.3
Shrub/ low vegetation on riparian peatland	Tall shrub on riparian peatland	0.0	0.3	-	0.0	2.7	0.3	0.0	29.7	5.1	0.9	23.1	3.1	0.3	2.5
	Low vegetation on riparian peatland	0.1	1.0	-	0.0	3.7	0.3	-	10.9	1.4	0.4	0.1	2.5	0.9	2.1
Nelson River shore zone	Nelson River shrub and/or low vegetation on ice scoured upland	5.7	0.3	-	0.6	1.1	3.5	9.4	3.9	3.4	-	34.8	1.6	0.6	1.4
	Nelson River shrub and/or low vegetation on upper beach	-	0.0	-	0.3	0.4	0.1	1.5	27.9	7.6	0.6	19.7	2.1	0.9	1.8
	Nelson River shrub and/or low vegetation on sunken peat	-	0.8	-	0.5	-	2.7	0.0	-	0.1	-	0.0	0.3	1.3	0.5
	Nelson River marsh	-	-	-	-	0.0	-	-	1.8	0.9	-	-	0.2	0.0	0.1
Off-system shore zone	Off-system marsh	0.0	-	-	-	0.2	0.0	-	0.4	0.1	0.0	-	0.1	0.0	0.1
Total habitat area (ha)		*246*	*405*	*5*	*1,466*	*3,414*	*262*	*14*	*277*	*631*	*138*	*14*	*6,872*	*2,055*	*8,927*

Note: Reported areas are terrestrial habitat areas only (i.e., areas do not include human infrastructure or deep water).

Table 2-13: Predicted Coarse Habitat Composition of the Borrow Area E-1 Footprint Components Before Mitigation

Coarse Habitat Type	Borrow Area and Access Road	Corridor and zone of influence	All
Black spruce treed on mineral soil	38.1	6.7	24.3
Black spruce treed on thin peatland	16.8	21.1	18.7
Black spruce treed thin peatland	0.9	1.1	1.0
Jack pine treed on mineral or thin peatland	0.9	1.5	1.1
Low vegetation on mineral or thin peatland	8.7	14.3	11.2
Black spruce treed on riparian peatland	0.5	0.7	0.6
Black spruce treed on shallow peatland	20.5	26.6	23.2
Black spruce treed on wet peatland	1.0	1.2	1.1
Tamarack treed on shallow peatland	0.2	0.4	0.3
Low vegetation on shallow peatland	9.0	21.2	14.3
Low vegetation on wet peatland	2.7	4.3	3.4
Low vegetation on riparian peatland	0.7	0.8	0.8
Total	100	100	100
Area (ha)	*80*	*63*	*143*

Disturbance and Access Effects

Construction activities and workers living and working in the area would disturb habitat. Some of the potential sources of disturbance are accidental spills, equipment movement outside of the Project Footprint, small patches of accidental clearing, foot trails created by people and airborne deposition of dust and emissions generated by vehicles and construction equipment.

The amounts and locations of disturbance outside of the Project Footprint cannot be identified prior to construction. Based on experience during construction of other generating stations in Northern Manitoba, the vast majority of the total disturbance area, if any, is expected to occur within the habitat zone of influence.

Increased access could increase harvesting of plants and habitat components such as dead trees for firewood. Based on recent experience during construction of the Wuskwatim Generation Project these effects are not expected to be substantial.

As described in Section 2.3.6, Project-related fire regime effects are not expected.

Downstream

Construction Flooding and River Management

More than half of the 14 ha of habitat likely to be affected by altered water levels downstream of the dam are shrub and/or low vegetation, primarily on ice scour mineral (35%) and upper beach (20%) ecosites (Table 2-12). Most of the remaining affected habitat would be tall shrub on riparian peatland and black spruce treed on mineral (Appendix 2C). Almost all of the area in this footprint corresponds with **dewater**ed areas and disturbed islands.

2.3.6.3 Operation Period

2.3.6.3.1 Potential Operation Effects

Overview

Flooding at the start of Project operation would be contained within areas already affected during construction. Reservoir expansion due to peatland disintegration and mineral bank erosion will remove additional terrestrial habitat during Project operation. It is predicted that approximately 671 ha of terrestrial habitat will become aquatic areas during the first 30 years of operation and that losses will continue for 50 to 100 years, but at declining rates (PE SV Section 6). Reservoir expansion would be somewhat offset by **habitat recovery** in disturbed, unused and temporarily cleared areas. At Year 30, the Project is predicted to affect approximately 9,416 ha of terrestrial habitat (Table 2-17) but this could increase to approximately 9,558 ha in the unlikely event that borrow area E-1 is used. Over the longer term, it is anticipated that much of the temporarily altered habitat at Year 30 would recover to native habitat types.

The predicted land cover composition of terrestrial habitat affected during operation is primarily needleleaf treed on mineral, thin peatland and other peatlands (78% combined), with low vegetation types, mostly on other peatlands, comprising more than 10% of the total area (Table 2-14).

The remainder of this section describes terrestrial habitat effects during operation. Further details are provided in Appendix 2C. The ecological implications of these habitat composition effects are addressed by the VECs and supporting topics.

Table 2-14: Predicted Land Cover Affected During Operation to Year 30 By Source and Permanence as a Percentage of Total Area (ha)

Land Cover Type	Permanent habitat loss			Permanent habitat alteration		Temporary habitat Alteration	Total Area
	Infra-structure/ Dewatered area	Initial Flooding	Reservoir Expansion	Indirect reservoir effects	Other long term indirect effects	Undisturbed potential construction areas and regenerating construction areas	
Broadleaf treed on all ecosites	3.1	1.5	1.8	4.1	3.3	2.7	2.4
Needleleaf treed on mineral or thin peatland	60.4	34.5	41.0	60.2	49.0	69.7	47.4
Tall shrub on mineral or thin peatland	0.3	0.5	0.4	0.1	1.3	1.1	0.7
Low vegetation on mineral or thin peatland	6.9	2.1	1.5	1.1	7.5	4.6	3.3
Needleleaf treed on other peatlands	17.8	37.5	42.1	27.9	24.4	15.9	30.2
Tall shrub on other peatlands	0.1	0.9	1.3	0.3	0.6	0.0	0.6
Low vegetation on other peatlands	6.6	9.0	5.0	3.5	8.7	4.5	7.1
Shrub/ low vegetation on riparian peatland	1.6	8.6	3.9	1.6	1.6	0.1	4.6
Nelson River shore zone	3.2	5.2	3.2	1.3	3.6	1.5	3.6
Off-system shore zone	0.0	0.2	0.0	0.0	0.1	0.0	0.1
Total habitat Area (ha)	*494*	*4,173*	*671*	*1,266*	*1,314*	*1,497*	*9,416*

Note: Reported areas are terrestrial habitat areas only (*i.e.*, areas do not include human infrastructure or deep water).

Upstream

Habitat Loss

Reservoir expansion is expected to be the only Project effect that will increase terrestrial habitat loss in upstream areas during operation. It is predicted that reservoir expansion could remove approximately 671 ha of terrestrial habitat during the first 30 years of operation, with losses on a mean annual basis being highest in the first five years and declining steadily thereafter (Table 2-15). Most of the reservoir expansion occurs during the first 15 years of operation.

While this predicted habitat loss is distributed in narrow bands throughout the reservoir, larger losses tend to occur in bays where large peatlands are disintegrating and along shorelines exposed to high wave energy (see Shoreline Erosion section of the PE SV for a description of reservoir expansion by reach). Edge effects, elevated groundwater tables (PE SV Section 8) and other reservoir-related changes to habitat driving factors would indirectly alter soils, vegetation and other habitat attributes to further increase habitat loss and alteration.

The habitat lost during reservoir expansion is predominantly black spruce treed on shallow peatland and on thin peatland (39% and 30%, respectively). Black spruce treed on mineral soil makes up an additional 10%, with most of the remaining area in low vegetation types, and shrub/low vegetation on riparian peatland. Nelson River shore zone wetlands account for an additional 3% of land area, primarily shrub and/or low vegetation on upper beach and ice scoured upland.

Reservoir expansion to Year 15 is generally highest in the Gull Lake area, becoming more pronounced with time since flooding. After Year 15, reservoir expansion generally ceases upstream of Nap Creek, while after Year 30 it generally ceases upstream of Gull Lake.

Reservoir expansion resulting from mineral erosion is generally higher in shore segments exposed to relatively high wave energy (*e.g.*, south shorelines, some islands). Reservoir expansion resulting from peatland disintegration is highest in sheltered bays and inlets along the north shore of Gull Lake, and in two large bays along the north bank of the Nelson River upstream of Gull Lake (PE SV Maps 6.4-6 and 6.4-7).

The composition of habitat lost to reservoir expansion varies during the different prediction periods. During Year 1, mineral and thin peatland and Nelson River shore zone habitat types are most likely to be affected whereas peatland types become most affected by Year 15 and thereafter (Figure 2-37). Affected habitat types transition from predominately black spruce treed on mineral soil (36%), Nelson River shore zone (26%) and tall shrub on riparian peatland (11%) during year 1; to black spruce treed on shallow peatland (38%) and black spruce treed on thin peatland (30%) by Year 30. Appendix 2C provides a detailed description of habitat losses during each Project operation prediction period.

After Year 30, it is predicted that reservoir expansion resulting from peatland disintegration would generally be confined to sheltered bays and inlets around and just upstream of Gull Lake (PE SV Section 6.4.2.1). Relative to the first 30 years of operation, the habitat in these potential expansion areas includes a higher proportion of black spruce treed shallow peatland and on thin peatland habitat, and almost no black spruce treed on mineral. The shallow peatland habitats are predominantly ground ice peatlands.

Table 2-15: Total and Mean Annual Area of Habitat Lost Due to Flooding and Reservoir Expansion During the First 30 Years of Project Operation, by Prediction Period

Operation Period	Total Area Lost (ha)		Mean Annual Loss (ha/yr)
	Over the Period	Cumulative	
Year 1	48	48	48
Years 2 to 5	182	230	46
Years 6 to 15	266	496	27
Years 16 to 30	176	671	12
Reservoir Expansion	**671**		**22**
Habitat lost to initial flooding		**4,173**	
Habitat lost to 30 years of reservoir expansion		**671**	
Habitat lost to the reservoir at Year 30		**4,845**	

Note: Reported areas are terrestrial habitat areas only (*i.e.*, areas do not include human infrastructure or deep water). Totals may not equal sum of components due to rounding.

Table 2-16: Percentage Composition of Land Cover Lost Due to Initial Flooding and Reservoir Expansion During the First 30 Years of Project Operation, by Prediction Period.

Land Cover Type	Initial Flooding	Reservoir Expansion					Reservoir Expansion Habitat Zone of Influence at Year 30
		Year 1	Years 2 to 5	Years 6 to 15	Years 16 to 30	Cumulative	
Broadleaf treed on all ecosites	1.5	4.6	2.7	1.4	0.6	1.4	4.1
Needleleaf treed on mineral or thin peatland	34.5	41.7	48.4	44.0	28.3	35.4	60.2
Tall shrub on mineral or thin peatland	0.5	0.1	0.3	0.5	0.4	0.5	0.1
Low vegetation on mineral or thin peatland	2.1	0.2	1.5	1.3	2.2	2.0	1.1
Needleleaf treed on other peatlands	37.5	7.8	33.7	44.9	55.6	38.2	27.9
Tall shrub on other peatlands	0.9	0.6	1.2	1.0	2.1	0.9	0.3
Low vegetation on other peatlands	9.0	4.0	3.1	4.7	7.6	8.4	3.5
Shrub/ low vegetation on riparian peatland	8.6	14.9	7.2	1.0	1.6	8.0	1.6
Nelson River shore zone	5.2	26.2	1.7	1.2	1.5	5.0	1.3
Off-system shore zone	0.2	0.0	0.0	-	-	0.2	0.0
Total	100	100	100	100	100	100	100
Total habitat area (ha)	*4,173*	*48*	*182*	*266*	*176*	*4,845*	*1,266*

Note: Reported areas are terrestrial habitat areas only (*i.e.*, areas do not include human infrastructure or deep water).

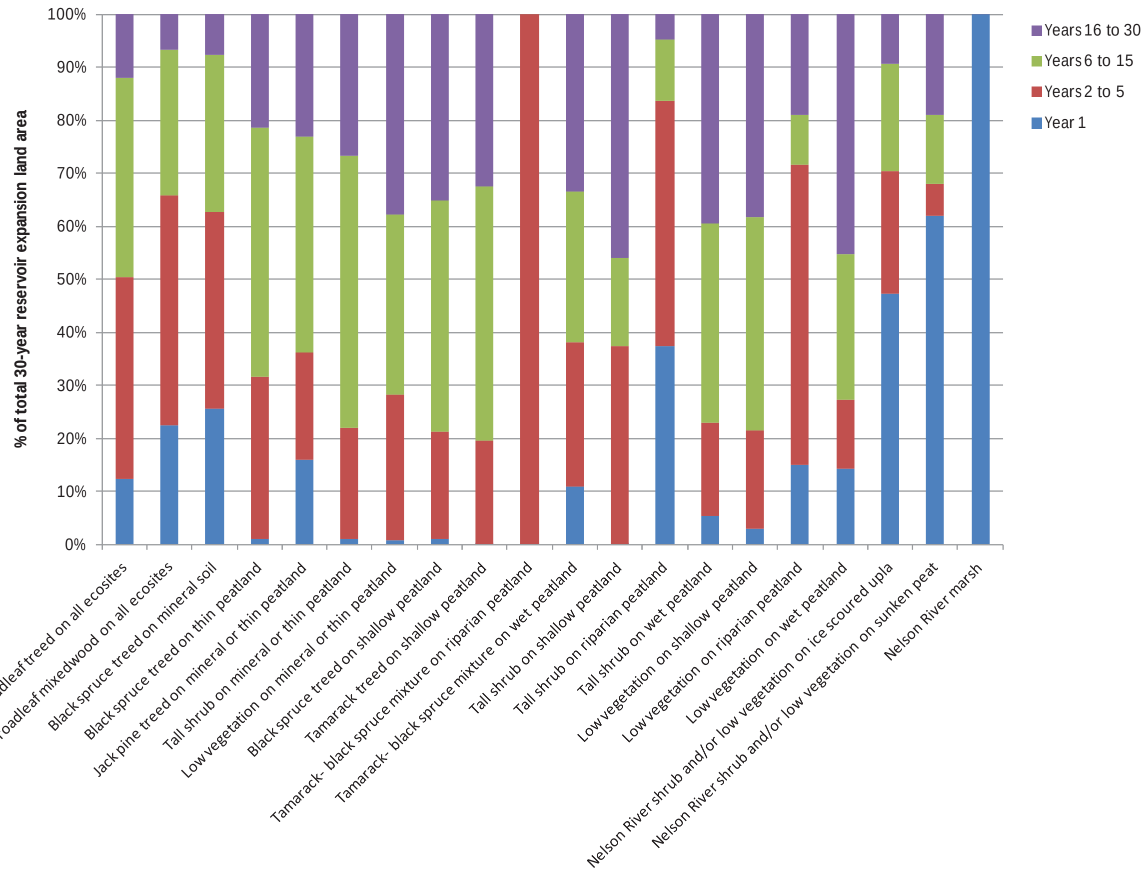


Figure 2-37: Proportion of the Total Area of Each Habitat Type with Greater Than 1 Ha in the 30-Year Reservoir Expansion Area by Operation Period.

Habitat Alteration

It is expected that additional Project-related habitat disturbance during operation will be low since Project activity will be much reduced.

As previously described, the reservoir would have a zone of influence on habitat composition. By creating edge and elevating the groundwater table into the soil layers and the plant rooting zone, the reservoir would indirectly alter terrestrial habitat along the reservoir shoreline. Inland areas that have hydrological connections to the reservoir could also experience higher groundwater, which could alter terrestrial habitat. Terrestrial habitat along the dykes could also be affected in localized areas by pooling water that is not carried away by the drainage channels.

The regional groundwater model predicted there would be no inland areas where the Project would elevate the groundwater table to within 2 m of the surface (PE SV Section 8.4.2). This conclusion was not contradicted by analysis of available historical air photos and aerial surveys from the proxy areas. This proxy area study searched for inland areas where changes to vegetation or ecosite indicated that the reservoir had elevated groundwater. No examples of such changes were found, presumably because most inland areas are at higher elevations than the reservoir thereby creating a physical limitation on the locations where groundwater can be raised to within 2 m of the surface.

Given the drainage features incorporated into the Project design, it is expected that the localized effects of dykes and associated drainage channels would be contained within the terrestrial habitat affected by the Project Footprint and terrestrial habitat zone of influence.

Regarding groundwater and edge effects on shoreline wetlands, Project studies indicated that edge and elevated groundwater effects on terrestrial habitat typically extended less than 50 m from the shoreline in the proxy areas, but this distance varied with inland edge topography and ecosite type. Based on these studies, the predicted areas of reservoir-related edge and groundwater effects on terrestrial habitat at Year 30 (when most reservoir expansion is expected to have already occurred) were as follows:

- All of the reservoir shoreline areas with surface elevations between 159 m and 160 m ASL would be altered by elevated groundwater;
- All areas within 50 m of the Year 30 reservoir shoreline would experience edge effects; and,
- All of the peatlands in back bay areas with strong hydrological connections to the reservoir (determined by peatland type and surface elevation).

To estimate terrestrial habitat alteration beyond Year 30, it was assumed that habitat alteration would persist over the long term in the following locations:

- A 50 m buffer of the permanent infrastructure to account for edge effects;
- All of the PDAs and road corridors to account for permanent infrastructure edge effects and areas heavily disturbed during construction. Note that these areas overlap the 50 m permanent infrastructure buffer;
- A 50 m buffer of the reservoir at 30 year to account for reservoir-related edge effects. Shoreline erosion predictions indicated that by Year 30 most of the shoreline will either be relatively stable or

will be receding at low rates (Section 6.4.2);

- Areas adjacent to the reservoir with surface elevations between 159 and 160 m ASL to account for reservoir-related groundwater effects. Note that these areas overlap the 50 m buffer of the 30 year reservoir;
- Low-lying peatlands adjacent to the year 30 reservoir shoreline to capture reservoir-related hydrological effects in these peatlands and reservoir expansion beyond Year 30. Predictions are that the majority of reservoir expansion will have occurred by Year 30; Section 6.4.2). Note that these low lying peatlands overlap the areas delineated by the previous two bullets.

These assumptions were expected to overestimate the total amount of permanent habitat alteration because it is likely that all of the road corridors and a substantial proportion of the PDA area included by the second bullet will not be used.

Temporary habitat alteration was assumed to include all of the remaining areas affected during construction since most of these areas would be rehabilitated and/or undergo natural regeneration. It is anticipated that a substantial proportion of the borrow areas will not be used. While it is likely that portions of the used borrow areas would remain permanently altered, this area could be offset by the portions of the PDAs that are not disturbed and where alteration is temporary.

Map 2-10 shows the predicted areas of Project-related edge and groundwater effects on terrestrial habitat. All areas that are within 50 m of the shoreline also experience edge effects. Where edge and groundwater related effects overlap, groundwater is identified as the source of effects. Some of the peatlands in the groundwater zone of influence adjacent to the reservoir may undergo reservoir expansion after Year 30. Given drainage measures incorporated into the Project design, Project-related groundwater effects on terrestrial habitat are only expected to occur at the reservoir edge and near the dykes.

On this basis, the reservoir habitat zone of influence could potentially affect an additional 1,266 ha of terrestrial habitat. The largest areas where the water table could either rise into or become more elevated within the soil and the plant rooting zone are located in bays along the Nelson River, particularly in Gull Lake and at stream outlets (Map 2-10).

Most of the affected habitat within the entire terrestrial habitat zone of influence (Map 2-11) is needleleaf treed (primarily black spruce) on mineral, thin peatlands and other peatlands (88%), with most of the remaining habitat comprised of broadleaf treed on all ecosites and low vegetation on shallow peatland (Table 2-17). Compared with the Year 30 reservoir expansion area, the habitat zone of influence has a relatively high proportion of upland habitat, including broadleaf habitat. A description of coarse and broad habitat types in the Year 30 reservoir habitat zone of influence is provided below.

Habitat Recovery

As shown in Map 2-11, some of the direct and indirect construction effects on terrestrial habitat are predicted to be permanent (*i.e.*, persist for the 100 year prediction period). Habitat effects in other construction areas will be temporary. Some of the areas that were assumed to be affected during construction will not have been disturbed (*e.g.*, portions or all of some potential disturbance areas and borrow areas). In some of the remaining temporary construction areas, recovery to native habitat types would occur either naturally or be assisted by rehabilitation.

The degree to which habitat recovers to a native type in a particular temporarily cleared construction footprint and the surrounding area will largely depend on the degree of vegetation, organic material, topsoil and subsoil removal during construction and the nature of rehabilitation efforts. Studies conducted in old borrow areas in Study Zone 4 and other nearby locations found that habitat recovery during the first 30 years was generally quite limited in areas where vegetation and soil were stripped and the standard rehabilitation practices were applied. Under these conditions, sparse vegetation and thin soil is expected to develop in a narrow band around the periphery of cleared areas. Better habitat recovery may occur in localized areas where there is thicker spreading of stock-piled material and the site conditions and **propagule** availability are more favourable for soil development, plant colonization and plant growth. Habitat recovery was only marginally better in locations where a variety of more intensive rehabilitation measures were applied.

Standard Project rehabilitation practices for EMPAs and temporarily cleared areas will include spreading the stripped organic material, topsoil, subsoil and woody material that was stock-piled during construction for future site rehabilitation. Areas that should receive rehabilitation treatments beyond the standard practices due to special concerns are discussed in the relevant VEC and supporting topic sections.

The situations where native habitat loss and alteration in the temporarily cleared construction footprints and their zones of influence is assumed to be permanent (*i.e.*, will continue through the entire 100 year post-Project prediction period) are as follows:

- In used portions of borrow areas. Excavation completely removes soil and, in some locations, exposes the water table. Even with rehabilitation, the period required for soil and native vegetation to redevelop in areas where borrow material has been excavated is typically longer than 100 years;
- In affected permafrost peatlands. Indirect effects on permafrost peatlands will not decline substantially because permafrost melting and the subsequent habitat effects generally cannot be reversed within 100 years. Note that ground ice melting is expected to occur as a lagged response to past climate change (Section 2.3.3.2) even if the Project does not proceed; and,
- In areas where the groundwater has risen to within 50 cm of the ground surface. As described above, depth to water table is generally the strongest influence on vegetation structure and a strong influence on vegetation composition when it is this close to the ground surface.

Because the locations and extents of borrow area use will not be known until construction is complete and because the degree of rehabilitation success will not be known for many years into operation, it was assumed that undisturbed potential construction areas and regenerating construction areas would still be altered habitat at Year 30. It was also assumed that 50% of the undisturbed potential construction areas and regenerating construction areas would be permanently affected habitat (*i.e.*, still altered at Year 100). These were expected to be an overestimates for the reasons described in Section 2.3.6.2.1 and because all of the PDAs were classified as long-term habitat alteration (see below).

Temporary Project effects would occur in construction areas that were disturbed but not cleared and by disturbance within the habitat zone of influence. However, the amounts, locations and nature of the disturbances will not be known until construction completion. For this reason, and because the permanent portion of the Project Footprint would create edge effects (which includes physical disturbance by people using the area during operation), it was assumed that all of the PDAs would be permanently altered habitat. These potential construction areas were not buffered to account for edge effects. In other words, the PDAs captured the terrestrial habitat zone of influence of the adjacent Project Footprint as well as long-term habitat disturbance. The permanent portion of the Project Footprint that did not have a construction PDA were buffered by 50 m to capture the zone of edge effects.

Habitat Affected at Year 30

Based on the above assumptions, the net amount of native habitat affected at Year 30 is estimated to be approximately 8,667 ha (Table 2-18).

The predicted land cover composition of habitat affected during operation is primarily needleleaf treed on mineral, thin peatland and other peatlands (78% combined), with low vegetation types, mostly on other peatlands, comprising over 12% of the total area. Most of the habitat area affected is located in the flooded areas north and south of Gull Lake and in the larger borrow areas on the north esker and at the west end of the south access road.

The remainder of this section describes the land cover and coarse habitat that is predicted to be affected at Year 30 by degree of permanence and primary influence.

Permanent Habitat Loss

Infrastructure

A total of 179 ha of habitat is predicted to be lost to permanent infrastructure, such as the generating station and dykes. Most of the habitat lost is composed of black spruce on thin peatland, mineral soil and shallow peatland at 56% (Appendix 2C). Broadleaf treed on all ecosites forms a relatively large proportion of habitat loss (7.5%) compared to other sources, most of which is located in the dyke footprint north of Gull Lake. Low vegetation types make up most of the remaining affected habitat. The only shore zone habitat affected would be shrub / low vegetation on ice scour mineral.

Permanent roads are predicted to remove 301 ha of habitat, more than half of which (57%) would be black spruce treed on thin peatland. Black spruce treed on shallow peatland and on mineral make up most of the rest of the affected area. No substantial amounts of shore zone wetlands are predicted to be lost to this feature.

Reservoir (including predicted reservoir expansion)

A total of 4,845 ha of terrestrial habitat is predicted to be lost to the reservoir by year 30 (Table 2-18). Black spruce treed on shallow and on thin peatland make up 63% of the habitat loss combined. Black spruce treed on mineral, low vegetation types and tall shrub on riparian peatland make up most of the remaining habitat loss. Shore zone wetlands make up approximately 5% of the total habitat lost.

Permanent Habitat Alteration

Reservoir Zone of influence

It is estimated that 1,266 ha of terrestrial habitat would be permanently altered by reservoir effects on groundwater (Table 2-18). The composition of affected habitat is similar to that of the reservoir, but there is a higher proportion of black spruce treed on mineral soil and thin peatland (22% and 37%, respectively), and a lower proportion of the same on shallow peatland. Additionally, broadleaf habitat makes up 4% of the altered area. The larger proportion of mineral habitat affected is due to edge effects, while the larger proportion of peatland habitat alteration is due to groundwater effects (Appendix 2C).

Other long-term indirect effects

Other indirect effects due to infrastructure, road corridors and potential disturbance areas are predicted to alter 1,314 ha of habitat (Table 2-18). The composition of habitat is very similar to that of the reservoir zone of influence. Black spruce treed on thin peatland (33%) and on shallow peatland (22%) made up the highest proportion of altered habitat. This is followed by jack pine treed on mineral or thin peatland and low vegetation on shallow peatland (8% each), and black spruce treed on mineral (7%).

Temporary Habitat Alteration

Borrow Areas

It is estimated that 1,181 ha of terrestrial habitat will be unused or temporarily altered in borrow areas earmarked for construction (Table 2-18). The habitat types in these areas are predominantly mineral and thin peatland types, including black spruce treed on thin peatland (41%) and on mineral soil (24%). This is followed by jack pine treed on mineral or thin peatland (9%), low vegetation on mineral or thin peatland (3%) and broadleaf treed types (2% combined). Most of the shallow peatland habitat temporarily affected would be comprised of black spruce treed on shallow peatland (14%).

Remaining Areas

A total of 316 ha of habitat is predicted to be unused or temporarily affected in the regenerating portions of other, non-borrow area construction footprint components (Table 2-18). The habitat in these areas are a mixture of types dominated by black spruce treed on thin peatland and on shallow peatland (42%), with most of the remaining area in low vegetation on mineral, thin and shallow peatland (24% combined) and black spruce treed on mineral (12%).

Table 2-17: Estimated Area (ha) of Terrestrial Habitat Affected During Operation By Source and Permanence.

Source and Permanence	Habitat Affected (ha)
Permanent Habitat Loss	
Project Footprint	
Infrastructure	494
Initial Flooding	4,173
Reservoir expansion to Year 30	671
Sub-total	**5,339**
Permanent Habitat Alteration	
Indirect reservoir effects over the long-term	1,266
Other long-term indirect effects	1,314
Sub-total	**2,580**
Temporary Habitat Alteration	
Undisturbed potential and regenerating borrow areas from construction	1,181
Other Undisturbed potential and regenerating construction areas	316
Total at Year 30	**9,416**
Complete Habitat Recovery by Year 100	**-748**
Total at Year 100	**8,667**

Table 2-18: Coarse habitat composition of areas affected at Year 30, by source and permanence.

Land Cover Type	Coarse Habitat Type	Permanent habitat loss			Permanent habitat alteration		Temporary habitat Alteration	Total Area
		Infra-structure	Initial Flooding	Reservoir Expansion	Indirect reservoir effects	Other long term indirect effects	Undisturbed potential construction areas and regenerating construction areas	
Broadleaf treed on all ecosites	Broadleaf treed on all ecosites	3.1	0.6	0.7	1.4	2.9	2.6	1.5
	Broadleaf mixedwood on all ecosites	-	0.9	1.1	2.7	0.4	0.1	0.9
Needleleaf treed on mineral or thin peatland	Black spruce mixedwood on mineral or thin peatland	0.4	0.1	0.1	0.8	0.1	0.2	0.2
	Jack pine mixedwood on mineral or thin peatland	0.6	0.0	0.0	0.0	1.7	1.3	0.5
	Jack pine treed on mineral or thin peatland	2.7	0.1	0.2	0.5	7.9	8.7	2.8
	Black spruce treed on mineral soil	12.1	6.8	10.1	22.0	6.5	21.9	11.7
	Black spruce treed on thin peatland	44.6	27.5	30.5	36.9	32.8	37.7	32.2
Tall shrub on mineral or thin peatland	Tall shrub on mineral or thin peatland	0.3	0.5	0.4	0.1	1.3	1.1	0.7
Low vegetation on mineral or thin peatland	Low vegetation on mineral or thin peatland	6.9	2.1	1.5	1.1	7.5	4.6	3.3
Needleleaf treed on other peatlands	Jack pine treed on shallow peatland	0.0	-	-	-	0.5	0.0	0.1
	Black spruce mixedwood on shallow peatland	-	0.0	0.1	0.0	0.1	0.0	0.0
	Black spruce treed on shallow peatland	13.9	34.2	38.6	25.8	21.6	15.1	27.5
	Black spruce treed on wet peatland	2.0	1.3	1.3	0.9	0.7	0.4	1.1
	Tamarack- black spruce mixture on wet peatland	0.3	0.5	0.6	0.4	0.2	-	0.3
	Tamarack treed on shallow peatland	1.4	0.9	0.8	0.4	1.0	0.3	0.8
	Tamarack treed on wet peatland	-	0.0	0.1	0.0	-	-	0.0
	Black spruce treed on riparian peatland	0.2	0.6	0.5	0.2	0.4	0.0	0.4
	Tamarack- black spruce mixture on riparian peatland	0.0	0.0	0.3	0.3	0.0	-	0.1
Tall shrub on other peatlands	Tall shrub on shallow peatland	0.1	0.3	0.5	0.2	0.5	0.0	0.3
	Tall shrub on wet peatland	-	0.6	0.8	0.1	0.1	-	0.3
Low vegetation on other peatlands	Low vegetation on shallow peatland	5.4	6.8	3.8	3.0	7.7	4.5	5.8
	Low vegetation on wet peatland	1.2	2.1	1.2	0.4	0.9	0.0	1.3
Shrub/ low vegetation on riparian peatland	Tall shrub on riparian peatland	0.8	4.8	2.2	0.6	0.3	0.0	2.5
	Low vegetation on riparian peatland	0.7	3.8	1.7	1.0	1.3	0.1	2.2
Nelson River shore zone	Nelson River shrub and/or low vegetation on ice scoured upland	2.6	2.0	1.6	0.3	0.7	0.0	1.3
	Nelson River shrub and/or low vegetation on upper beach	0.5	3.0	1.2	1.0	0.9	0.3	1.8
	Nelson River shrub and/or low vegetation on sunken peat	0.0	-	-	-	2.0	1.1	0.5
	Nelson River marsh	-	0.2	0.3	-	-	-	0.1
Off-system shore zone	Off-system marsh	0.0	0.2	0.0	0.0	0.1	0.0	0.1

Total habitat area (ha)	*494*	*4,173*	*671*	*1,266*	*1,314*	*1,497*		*9,416*

Note: Reported areas are terrestrial habitat areas only (*i.e.*, areas do not include human infrastructure or deep water).

Incremental Reservoir Expansion

Some terrestrial habitat loss and alteration would occur even if the Project does not proceed (see Section 2.3.2). Table 2-19 provides predicted incremental Project land cover losses after considering existing Nelson River mineral bank erosion. Accounting for baseline mineral shore erosion reduces the overall area of Project-related effects, but does not substantially change the proportion of the Regional Study Area affected. As well, land cover composition effects do not substantially change after considering baseline erosion, but there is a reduction in the contribution of Project to effects on tall shrub on uplands habitat, to the extent this type does not naturally developing at the new shoreline location (Table 2-19).

Table 2-19: Predicted Future Hectares of Inland habitat Loss Due to Nelson River Expansion from Mineral Bank Erosion Without the Project, by Prediction Period

Land Cover	Predicted Effects: First 30 Years			Net % Land Area
	Project Operation Effects	Baseline Erosion	Net Project-related Effects	
Broadleaf treed on all ecosites	223	2	221	2.4
Needleleaf treed on mineral or thin peatland	4,460	32	4,428	47.5
Tall shrub on mineral or thin peatland	61	0	61	0.7
Low vegetation on mineral or thin peatland	312	3	309	3.3
Needleleaf treed on other peatlands	2,850	8	2,842	30.5
Tall shrub on other peatlands	57	-	57	0.6
Low vegetation on other peatlands	666	1	665	7.1
Shrub/ low vegetation on riparian peatland	435	15	420	4.5
Nelson River shore zone	342	28	314	3.4
Off-system shore zone	9	-	9	0.1
Land area (ha)	*9.416*	*89*	*9,326*	

Note: Reported areas are terrestrial habitat areas only (*i.e.*, areas do not include human infrastructure or deep water).

Downstream

An area of the existing Nelson River below the spillway would be dewatered and become relatively dry during most Project operating conditions. Dewatering is not expected to increase inland habitat area because the high **velocity** discharges that would periodically pass through the spillway should prevent the development of inland habitat.

Dewatering would reduce the depth to water table in some areas adjacent to the south shoreline of the Nelson River. The extent and nature of related indirect effects on soils, vegetation and other habitat attributes would depend on the existing soil moisture regime. Terrestrial habitat effects in this area are generally expected to be minimal because most of the surface is already considerably elevated above the high water line.

2.4 INTACTNESS

2.4.1 Introduction

Intactness is the degree to which an ecosystem remains unaltered by human features that remove habitat and increase **fragmentation**. Fragmentation is a landscape-level process in which human features progressively subdivide habitat blocks into smaller and more isolated fragments (McGarigal and Cushman 2002). Fragmentation affects ecosystem processes as well as species (Saunders *et al.* 1991; Soulé *et al.* 2004; McGarigal and Cushman 2002; Lindenmayer and Fischer 2006; Fischer and Lindenmayer 2007). Among other things, fragmentation creates edges, reduces the size of interior areas, isolates habitat and reduces connectivity.

In the context of intactness, edges are the peripheral areas of intact habitat blocks that are adjacent to human features. Ecosystem attributes such as vegetation composition, soil conditions and microclimate are altered in edges. Edges also include the zone where the adjacent human features create conditions (*e.g.*, noise) that cause some animals to either partially or completely avoid areas that would otherwise be high quality habitat for them (*i.e.*, reduced **effective habitat**).

A **core area** is the interior area of an intact habitat block that remains after the edge width is removed (Forman 1995). Core areas are large undisturbed areas. Core areas are important for species that require remoteness from human features and activities. Minimum core area size and shape requirements vary by species (Environmental Law Institute 2003).

Human linear features can have effects beyond habitat fragmentation when they improve movement or dispersal. For example, linear features can facilitate increased predation (see Section 7.4) or the migration of invasive plants (see Section 3.3).

Intactness was selected as a VEC to provide an overall assessment of Project effects on intactness for species and ecosystems. Highly sensitive species are addressed separately in the bird and mammal sections of the TE SV. Table 1A-1 provides additional details explaining why intactness was selected as a VEC.

Road density (*i.e.*, km of roads per km^2 of study area) is often used as a single, synthetic indicator of fragmentation effects on plant and animal populations (Forman 1995). Among other things, higher road density improves access, which can lead to increased resource harvesting, collision mortality, habitat disturbance and fire frequency. Trails, cutlines and other linear features can also contribute to fragmentation but to a lesser degree (Mattson 1993 cited in AXYS 2001). Although some authors have recommended that each type of human linear feature be included and assigned a weight that reflects a qualitative degree of effects (Mattson 1993 cited in AXYS 2001), a literature review revealed no examples of a weighted linear feature density being applied in an environmental assessment or for management purposes. However, some authors implicitly weight the effects of different types of linear features when delineating core areas by using buffer widths that vary with the linear feature type (Mace *et al.* 1996; Anderson *et al.* 2002; Salmo Consulting Inc. *et al.* 2003; Strittholt *et al.* 2006).

Recent approaches to evaluating intactness have used linear feature density and core area abundance as indicators for intactness (*e.g.*, Salmo Consulting Inc. *et al.* 2003). Core area abundance is used as a complementary indicator because linear feature density ignores the spatial distribution of linear features. For example, are most of the linear features concentrated in a single corridor or are they dispersed throughout a study area? These two situations have very different implications for intactness and regional ecosystem health as demonstrated by the single large or several small (SLOSS) debate.

2.4.2 Assessment Approach and Methods

2.4.2.1 Overview

Linear feature density and core area abundance were the indicators used for intactness. Measured indicator attributes for linear feature density (*i.e.*, km of linear features per square km of land area) were total linear feature density, transportation density and linear density by feature type. Core area indicator attributes included total core area as a percentage of land area, the total number of core areas by size class and the sizes of the largest core areas. When delineating core areas, larger buffers were applied to linear feature types that facilitate relatively high human use.

The general assessment approach and methods for intactness were the same as those used for all of the key topics (see Sections 1.3, 1.4 and 2.2). Details specific to the intactness assessment are provided below.

2.4.2.2 Study Areas

The Intactness Local and Regional Study Areas were Zones 3 and 5 in Map 2-1, respectively. The Local Study Area is the area where **Project feature**s could directly or indirectly create **linear disturbance** and/or affect individual core areas. The Regional Study Area was large enough to represent a region level ecosystem in the Keeyask area (see Section 1.3.5).

Proxy and benchmark areas were not required for the intactness assessment.

2.4.2.3 Information Sources

Sections 1.4.6 and 2.2.4 describe the information sources generally used in the assessment.

The Split Lake Post-Project environmental review (Split Lake Cree – Manitoba Hydro Joint Study Group 1996) includes information regarding historical terrestrial area losses due to development.

Published studies specifically examining intactness in the Regional Study Area were not discovered.

Environmental impact assessment studies for intactness were conducted in the Regional Study Area over a nine-year period (2004-2011). Linear features in the Intactness Regional Study Area were mapped from a combination of digital ortho-rectified imagery produced from 1:60,000 stereo air photos acquired in 1999, Landsat 7 panchromatic imagery acquired circa 2000, large scale stereo air photos acquired over several years in the 1990s and infrastructure mapping from NTS and other sources. Large scale (1:15,000) stereo air photos acquired in 2003 and 2006 were available for Study Zone 4 (Map 2-1). Portions of the linear feature mapping were validated during helicopter surveys.

Some of the cutlines mapped from the older remote sensing were regenerating back to shrubland or woodland. It is also possible for cutlines to revegetate within a forest landscape and become non-existent from the perspective of predators or prey. The point at which a cutline becomes sufficiently overgrown to no longer function as a predator travel corridor is not well understood. Following Salmo Consulting

Inc. *et al.* (2003), cutlines with woody vegetation that was at least 1.5 m tall and having total canopy closure of either at least 75% or between 25% and 75% with no game trails or evidence of human use were assumed to no longer function as corridors. Vegetation regeneration was evaluated in 883 km of the mapped cutlines using low level oblique helicopter-based photography acquired during summer 2011.

The non-linear human features relevant for the core area analysis were identified by selecting the human land cover class from the terrestrial habitat mapping completed for Study Zone 4 (Section 2.2) and from air photos and satellite imagery for the remainder of the Regional Study Area.

2.4.2.4 Methods

All highways, roads outside of settlements, winter roads, rail lines, transmission lines, dykes and cutlines were included in the total linear feature length calculations. For each study area, total linear feature density in kilometres per square kilometre was measured as the total length of all linear features divided by the total land area in the Regional Study Area. Transportation density was the combined density of roads and rail lines.

Core areas were mapped as the residual areas left after buffering linear features and other human footprints. Three key considerations when measuring core area are which human features to include, the buffer width for various types of human features and the minimum size and shape before a patch is considered to be a core area. Low use linear features (transmission lines, trails, dykes and cutlines) were buffered 200 m (Mace *et al.* 1996). High use linear features (railways and all types of roads) and settlements were buffered 500 m (Salmo Consulting Inc. *et al.* 2003). Core areas were the residual polygons remaining after the following areas were removed: (i) the buffers of human features; (ii) polygons that were not at least 350 m wide somewhere within their perimeter; and, (iii) polygons smaller than 200 ha in size. Since some species or ecosystem processes may require larger core areas, changes to core area indicator attributes using a 1,000 ha minimum core area size and effects on the largest core areas were also considered.

For the historical analysis, it was assumed that linear feature density and the human feature footprint were virtually nil in 1900 (SE SV Section 2.2). Thus, the linear features included in the current conditions map captures historical changes that have not been eliminated by flooding and Nelson River surface area expansion due to water regulation. Historical changes to the non-linear component of human features was provided by the terrestrial habitat map information regarding historical conditions (Section 2.3.3.1).

Future changes to human features, with and without the Project, were obtained from the predictions provided in Sections 2.6.3.3 and 1.5.

Separate benchmark values were used to evaluate the degree of **adverse** effects related to linear feature density and core areas. For total linear feature density, the magnitude of adverse effects were as follows: small for regional values below 0.40 km/km^2; moderate for regional values between 0.40 km/km^2 and 0.60 km/km^2; and, high for regional values greater than 0.60 km/km^2 (Salmo Consulting Inc. *et al.* 2003). For total core area percentage of land area, the magnitude of adverse were as follows: small for regional values greater than 65% of land area; moderate for regional values between 40% and 65%; and, high for regional values lower than 40% of land area (Salmo Consulting Inc. *et al.* 2003; Athabasca Landscape Team 2009; and Dzus *et al.* 2010). These benchmark values should be cautious given the buffer widths and the fact that some linear features only serve as movement corridors when the ground is frozen.

2.4.3 Environmental Setting

2.4.3.1 Historical Conditions

The human linear features and other infrastructure present in 2010 were constructed after 1900, particularly starting with the completion of the rail line to Churchill in 1929 (SE SV Section 2.2). Most of the features were constructed after 1957, with the communities of Gillam and Split Lake being the largest of these in area (Section 2.3.3.1). As described in Section 2.3.3.1, the human infrastructure footprint has removed and altered terrestrial habitat, which has reduced total core area in the Regional Study Area.

Past and existing linear features (*e.g.*, roads, railways, transmission lines) and other permanent infrastructure have reduced the intactness of the regional terrestrial ecosystem. Linear features have had a range of effects such as wildlife disturbance, increased wildlife mortality and human initiated fires through improved access for people and predators. Permanent human features have removed portions of core areas (*i.e.*, a large undisturbed area) and subdivided other core areas into smaller blocks. The extent of these changes are reflected in the core area map for current conditions (see next section).

2.4.3.2 Current Conditions

2.4.3.2.1 Linear Disturbance

There were 549 km of linear features in the Local Study Area in 2010 (Table 2-20), yielding a total linear feature density of 1.49 km/km^2 and a transportation density of 0.13 km/km^2 (Table 2-21). The 463 km of cutlines (most of which were created during pre-Project feasibility studies) accounted for the highest proportion of the linear feature density (1.29 km/km^2). Roads, including the 23 km access road developed for the Keeyask Infrastructure Project, accounted for 0.13 km/km^2 of the local total linear feature density.

The Regional Study Area included 5,628 km, or 0.45 km/km^2, of linear features (Table 2-20; Table 2-21). Roads comprised only 0.06 km/km^2 of this total, with PR 280 making the largest contribution. Most of the remaining roads occur around small communities, such as York Landing and Ilford (Map 2-12), with about half of these being winter roads. Roads and rail lines combined to create a regional transportation density of 0.07 km/km^2. Transmission lines and cutlines accounted for the majority of the non-transportation linear features in the Regional Study Area (Table 2-20), occurring at densities of 0.06 km/km^2 and 0.30 km/km^2, respectively (Table 2-21).

It is likely that portions of cutlines and transmission line rights-of-way were not being used as human or wildlife corridors because they are partially overgrown, distant from any current human uses and/or are accessible only in winter due to natural barriers (Salmo Consulting Inc. *et al.* 2003). A survey of 883 km of cutlines older than 10 years conducted in 2011 showed that approximately 35% of cutlines had regenerated to the degree that they likely no longer functioned as travel corridors. Additional portions of cutlines are expected to regenerate over time. It was likely that some of the cutlines segments not surveyed also had sufficient regeneration to inhibit travel. To illustrate the effect of cutlines in the Regional Study Area, linear feature density declined from 1.49 km/km^2 to 0.20 km/km^2 for the Local Study Area and from 0.45 km/km^2 to 0.15 km/km^2 for the Regional Study Area when cutlines were excluded.

There was a very high concentration of linear features near Thompson (Map 2-12), which skewed the linear feature densities for the rest of the Regional Study Area. Although the Thompson area comprised only 15% of the Regional Study Area, it included 38% of the linear features (Table 2-20). Total linear feature density in the Thompson area was 1.27 km/km^2 compared with only 0.32 km/km^2, in the rest of the Regional Study Area. When cutlines were excluded for the portion of the Regional Study Area away from Thompson, linear feature density declined from 0.32 km/km^2 to 0.15 km/km^2.

Total linear feature density for the entire Regional Study Area was at the low end of the moderate magnitude effects range (between 0.40 km/km^2 and 0.60 km/km^2) and well within the small magnitude range for the Regional Study Area outside of the Thompson area.

Table 2-20: Linear Feature Length by Feature Type in the Local and Regional Study Areas and the Thompson portion of the Regional Study Area in 2010

Linear Feature Type	Regional Study Area			Local Study Area
	Overall	Thompson Area	Rest of the Regional Study Area	
Highway	345	83	262	18
Road	244	117	127	38
Winter road	149	-	149	-
Rail line	149	4	145	2
Sub-total for transportation density	887	204	683	57
Transmission line	752	84	667	3
Dyke	21	-	21	6
Path	213	10	203	21
Cutline	3,755	1,865	1,891	463
Sub-total for other linear features	4,741	1,959	2,782	492
All linear features	5,628	2,163	3,465	549

Table 2-21: Linear Feature Density by Feature Type in the Local and Regional Study Areas and the Thompson portion of the Regional Study Area in 2010

Linear Feature Type	Regional Study Area			Local Study Area
	Overall	Thompson Area	Rest of the Regional Study Area	
Highway	0.03	0.05	0.02	0.04
Road	0.02	0.07	0.01	0.09
Winter road	0.01	0.00	0.01	0.00
Railway	0.01	0.00	0.01	0.00
Sub-total for transportation density	0.07	0.12	0.06	0.13
Transmission line	0.06	0.05	0.06	0.01
Dyke	0.00	0.00	0.00	0.01
Path	0.02	0.01	0.02	0.05
Cutline	0.30	1.09	0.18	1.29
Sub-total for other linear features	0.38	1.15	0.26	1.36
All linear features	0.45	1.27	0.32	1.49
Study area land area (km^2)	12,385	1,708	10,677	425

2.4.3.2.2 Core Areas

The 111 core areas larger than 200 ha and wider than 350 m accounted for 84% of Regional Study Area land area in 2010 (Table 2-22), which is well above the 65% benchmark value for shifting from small to moderate magnitude core area effects.

The 57 core areas larger than 1,000 ha and wider than 350 m comprised 83% of land area (Table 2-22). Reducing the core area size cutoff from 1,000 ha to 200 ha only increased core area percentage by 2%, demonstrating that most of the core area occurs in patches larger than 1,000 ha.

A few very large core areas contributed over half of the total core area. The five largest core areas were 270,769 ha, 181,147 ha, 87,329 ha, 69,165 ha and 33,809 ha in size. The largest core area was located north of PR 280 between Split Lake and Long Spruce Generating Station (Map 2-13). The second largest core area occurred north of PR 280 between Split Lake and Thompson.

Table 2-22: Core Area Measures by Minimum Core Area Size

Core Area Minimum size	Number	Total area (ha)	Core Area Percentage of RSA
200 ha	111	1,046,097	84
1,000 ha	57	1,022,169	83

Notes: RSA= Regional Study Area.

Although several of the islands in the Gull and Stephens reaches of the Nelson River had core areas larger than 200 ha, none were larger than 1,000 ha. Core areas on Nelson River islands totalled 3,704 ha with the largest being 941 ha, 811 ha and 682 ha in size (Table 2-23).

Table 2-23: Core areas on Nelson River islands.

Island	Island Name	Lake Name	Area (ha)
1	Caribou Island	Gull Lake	279
2		Split Lake	941
3		Split Lake	811
4		Split Lake	399
5		Split Lake	362
6	Callan Island	Stephens Lake	682
7		Stephens Lake	230
All			3,704

2.4.3.3 Current Trends (no future climate change)

With the exception of the conversion of terrestrial to aquatic areas, the intactness measures capture the cumulative effects of past and existing human activities on intactness. Ongoing Nelson River shoreline erosion resulting from hydroelectric development and natural processes would further reduce core area. Portions of existing cutlines and trails will become overgrown with time, which would increase intactness by reducing total linear feature density and increasing core area. While these ongoing adverse core area responses to past human developments are locally important, their magnitude at the regional scale is very small since they are typically located on the fringes of existing core areas.

2.4.4 Project Effects, Mitigation and Monitoring

Potential Project effects on intactness include increased fragmentation from linear features, lower total core area and fewer large core areas. Newly constructed roads, transmission lines, trails and cutlines add to linear feature density. Core area is reduced by Project features that either remove existing core area or occur within 500 m of an existing core area.

2.4.4.1 Construction Period

2.4.4.1.1 Potential Project Effects

Linear Disturbance

The Project is expected to reduce total linear feature density in the Local Study Area from 1.49 km/km^2 to 1.24 km/km^2 during construction (Table 2-24). This occurs because cutlines would be replaced by Project features such as borrow areas and reservoir clearing. Most of the roads used by the Project during construction are either already existing or would be built on existing cutlines (Map 2-14). Local transportation density would increase from 0.13 km/km^2 to 0.17 km/km^2, primarily due to temporary access roads to borrow areas and excavated material placement areas.

Similarly, total linear feature density in the Regional Study Area is predicted to decline from 0.45 km/km^2 to 0.44 km/km^2 for the entire Regional Study Area and from 0.32 km/km^2 to 0.31 km/km^2 in the portion of the Regional Study Area outside of the Thompson area (Table 2-24). Regional transportation density would remain at 0.07 km/km^2 due to the short length of new Project roads relative to the size of the Regional Study Area.

Total linear feature density for the entire Regional Study Area is expected to remain at the low end of the moderate magnitude effects range (between 0.40 km/km^2 and 0.60 km/km^2) and well within the small magnitude range for the Regional Study Area outside of the Thompson area.

Table 2-24: Linear Feature Density by Feature Type in the Local and Regional Study Areas and the Thompson portion of the Regional Study Area During Construction

Linear Feature Type	Local Study Area	Regional Study Area		
		Overall	Thompson Area	Rest of the Regional Study Area
Highway	0.04	0.03	0.05	0.02
Road	0.12	0.02	0.07	0.01
Winter road	0.00	0.01	0.00	0.01
Railway	0.00	0.01	0.00	0.01
Sub-total for transportation density	0.17	0.07	0.12	0.07
Transmission line	0.01	0.06	0.05	0.06
Dyke	0.07	0.00	0.00	0.00
Path	0.05	0.02	0.01	0.02
Cutline	0.95	0.29	1.09	0.16
Sub-total for other linear features	1.07	0.37	1.15	0.25
All linear features	1.24	0.44	1.27	0.31

Core Areas

Project construction would have localized core area effects, primarily resulting from reservoir clearing, dyke construction and coffer dam diversion. One core area slightly larger than 1,000 ha and two core areas between 200 ha and 1,000 ha would be removed. In addition, several larger core areas on the north and south sides of the Nelson River would become smaller (Map 2-15). One of these latter core areas is on Caribou Island and is the largest core area on an island in the Keeyask reach of the Nelson River. The largest core area along the north side of the Nelson River would be reduced by 879 ha, or 36%. Not including the 270,800 core area north of PR 280, the number of core areas at least 200 ha in size that overlap the Local Study Area would decline from 13 to 12 and their combined area would decline by from 115,308 ha to 106,754 ha.

Regional effects on core area during construction are considerably lower than local effects. The Project is not predicted to reduce the percentage of the Regional Study Area in core areas larger than 200 ha (Table 2-25). The percentage of the Regional Study Area in core areas larger 1,000 ha would be reduced by 1% from approximately 83% to 82%, which is still well within the small magnitude range of 66% to 100%.

The total number of core areas in the Regional Study Area larger than 200 ha is predicted to remain at 111 because, although a few core areas are completely removed, several other core areas are fragmented into smaller blocks (Table 2-25). The total number of core areas larger than 1,000 ha would be reduced by one. None of the very large core areas would be lost.

These are overestimates of core area reductions because some portions of the Project Footprint will not be used (see Section 2.3.6.2.1).

Table 2-25: Number, Percentage of Regional Study Area and Mean Size of Core Areas During Construction, by Minimum Core Area Size

Core Area Minimum size	Core Area as a Percentage of Land Area			Number			Mean size (ha)		
	Existing	Post-Project	Change	Existing	Post-Project	Change	Existing	Post-Project	Change
200 ha	84	84	-1	111	111	0	9,424	9,347	-77.0
1,000 ha	83	82	-1	57	56	-1	17,933	18,091	158.5

Notes: RSA= Regional Study Area. EE= existing environment; PP= post-Project.

2.4.4.1.2 Mitigation

Some of the potential Project effects on intactness were mitigated by minimizing the size of the Project Footprint during Project design (Section 4.2.3). Important design adjustments were selecting a low-head option that considerably reduced Project-related flooding and reducing the total size the borrow area and EMPA footprints. Additional mitigation during construction will include the following:

- Clearing and disturbance within the Project Footprint will be minimized to the extent practicable;
- Disturbance of areas adjacent to the Project Footprint will be avoided to the extent practicable; and,
- A rehabilitation plan will be developed that gives preference to rehabilitating the most affected priority habitat types using approaches that "go with nature" (Keeyask JKDA Schedule 7-1); and,
- Except for existing resource-use trails (see Construction Access Management Plan), Project-related cutlines and trails will be blocked where they intersect the Project Footprint, and the portions of these features within 100 m of the Project Footprint will be revegetated to minimize the risk of invasive plant, accidental fire and other access-related effects.

2.4.4.1.3 Residual Effects

After considering mitigation and the effects of other past and existing human features, residual Project effects on regional intactness during construction are expected to include slight positive changes to linear feature density and slight adverse changes to core area percentage. Total linear feature density is predicted to decline slightly. The predicted minimum core area percentage during construction would be slightly reduced to 82%, which is considerably above the 65% value for the transition from small to moderate magnitude effects.

Using the criteria established to determine the significance of Project effects for regulatory purposes (Section 1.4.4), the likely residual effects of Project construction on intactness are expected to be adverse, small in extent, long-term in duration and small in magnitude.

2.4.4.2 Operation Period

2.4.4.2.1 Potential Project Effects

Linear Disturbance

Operation commencement would have no immediate effects on linear disturbance because flooding occurs on linear features already affected during construction. Reservoir expansion would remove portions of cutlines and temporary access roads, slightly reducing linear feature density in the Local Study Area from 1.24 km/km^2 to 1.23 km/km^2 by Year 30.

For the Regional Study Area, total linear feature density, transportation density and non-transportation density are predicted to remain at to 0.07 km/km^2 and to 0.37 km/km^2 during the first 30 years of operation.

Over time, there would be some native habitat recovery in portions of existing and Project-related linear features, which would further reduce the total linear feature density. To illustrate, 35% of the 883 km of cutlines older than ten years that were surveyed for regeneration had regenerated to the degree where they were no longer expected to function as travel corridors.

Table 2-26: Linear Feature Density by Feature Type in the Local and Regional Study Areas and the Thompson portion of the Regional Study Area After 30 Years of Operation

Linear Feature Type	Local Study Area	Regional Study Area		
		Overall	Thompson Area	Rest of the Regional Study Area
Highway	0.04	0.03	0.05	0.02
Road	0.12	0.02	0.07	0.01
Winter road	0.00	0.01	0.00	0.01
Railway	0.00	0.01	0.00	0.01
Sub-total for transportation density	0.17	0.07	0.12	0.07
Transmission line	0.01	0.06	0.05	0.06
Dyke	0.07	0.00	0.00	0.00
Path	0.05	0.02	0.01	0.02
Cutline	0.94	0.29	1.09	0.16
Sub-total for other linear features	1.06	0.37	1.15	0.25

All linear features	1.23	0.44	1.27	0.31

Core Areas

The first 30 years of operation is not predicted to remove any of the individual 200 ha or 1,000 ha core areas but would reduce the total amount of core area by 179 ha (Table 2-27; Map 2-15). Mean core area size would decrease by approximately 2 ha for both minimum core area sizes (Table 2-27).

The percentage of the Regional Study Area in core area measured to one decimal place is expected to remain over 80% during the first 30 years of operation (Table 2-27), which is well within the small magnitude range of 66% to 100%.

Habitat recovery in the temporarily cleared and rehabilitated areas would slightly increase core area, somewhat offsetting Project related habitat loss. Natural regeneration on portions of existing cutlines would further increase core area. In summary, the Regional Study Area core area percentage is expected to remain over 80%, which is well above the 65% value for the transition from small to moderate magnitude effects.

Table 2-27: Number, Percentage of Regional Study Area and Mean Size of Core Areas After 30 Years of Operation, by Minimum Core Area Size

Core Area Minimum size	Core Area Percentage of RSA			Number		
	Construction	Operation	Change	Construction	Operation	Change
200 ha	84	84	0	111	111	0
1,000 ha	82	82	0	56	56	0

2.4.4.2.2 Mitigation

Mitigation during operation, in addition to that already incorporated into Project design and the construction phase, will include the following:

- The rehabilitation plan developed and initiated during construction will extend into the operation phase, and continue until all necessary rehabilitation is completed; and
- Except for existing resource-use trails (see Construction Access Management Plan), Project-related cutlines and trails will be blocked where they intersect the Project Footprint, and the portions of these features within 100 m of the Project Footprint will be revegetated to minimize the risk of invasive plant, accidental fire and other access-related effects.

Improved public access will be somewhat offset if and when Manitoba Infrastructure and Transportation closes PR 280 between the junctions of the north access road and PR 290.

2.4.4.2.3 Residual Effects

After considering mitigation and the effects of other past and existing human features, residual Project effects on regional intactness during operation are expected to include a slight adverse change to core area percentage.

Using the criteria established to determine the significance of Project effects for regulatory purposes, the likely residual effects of Project operation on intactness are expected to be adverse, small in extent, long-term in duration and small in magnitude.

2.4.4.3 Residual Effects Conclusion

Overall, the likely residual Project effects on regional intactness are expected to be adverse but regionally acceptable because linear feature density declines slightly, no very large core areas are lost and core area percentage is expected to remain over 80%, which is well within the small magnitude range. This occurs because the Project is located in a portion of the Regional Study Area where intactness is already low due to past and current human development.

Using the criteria established to determine the significance of Project effects for regulatory purposes, the likely residual effects of Project operation on intactness are expected to be adverse, small in extent, long-term in duration and small in magnitude.

2.4.4.4 Uncertainty

Overall, the uncertainty related to intactness assessment is moderately low. Existing human infrastructure can be mapped with high accuracy. The spatial extent of Project-related physical terrestrial loss as a percentage of the Regional Study Area can also be predicted with relatively high accuracy. For Project effects on intactness to substantially increase beyond the residual effects predictions, Project effects on core areas would need to be considerably higher than the estimates used for the effects assessment. Although the risk of access-related effects such as a large and severe burn are low, such events could occur.

2.4.4.5 Environmental Monitoring and Follow-up

KCNs have expressed concern regarding cumulative effects of the Project on Local Study Area intactness. It was perceived that linear features such as transmission lines reduce forest habitat for wildlife (Split Lake Cree – Manitoba Hydro Joint Study Group, 1996). There are concerns that the construction of roads, camps and transmission lines disrupt habitat and migratory paths of wildlife, and increased access would increase the stress on wildlife populations (FLCN Traditional Knowledge Report 2010 Draft).

Monitoring will be conducted to determine actual Project effects on the intactness indicators and to confirm the effectiveness of mitigation measures used to minimize access from the Project Footprint to existing linear features that were previously difficult to access (see Section 2.12, Table 2.12-1 for a summary of planned monitoring). Monitoring details are provided in the Terrestrial Environment Monitoring Plan (Manitoba Hydro 2012b).

2.5 FIRE REGIME

2.5.1 Introduction

Fire is the keystone ecosystem process in the boreal forest (Weber and Flannigan 1997; Burton et al. 2008). Large wildfires are the dominant type of stand-replacing natural disturbance throughout most of the Canadian boreal forest (Payette 1992). Although other disturbances such as windthrow or insect and disease infestations can also affect large areas, wildfire causes complete vegetation mortality over a much larger area. Large wildfires have played and continue to play critical roles in producing the vegetation mosaic that exists in the Regional Study Area and maintaining regional ecosystem health.

A fire regime is the pattern, type, intensity, frequency and seasonality of fires that prevails in an area (Stocks *et al.* 2003). In the boreal forest, fires are generally large crown fires that occur infrequently and cause complete above ground vegetation mortality in the areas that they burn. Due to the conditions which favour them, large fires tend to be moderate to high intensity (*i.e.* “hot”) fires that pass through rapidly and thus kill the aboveground but not the belowground parts of trees and understorey vegetation (Heinselman 1981; Rowe 1983; Cogbill 1985; Eberhart and Woodard 1987; Johnson 1992).

Many boreal plant species are adapted to a particular fire regime. Factors that change fire regime parameters (*e.g.*, average annual area burned, average time between large fires) can indirectly change the most abundant species (Weber and Flannigan 1997). For example, increases in fire frequency, severity and/or total area burned could create long-term effects on regional habitat composition and many ecosystem patterns and processes (*e.g.*, ecosystem diversity, species distributions and abundances, carbon storage). Some of the potential changes include:

- A higher percentage of area in young habitat and lower percentages of area in mature and old habitat;
- Increases in the abundances of post-fire pioneer plant species (e.g., Bicknell’s geranium, fireweed or haircap mosses) and a reduction in the abundances of plant species found in mature to old vegetation (e.g., reindeer lichens); and,
- A higher percentage of area that is regenerating poorly relative to what was typically found there (e.g., the conversion of forests to shrublands and/or grasslands).

Fire regime was selected as a supporting topic to provide information on the keystone driver for terrestrial habitat and ecosystems. Table 1A-1 provides additional details explaining why fire regime was selected as a supporting topic.

Humans can alter the fire regime in several ways. Fire suppression has reduced the area burned in commercial forestry zones and near communities. As well, roads may limit the spread of some fires (Lesieur *et al.* 2002). In contrast, improved access can increase the total area burned and change other fire regime attributes because humans are a major cause of fire ignitions. Fire ignition data for Manitoba indicates that humans started 56% of the forest fires that occurred in the 30 years from 1985 to 2004 (Table 2D-1). Unsuppressed human-caused fires accounted for 15% of the total area burned (Table 2D-2), which is substantial considering that the total area burned includes very large natural burns in remote areas.

2.5.2 Assessment Approach and Methods

2.5.2.1 Overview

Annual burn rate and fire size distribution were the measurable indicators for the fire regime supporting topic.

The general assessment approach and methods for the fire regime were the same as those used for all of the key topics (see Sections 1.3, 1.4 and 2.2). Details specific to the fire regime are provided below.

2.5.2.2 Study Areas

The Fire Regime Local and Regional Study Areas were Study Zones 3 and 6 in Map 2-1, respectively. The 41,966 ha Local Study Area is the area where direct and indirect Project effects on the fire regime may occur. These potential effects include the Project causing a large fire and/or altering the behaviour of a naturally started fire.

The 3,050,000 ha Regional Study Area was an area large enough to capture a relatively stable fire size distribution for a geographic area surrounding the Project Footprint. Regional Study Area boundaries were delineated based on burns in the geographic area surrounding the Project where climate and surface materials were relatively homogenous. See Appendix 2A Section 2.14.2 for details regarding how this was completed.

Proxy and benchmark areas were not required for the fire regime assessment.

2.5.2.3 Information Sources

Sections 1.4.6 and 2.2.4 describe the information sources generally used in the assessment.

There are numerous scientific publications regarding the fire regime and its role in maintaining ecosystem health in the boreal forest of Canada (*e.g.*, Rowe and Scotter 1973; Bonan and Shugart 1989) and Manitoba's boreal shield (Ehnes 1998).

The governments of Manitoba and Canada have maintained fire history records that include the Regional Study Area, either in GIS format or with attributes that facilitate spatial referencing (Manitoba Conservation 2010; Stocks *et al.* 2003).

Environmental impact assessment studies for the fire regime were conducted in the Regional Study Area over a seven-year period (2004-2009). Recent fire history for Study Zone 4 was mapping by photo-interpreting and digitizing burned patches from the same large scale stereo photography used to produce the habitat mapping (Section 2.2.4.4). For the portions of Study Zone 6 outside of Study Zone 4, burns were mapped using a combination of the Manitoba Conservation fire database (Manitoba Conservation 2010), the Canadian large fire database (Stocks *et al.* 2003) and Landsat 7 composite imagery. Due to the mapping scale and the nature of these data, they were only adequate to map coarse boundaries and large skips (*i.e.*, areas skipped over and left unburned). Burns were dated using a combination of stereo photos from multiple years and the Manitoba Conservation fire database (Manitoba Conservation 2010).

2.5.2.4 Methods

A fire history database capturing the 1979 to 2008 period was created for the Regional Study Area from the available information (Section 2.5.2.3). Like most fire databases developed for remote regions, the Regional Study Area fire history database had two limitations. It was missing substantial portions of older burns because they have been hidden by more recent burns. In addition, areas that the fire skipped over often cannot be distinguished from the surrounding area in older burns. The first limitation underestimates total area burned while the second overestimates total area burned.

The annual burn rate, size class distribution of burns and other fire regime attributes were calculated from the Regional Study Area fire history database. The annual burn rate was the average area burned each year in the Regional Study Area over the 30 year period from 1979 to 2008.

Since the Project does not include features that intentionally alter the fire regime, the focus of the fire regime assessment is the risk that the Project could alter the fire regime.

Historical conditions and trends in the Regional Study Area fire regime were inferred from published literature that included this area in its geographic scope.

2.5.3 Environmental Setting

2.5.3.1 Historical Conditions

Prior to fire suppression, most of the area that burned in the boreal forest burned in a small proportion of years when weather events created conditions that favoured the spread of wildfires over large areas (Cogbill 1985; Johnson 1992; Hunter 1993). Consequently, infrequent large fires accounted for the majority of the area burned in the boreal forest. It has been estimated that 3% of the wildfires were responsible for 98% of the area burned under natural conditions (Weber and Stocks 1998) or that 5 % of the wildfires were responsible for 95 % of the area burned (Straus et al. 1989 cited in Johnson *et al.* 1995).

The fire regime is highly dependent on climate (Weber and Flannigan 1997). There are numerous scientific publications documenting the effects of past climate change and predicting future effects of climate change on the fire regime and ecosystem patterns and processes in the Canadian boreal forest (*e.g.*, Flannigan and Van Wagner 1991; Payette 1992; Bergeron *et al.* 2004; Tornacai 2009; Gillet *et al.* 2004; Soja *et al.* 2007; Bond-Lamberty *et al.* 2007; Girardin and Mudelsee 2008). Many of these studies have included the Regional Study Area in their geographic extents. The reported trends include higher fire activity in the Regional Study Area.

Although there is evidence that humans can alter the fire regime in several ways (Section 2.5.1), there is insufficient data to characterize the extent to which this has occurred in the Regional Study Area.

2.5.3.2 Current Conditions

Available fire history data indicates that fires burned approximately 1,045,000 ha in the Regional Study Area between 1979 and 2008 (Table 2-28). Keeping in mind the limitations of these data described above (Section 2.5.2.4), the annual burn rate is crudely estimated to be nearly 35,000 ha/year, or 1.3% of the Regional Study Area (Table 2-28). Using this burn rate, the recent fire cycle is crudely estimated to be nearly 78 years (note that some burned area for older burns is hidden by overlapping recent burns and a longer period is required to reliably estimate fire cycle length).

Approximately 39% of Study Zone 6 and 34% of the Regional Study Area burned at least once between 1979 and 2008, with some locations burning more than once during this period. The years that had the largest area burned, in descending order, were 1989, 1992, 2003, 1998, 1994, 1981, 1995 and 2005 (Table 2D-3).

Only 4% of the fires accounted for 58% of the area burned in the Regional Study Area (see Appendix 2D). The latter percentage was much lower than the boreal forest historical value of approximately 98%, possibly due to the described data limitations and human intervention, among other reasons.

Large burns were distributed throughout the Regional Study Area (Map 2-16). The most recent burns were near the Nelson River, encompassing a large proportion of the Local Study Area. Most of the proposed reservoir area south of the Nelson River in the Gull Lake reach burned in 2005. The eastern portion of the north esker burned in 1999 and 2001 and the eastern portion of Caribou Island burned in 2003.

Much of the Regional Study Area consists of young regenerating habitat. As of 2010, approximately 9% of the Regional Study Area was less than 11 years old and 39% was 30 years old or younger.

Table 2-28: Area Burned from 1979 to 2008 for the Study Areas and Fire Regime Study Area Fire Cycle Length

Study Area	Land Area (ha)	Area Burned (ha)	Annual Rate	
			Area (ha)	% of Area
Regional Study Area	2,700,000	1,045,059	34,835	1.29
Study Zone 5	1,240,000	425,879	n/a	n/a
Study Zone 4	167,255	42,088	n/a	n/a
Local Study Area	13,043	4,058	n/a	n/a

Table 2-29: Burned Area Attributes by Size Class

Size Class	Burns		Percentages	
Size Class (ha)	Number of Burns	Total Area Burned (ha)	Percentage Of Total Number of Burns	Percentage Of Total Area of Burns
100	550	4,454	75	0

Size Class	Burns		Percentages	
1,000	90	34,221	12	3
10,000	65	264,973	9	25
100,000	28	741,411	4	71
All sizes	733	1,045,059	100	100

2.5.3.3 Current Trends (no future climate change)

The key driving factors for future changes in the fire regime are climate, the pattern of human development, human fire ignitions and fire suppression policy. It is possible that the annual burn rate has not completely adjusted to climate change that has already occurred (see Sections 2.3.3 and 2.5.3.1). To the extent this is the case, the proportion of the Regional Study Area that is recently burned may increase somewhat in the future.

2.5.4Project Effects, Mitigation And Monitoring

Potential Project effects on the fire regime relate to pathways that could change fire frequency, size and/or severity. Better access and more traffic and people could lead to a higher number of large and/or severe wildfires, increased fire severity or increased fire frequency, among other things. Project features such as the reservoir, windrowed **debris** or permanent access roads could alter fire behaviour. If such effects occur, they could alter vegetation, facilitate spreading invasive species and/or affect terrestrial ecosystem health.

2.5.4.1 Construction Period

2.5.4.1.1 Potential Project Effects

There are no defined components of the Project that are expected to alter the fire regime. Burning of brush piles produced by reservoir clearing will occur in the winter. Measures to minimize the risk of starting a peat fire include burning material in the winter when the ground is frozen, and burning in areas selected to minimize the risk of peat fires (PD SV Section 3.5). Windrows and other Project features may be too small to impede the spread or alter the behaviour of a large wildfire.

2.5.4.1.2 Mitigation

Mitigation to minimize the risk of Project-related fire regime effects during construction will include the following:

- Fire control precautions contained in the construction EnvPP will include roving fire patrols, fire suppression training for personnel and maintaining fire suppression equipment, infrastructure, and fire detection sensors in the generating station work area;
- Except for existing resource-use trails (see Construction Access Management Plan), Project-related

cutlines and trails will be blocked where they intersect the Project Footprint, and the portions of these features within 100 m of the Project Footprint will be revegetated to minimize the risk of habitat disturbance, invasive plant spreading, accidental fires and access-related effects; and

- Public access to the Project will be restricted at PR 280 and the Butnau dyke.

Wildfires that cannot be controlled by the Project, if any, may be addressed by Manitoba Conservation based on the policies in place at the time.

2.5.4.1.3 Residual Effects

With mitigation, the Project construction is not expected to affect the fire regime.

2.5.4.2 Operation Period

2.5.4.2.1 Potential Project Effects

The risk of Project-related fire regime effects could either decline or increase slightly during operation. Although Project activity in the area will be greatly reduced, better public access would increase the risk of human-caused wildfires. This improved public access would be somewhat offset in the event that Manitoba Infrastructure and Transportation closes PR 280 between the junctions of the north access road and PR 290. The reservoir flooding and expansion that widens the Nelson River around Gull Lake could reduce the probability that a wildfire will cross the river, thereby potentially reducing burn size.

2.5.4.2.2 Mitigation

Mitigation during operation will include the following:

- Fire control precautions such as maintaining fire suppression equipment in the generating station area, water trucks, as well as fire procedure manuals and emergency response crews (see EnvPP Volume); and,
- Except for existing resource-use trails (see Construction Access Management Plan), Project-related cutlines and trails will be blocked where they intersect the Project Footprint, and the portions of these features within 100 m of the Project Footprint will be revegetated to minimize the risk of habitat disturbance, invasive plant spreading, accidental fires and access-related effects.

Wildfires resulting from improved access on PR 280 would be addressed by Manitoba Conservation based on the policies in place at the time.

2.5.4.2.3 Residual Effects

Project mitigation is expected to minimize the risk of fire regime effects during operation.

2.5.4.3 Residual Effects Conclusion

Overall, the likely residual Project effects on the fire regime are expected to be adverse but negligible assuming that the fire prevention measures are effective. It is expected that any accidental Project-related fires will be extinguished before they become large. There is a risk that better public access could increase the number of human-caused fires during the operation phase.

2.5.4.4 Uncertainty

There is unavoidable uncertainty regarding the prediction that the Project will not substantially increase the risk of a producing a large fire that would not otherwise occur.

2.5.4.5 Environmental Monitoring and Follow-up

Although the Project is not expected to create large accidental fires or to alter fire behaviour, a single large and/or severe fire could substantially alter habitat composition over the long-term, which could affect many of the terrestrial environment predictions. Therefore, the occurrence and nature of Project-related fire regime effects will be monitored. Monitoring details are provided in the Terrestrial Environment Monitoring Plan (Manitoba Hydro 2012b).

2.6 TERRESTRIAL HABITAT

2.6.1 Introduction

Habitat was the foundation for understanding the terrestrial environment, and for predicting the potential effects of the Project on it. Habitat effects were of interest in their own right. Plants and animals use habitat for survival and reproduction. Habitat effects also served as a proxy for many terrestrial ecosystem effects. Indicators for some components of ecosystem health were derived from terrestrial habitat maps and descriptions.

2.6.2 Assessment Approach and Methods

2.6.2.1 Overview

The terrestrial habitat supporting topic provides an overall indication of Project effects on terrestrial habitat and serves as a proxy for many other pathways of effects on ecosystem health and on ecosystem components not directly addressed by assessment. Table 1A-1 provides additional details explaining why terrestrial habitat was selected as a supporting topic.

Total native habitat area and the areas of regionally common native broad habitat types were the indicators for the terrestrial habitat supporting topic since they summarize the overall effects on terrestrial habitat. Effects on other habitat types of concern are addressed by the ecosystem diversity and wetland function VECs (Sections 2.7 and 2.8, respectively).

The general assessment approach and methods for terrestrial habitat were the same as those used for all of the key topics (see Sections 1.3, 1.4 and 2.2). Details specific to the terrestrial habitat assessment are provided below.

2.6.2.2 Study Areas

The Habitat Local and Regional Study Areas were Study Zones 2 and 5 in Map 2-1, respectively.

The 18,689 ha Local Study Area (Map 2-1) consisted of the Project Footprint as well as a 150 m buffer around it. As described in Section 1.3.5, the Local Study Area was the maximum potential spatial extent of direct and indirect Project effects on terrestrial habitat. In addition, the Local Study Area was expected to capture Project features that cannot be defined with reasonable confidence prior to construction (*e.g.*, relocated trails to borrow areas, accidental disturbance). A 150 m wide buffer of the Project Footprint was thought to be a cautious approach (*i.e.*, worst case scenario) to capturing all potential indirect changes to habitat composition (Section 2.3.6.1).

As described in Section 1.1, the 1,420,000 Regional Study Area was an area encompassing the Project Footprint that was large enough to capture a region level ecosystem. That is, a relatively homogenous area in terms of its ecological context (*e.g.*, climate, surface materials) that was large enough to capture the key ecological processes operating at the regional ecosystem level (such as the fire regime) and populations of most of the resident wildlife species. In practical terms, the Regional Study Area size was determined such that it was large enough to maintain a relatively stable habitat composition in response to the natural fire regime. In other words, one large fire was unlikely to substantially change the proportion of any habitat type, thereby providing alternative habitat for species to move to when large fires occur. Appendix 2A Section 2.14.2 provides details on how the Regional Study Area boundaries were delineated.

2.6.2.3 Information Sources

Sections 1.4.6 and 2.2.4 describe the information sources generally used in the assessment. Information sources used to measure the terrestrial habitat indicators are described in Section 2.2.4.

2.6.2.4 Methods

The terrestrial habitat composition of the Regional Study Area was estimated by extrapolating the detailed habitat mapping completed for Study Zone 4 (Section 2.2.4.4) based on the existing proportions of terrestrial habitat types in Study Zone 4 (for details see Section 2.2.4.4).

Total native habitat area and the areas of common native broad habitat types were calculated from Regional Study Area terrestrial habitat composition. A common broad habitat was one that covered more than 10% of Regional Study Area land area and was expected to persist in the Regional Study Area. On this basis, ground ice peatland types were excluded from consideration (Section 2.3.3.2).

Information regarding historical conditions and current trends was drawn from Sections 2.3.3 and 2.3.5.

The benchmark values used to evaluate residual effects on terrestrial habitat were the rules of thumb provided by Hegmann *et al.* (1999), calculated as percentages of area affected as follows. Adverse residual effects of the Project in combination with past and existing projects on terrestrial habitat are: small magnitude for area losses below 1% of historical habitat area in the Regional Study Area; moderate magnitude for area losses between 1% and 10% of regional historical habitat area; and, high magnitude for area losses greater than 10% of regional historical habitat area.

2.6.3 Environmental Setting

The two common native broad habitat types were black spruce dominant on thin peatland and black spruce dominant on shallow peatland. Section 2.3.4.2 provides descriptions of these habitat types. A third broad habitat type that covered approximately 12% of Regional Study Area land area (black spruce dominant on ground ice peatland) was not included because this type is expected to disappear over time (Section 2.3.3).

2.6.3.1 Historical Change

Human impacts, climate change and fire regime changes have been the primary factors driving terrestrial habitat changes in the Regional Study Area over the past few hundred years (Section 2.3.3). Human infrastructure (*e.g.*, settlements, roads and transmission lines) and hydroelectric development have substantially altered inland and Nelson River shoreline habitat. Total historical inland habitat loss and alteration was estimated to be approximately 61,108 ha, or almost 5%, of Regional Study Area inland habitat area.

Natural climate warming that began about 150 years ago has already dramatically altered some peatland types, primarily through permafrost melting and fire regime changes. Analysis of historical air photos from the Regional Study Area indicated that permafrost melting in peat plateau bogs has converted some peatland area to open water that is too deep to support shoreline wetland habitat (Sections 2.3.3 and 2.3.5.2).

2.6.3.2 Current Conditions

Terrestrial habitat accounted for approximately 87% of the 1,420,000 ha Regional Study Area in 2010 (Table 2-2). The two common broad habitat types that will not eventually disappear due to natural permafrost melting covered approximately 53% of land area, consisting of black spruce dominant on thin peatland at 32.3% of land area and black spruce dominant on shallow peatland at 20.3% of land area (Table 2-30). Both of the common broad habitat types were widely distributed in Study Zone 4 (Map 2-17), which is the portion of the Regional Study Area with detailed habitat mapping (Section 2.3.4.1).

Compared with the Regional Study Area, the 13,043 ha of terrestrial habitat in the Local Study Area had lower percentages of the common broad habitat types (Table 2-2) because the uncommon and rare habitat types were predominantly associated with mineral ecosites, which were more prevalent in the Local Study Area. These mineral habitat types were concentrated along the esker north of Gull Lake, and along the banks of the Nelson River.

Table 2-30: Estimated total area and percentage of land area for the common broad habitat types

Broad Habitat Type	Regional Study Area	Local Study Area

	Area (ha)	Percentage of Land Area	Area (ha)	Percentage of Land Area
Black spruce dominant on thin peatland	400,572	32.3	3,748	28.7
Black spruce dominant on shallow peatland	251,951	20.3	1,994	15.3
Common broad habitat types	652,523	52.6	5,742	44.0
All broad habitat types	1,228,642	100.0	13,043	100.0

2.6.3.3 Current Trends (no future climate change)

Past and existing human impacts and climate change are expected to continue to drive future habitat change in the Regional Study Area even if the Project does not proceed. Ongoing shoreline erosion will continue to remove and alter habitat, including the common broad habitat types. For example, it is estimated that approximately 91 ha of inland habitat would be lost to ongoing mineral bank erosion in the Keeyask reach of the Nelson River between 2006 and 2047 (equivalent to 30 years post-Project; see Section 2.2.4). The two common habitat types make up a relatively low proportion of the habitat lost to ongoing shoreline erosion (18%; Appendix 2C). This is because there is a relatively high amount of mineral ecosites along the Nelson River banks, and erosion disproportionately affects mineral banks. Mineral and shore zone habitat types make up the majority of habitat lost to ongoing erosion by 2047 (see Section 2.7.3.3).

It is estimated that past climate change will convert at least one-quarter of the remaining peat plateau bog area to open water and other peatland types by 2047. Based on past experience, it is anticipated that only a small proportion of this area will convert to open water that is too deep to be classified as terrestrial habitat. Changes to the common terrestrial habitat types as a lagged response to past climate change are not expected.

2.6.4 Project Effects, Mitigation and Monitoring

2.6.4.1 Construction Period

2.6.4.1.1 Potential Project Effects

The Project Footprint could remove or alter up to 6,872 ha, or 0.6%, of terrestrial habitat during construction, but this could increase to 6,952 ha if borrow area E-1 is used (see Section 2.3.6.2.1). For the common broad habitat types, the Project Footprint could remove or alter up to 1,939 ha of black spruce dominant on thin peatland and 1,221 ha of black spruce dominant on shallow peatland, or 0.5% each of the total Regional Study Area cover for those types.

These estimates of habitat loss in the Project Footprint are cautious for several reasons. It is estimated that substantial portions of the borrow areas will not be used (Section 2.3.6.2.1). It is also likely that portions of the remaining potential disturbance areas will not be used. In addition, the environmental protection plans (EnvPPs; Section 8.3.2) include measures intended to minimize clearing and disturbance outside of the permanent Project components (*e.g.*, in the remaining potential disturbance areas). Finally, borrow area E-1 is unlikely to be used.

Disturbance and indirect habitat alteration in areas surrounding the Project Footprint are expected to generally extend less than 50 m into the surrounding area. Assuming that all of terrestrial habitat within the terrestrial habitat zone of influence (*i.e.*, within a 50 m buffer of the Project Footprint) is lost or altered, the total amount of affected habitat is predicted to increase to 8,927 ha, or 0.7%, of the terrestrial habitat in the Regional Study Area (Table 2-31).

In the unlikely event that borrow area E-1 is used, Project construction could directly and indirectly affect approximately 9,070 ha of terrestrial habitat. Even in this unlikely outcome, the Project is predicted to affect less than 1% of the area for total terrestrial habitat and each of the common habitat types.

Table 2-31: Potential Areas of All Terrestrial Habitat and the Common Broad Habitat Types Affected by the Project Footprint During Construction and Operation

Broad Habitat Type	Construction		Operation	
	Area Affected by Project (ha)	Percentage of Regional Study Area Land Area	Area Affected by Project (ha)	Percentage of Regional Study Area Land Area
Black spruce dominant on thin peatland	2,606	0.6	2,767	0.7
Black spruce dominant on shallow peatland	1,513	0.6	1,627	0.6
All broad habitat types	8,927	0.7	9,416	0.7

2.6.4.1.2 Mitigation

Mitigation of Project effects on terrestrial habitat already achieved through avoidance during Project design includes selecting a low-head option that considerably reduced Project-related flooding and reducing the total size the borrow area and EMPA footprints. Additional mitigation for terrestrial habitat effects during construction will include the following:

- The portion of borrow area N-6 identified as the N6 sensitive site in Map 2-19 will be avoided (see Section 2.7.4.1 for rationale);

- Clearing and disturbance within the Project Footprint will be minimized to the extent practicable;
- Disturbance of areas adjacent to the Project Footprint will be avoided to the extent practicable; and,
- Except for existing resource-use trails (see Construction Access Management Plan), Project-related cutlines and trails will be blocked where they intersect the Project Footprint, and the portions of these features within 100 m of the Project Footprint will be revegetated to minimize the risk of habitat disturbance, invasive plant spreading, accidental fires and access-related effects.

Mitigation implemented for ecosystem diversity and wetland function (Sections 2.7.4 and 2.8.4) are expected to further reduce Project effects on terrestrial habitat. The EnvPPs (Manitoba Hydro 2012a) will also include measures to minimize the risk that invasive plants, accidental fires and accidental spills will affect terrestrial habitat.

2.6.4.1.3 Residual Effects

With mitigation, the Project in combination with other past and existing projects is predicted to increase cumulative effects on total terrestrial habitat and the common broad habitat types from 5% to almost 6% of Regional Study Area habitat, which is considered to be a moderate magnitude effect.

2.6.4.2 Operation Period

2.6.4.2.1 Potential Operation Effects

Flooding at the start of Project operation would be contained within areas already affected during construction (Section 2.3.6.3). Over the long-term, the Project is predicted to directly and indirectly affect approximately 9,416 ha, or 0.8%, of terrestrial habitat (Table 2-17). In the unlikely event that borrow area E-1 was used during construction, habitat loss and alteration during operation would be approximately 9,558 ha.

As described in Section 2.3.6.3.1 and shown in Map 2-11, some of these habitat effects are predicted to be permanent while others represent areas that are either undergoing habitat regeneration or were not actually altered during construction. The permanent components of the Project Footprint account for approximately 4,667 ha of the 5,339 ha of permanent habitat loss (Table 2-17). Reservoir expansion is predicted to convert an additional 671 ha, or 0.05%, of terrestrial habitat to aquatic areas by Year 30 of operation, with most of this habitat change occurring during the first 15 years. The common broad habitat types make up 47% of the total habitat affected by Year 30 of operation, with black spruce dominant on thin peatland comprising the largest proportion (29%; Appendix 2C).

It is predicted that the Project could permanently alter an additional 2,580 ha, or 0.2%, of habitat over the long-term. Approximately half of this total area arises from reservoir-related groundwater and edge effects as described in Section 2.3.6.3.1 and shown in Map 2-11. A further 1,497 ha of altered habitat area arises from clearing-related edge effects and potential construction disturbance areas. This is expected to be an overestimate of habitat alteration because habitat edge effects are expected to generally extend less than 50 m from cleared areas and because portions of the potential construction disturbance areas will not actually be disturbed during construction. As with the Project Footprint, the two common habitat types make up the largest proportion of permanently altered habitat (46%), but a larger proportion (32%) is made up of black spruce dominant on thin peatland (Appendix 2C).

Temporary Project effects, which are estimated to account for approximately 748 ha of the affected habitat area (Table 2-17), are the potential construction areas that were not actually affected and the portions of cleared construction areas that are undergoing natural regeneration or rehabilitation. Black spruce dominant on thin peatland is proportionately the largest component of the recovery area. However, specific proportions would not be known until after Project construction, partially because portions of the temporarily cleared areas will be rehabilitated to priority habitat types (Section 2.7.4.1.2).

2.6.4.2.2 Mitigation

Mitigation during operation, in addition to that already incorporated into the Project design, will include the following:

- Except for existing resource-use trails (see Construction Access Management Plan), Project-related cutlines and trails will be blocked where they intersect the Project Footprint, and the portions of these features within 100 m of the Project Footprint will be revegetated to minimize the risk of habitat disturbance, invasive plant spreading, accidental fires and access-related effects.

Mitigation implemented for ecosystem diversity and wetland function (Sections 2.7.4 and 2.8.4) is expected to further reduce total Project effects on habitat. The EnvPPs will include measures to minimize the risk that accidental fires and spills will affect terrestrial habitat. Improved public access will be somewhat offset when Manitoba Infrastructure and Transportation closes PR 280 between the junctions of the north access road and PR 290.

2.6.4.2.3 Residual Effects

After considering mitigation, Project construction is expected to affect less than 1% of total terrestrial habitat area and the areas of the common habitat types. After considering mitigation and the effects of other past and existing projects and activities, it is predicted that Project construction could increase the affected amounts of total terrestrial habitat and the common habitat types to almost 6% of historical area, which is considered to be a moderate magnitude effect.

2.6.4.3 Residual Effects Conclusion

Overall, the likely Project residual effects on total terrestrial habitat and the common habitat types are expected to be adverse but within an acceptable range because the small Project-related incremental addition to the amounts affected maintains the magnitude of Project effects in combination with past and current projects and human activities well within the moderate range (*i.e.*, below 10% of historical area).

2.6.4.4 Uncertainty

Overall, the uncertainty related to the terrestrial habitat supporting topic assessment is moderately low. Existing terrestrial habitat can be mapped with relatively high accuracy. The spatial extent of Project-related physical terrestrial loss as a percentage of the Regional Study Area can also be predicted with relatively high accuracy. Although there is moderate uncertainty as to the total area of terrestrial habitat that could be indirectly affected, the total habitat area affected by the Project would need to increase by more than four times before the magnitude of effects would transition from the moderate to the high range.

2.6.4.5 Environmental Monitoring and Follow-up

Terrestrial habitat monitoring provides an effective means to monitor a wide array of terrestrial ecosystem effects because it is readily monitored and it is the foundation for the terrestrial environment assessment. Terrestrial habitat effects are of interest on their own and for plants and animals. Terrestrial habitat effects are also a key driver for effects on other ecosystem components.

Terrestrial habitat monitoring will include documenting the actual direct and indirect effects of the Project on terrestrial habitat. Monitoring details are provided in the Terrestrial Environment Monitoring Plan (Manitoba Hydro 2012b).

2.7 ECOSYSTEM DIVERSITY

2.7.1 Introduction

Maintaining native biodiversity is fundamental to maintaining overall ecosystem function and ecosystem health (CCFM 1995). The three main components of biodiversity are genetic, species and ecosystem diversity.

Ecosystem diversity refers to the number of different ecosystem types and the distribution of area amongst them. Like terrestrial habitat, ecosystem diversity is of particular interest in its own right and because it is a proxy for effects on many ecosystem components, such as species diversity and wildlife habitat availability.

Some ecosystem types are particularly important because they make disproportionately high contributions to ecosystem functions and/or biodiversity and/or are highly valued by people. Environmental assessment and land use management guidelines commonly identify effects on rare habitats or high quality habitats for focal wildlife species as an issue of high concern (*e.g.*, CCFM 1995; Canadian Environmental Assessment Agency 1996). Rarity is also one of the criteria used to identify priority habitats in biodiversity conservation action plans (*e.g.*, UK Biodiversity Partnership 2007; Raunio *et al.* 2008). In this vein, other recent EISs have used vegetation types of concern as a VEC (*e.g.*, Mackenzie Gas Project 2004; Encana Corporation 2007).

Ecosystem diversity was selected as a VEC to provide information on ecosystem diversity, partial information on plant species diversity and serve as a proxy for other ecosystem components and functions. The ecosystem diversity VEC evaluates inland ecosystem diversity since the wetland function VEC addresses shoreline wetland ecosystems. Table 1A-1 provides additional details explaining why ecosystem diversity was selected as a VEC.

Numerous metrics have been developed to measure stand and landscape level ecosystem diversity. Leitão *et al.* (2006) review potential patch and landscape diversity metrics and reduce them to a core set that they expect will meet the typical needs of land use planning. The core set includes two composition metrics (patch richness and class area proportion) and eight configuration metrics (*e.g.*, patch number). The patch richness, class area proportion and patch number metrics can be alternative names for the number of broad habitat types, proportions of each habitat type and number of stands, depending on how these are measured.

2.7.2 Assessment Approach and Methods

2.7.2.1 Overview

Habitat mapping was used as a proxy for ecosystem mapping, as is often done (*e.g.*, Leitão *et al.* 2006; Noss *et al*. 2009). The mapped habitat attributes (Section 2.2.4.4) represent most of the major stand level ecosystem components, biomass and controlling factors.

Indicators for ecosystem diversity were habitat composition and **priority habitat type**s. Habitat composition provided an overall representation of ecosystem diversity. Priority habitat types were those native habitat types that were particularly important for ecological and/or social reasons.

Since ecosystems are hierarchically structured (see Section 1.1), ecosystem diversity can be measured at multiple ecosystem levels. Habitat composition measured stand and landscape level ecosystem diversity (stand level habitat patches were the proxies for stand level ecosystem types). Site level ecosystem diversity was also partially captured by the priority habitat indicator in the sense that high species richness (*i.e.*, alpha diversity) and structural complexity were among the criteria for identifying priority habitat types.

Attributes measured for the habitat composition indicator were the number of native broad habitat types, the distribution of area amongst the native broad habitat types, the number of stands representing each native habitat type (ecosystem types represented by only a few stands in the Regional Study Area are more vulnerable to disappearing). The intactness VEC includes indicators that address the **landscape configuration** component of ecosystem diversity.

The priority habitat indicator for ecosystem represented stand level habitat, or ecosystem, types that were particularly important for one or more ecological and/or social reasons. Specifically, priority habitat types were the native inland broad habitat types that were regionally rare or uncommon, highly diverse (*i.e.*, species rich and/or structurally complex), highly sensitive to disturbance, had a high potential to support rare plants and/or were highly valued by people. The wildlife sections address habitat types that are especially important to wildlife. Especially important shoreline wetland types are addressed by the wetland function VEC. Table 1A-1 provides additional details explaining why priority habitat types was selected as an indicator for the ecosystem diversity VEC.

The attribute measured for the priority habitat indicator were the areas of each priority habitat type.

The general assessment approach and methods for ecosystem diversity were the same as those used for all of the key topics (see Sections 1.3, 1.4 and 2.2). Details specific to ecosystem diversity are provided below.

2.7.2.2 Study Areas

The Ecosystem Diversity Local and Regional Study Areas were Study Zones 2 and 5 in Map 2-1, respectively. The 18,689 ha Local Study Area is the area where direct and indirect Project effects on stand and landscape element composition may occur. The 1,420,000 ha Regional Study Area was large enough to represent a region level ecosystem, an ecologically homogenous area capable of supporting the key boreal processes (*e.g.*, fire regime) and populations of most resident wildlife species (Section 1.3.5).

Proxy and benchmark areas were not required for the ecosystem diversity assessment.

2.7.2.3 Information Sources

Sections 1.4.6 and 2.2.4 describe the information sources generally used in the assessment.

Published information on ecosystem diversity was not discovered for the Regional Study Area.

The detailed habitat mapping and habitat relationships analyses completed for the terrestrial environment assessment (Sections 2.2.4.4 and 2.2.4.5) provided the data for ecosystem diversity indicator attributes.

2.7.2.4 Methods

Existing stand and landscape diversity were measured from the broad habitat map (Section 2.2.4.4). The broad habitat composition of the Regional Study Area was estimated by extrapolating the detailed habitat mapping completed for Study Zone 4 as described Section 2.6.2.4.

A broad habitat type was classified as being regionally rare if it comprised less than 1% of Regional Study Area land area, regionally uncommon if it covered between 1% and 10% of land area and regionally common if it covered more than 10% of land area. The ground ice broad habitat types were not included as a priority habitat type because they are expected to disappear over time even if the Project does not proceed (Section 2.6.3.1).

Site level terrestrial habitat plot data (Section 2.2.4) were used to estimate the mean number of plant species, the occurrence of rare plant species and the typical number of distinct vegetation layers in each broad habitat type. Broad habitat types that had a mean number of plant species within the top 25th percentile for all of the inland broad habitat types were classified as having relatively high plant species density. Structurally diverse habitat types were those that typically had at least three distinct vegetation layers in most of the inland habitat plots. Broad habitat types that had high potential to support rare plant species were those in which the mean number of rare plant species per inland habitat plot was in the top 25th percentile of all of the inland broad habitat types. The KCNs indicated that all terrestrial habitat types are important (WLFN 2002, CNP Keeyask Environmental Evaluation Report) and did not identify any inland terrestrial habitat types that were of particular interest beyond the uses of these habitat types for other reasons such as habitat for favoured wildlife species (*e.g.* the importance of shrubby shoreline habitat for moose and other wildlife (Split Lake Cree 1996c, FLCN Traditional Knowledge Report 2010 Draft, YFFN Evaluation Report (*Kipekiskwaywinan*), CNP Keeyask Environmental Evaluation Report).

Stand level ecosystem diversity indicator measurements for the historical number and proportions of broad habitat types were derived from the historical habitat information provided in Section 2.6.3.1. Future changes to the ecosystem diversity measures, with and without the Project, were obtained from the habitat predictions provided in Sections 2.6.3.3 and 2.2.4.

The acceptability of residual Project effects on ecosystem diversity was evaluated based on the number of stand level habitat types that would be completely removed, changes in stand level habitat composition (Noss *et al*. 2009) and cumulative historical area losses for each of the priority habitat types. The complete removal of one or more stand level habitat types from the Regional Study Area is an unacceptable effect. For the habitat composition and priority habitat type indicators, effects that are small to moderate in magnitude are generally acceptable regardless of their duration or geographic extent because this degree of change is expected to fall within the range of natural variability. Exceptions could occur for a moderate magnitude residual effect if there was a substantial ongoing adverse trend in the amount of a habitat type being considered.

The benchmark values used to evaluate the magnitude of residual effects on the priority habitat types were derived from two sources. Hegmann *et al.* (1999) cite rules of thumb for measurable indicator attributes for which accepted thresholds or benchmarks do not exit. The 10% value they cite as the transition from moderate to high magnitude effects was also used as the critical cutoff to evaluate cumulative effects risks to rare and unique physical and vegetation features for the Deh Cho Plan area (Salmo *et al.* 2004). The benchmark values for evaluating adverse residual effects of the Project in combination with past and current projects and human activities on priority habitat types were as follows: small magnitude for area losses below 1% of regional historical area; moderate magnitude for area losses between 1% and 10% of regional historical area; and, high magnitude for area losses greater than 10% of regional historical area.

2.7.3Environmental Setting

2.7.3.1 Historical Conditions

As described in the terrestrial habitat section, recent climate change and the cumulative human footprint have altered habitat composition, which means that ecosystem diversity has also been altered. Cumulative historical change is estimated to have removed or altered approximately 5% of the total historical area of terrestrial habitat which likely has reduced the total area of most, if not all, priority habitat types.

Area losses have been relatively high for priority habitat types occurring on mineral ecosites, as these are the typical locations for roads, settlements and other infrastructure. Priority habitat types that tend to occur along the Nelson River were also disproportionately affected by hydroelectric development, which flooded some reaches of the Nelson River and altered water regimes along its remaining length.

Throughout much of the boreal forest, past climate change has altered the fire regime such that fire activity has increased (Section 2.5.3.1). These fire regime changes are thought to have shifted habitat composition towards vegetation types with higher proportions of plant species that regenerate quickly after fire (Sections 2.3.2.1 and 2.5.1) and reduced proportions of permafrost peatland types (Section 2.3.3).

2.7.3.2 Current Conditions

2.7.3.2.1 Habitat Composition

A total of 53 native inland broad habitat types occurred in the Regional Study Area in 2010. The distribution of area between the native inland broad habitat types in the Regional Study Area was very uneven. Three broad habitat types that had similar overstorey vegetation composition (black spruce dominant on thin, shallow and ground ice peatlands) accounted for approximately 65% of the total habitat area. In contrast, the combined cover of the 42 least abundant broad habitat types was just under 9% of land area (Table 2-33).

A total of 14 broad habitat types had 20 or fewer stands that were at least 2 ha in size in Study Zone 4 (Table 2-32). Tamarack dominant on riparian peatland, jack pine dominant on shallow peatland, jack pine mixedwood on shallow peatland, tamarack dominant on mineral, tamarack- black spruce mixture on riparian peatland and tamarack dominant on thin peatland had less than five stands mapped each.

Mean stand size for the majority of the broad habitat types represented by 20 or fewer stands was less than 10 ha (Table 2-32). Although tamarack dominant on mineral, jack pine mixture on shallow peatland and white birch mixedwood on all ecosites had the highest mean stand sizes, this was a reflection that there were a small number of stands and most of the total area was in only a few stands.

Table 2-32: Number of Stands Greater Than 2 ha, and Mean Stand Size of Broad Habitat Types with Less Than 20 Stands in Study Zone 4

Broad Habitat Type	# in Study Zone 4	Mean Size (*ha*)
Tamarack dominant on riparian peatland	1	2.3
Jack pine mixedwood on shallow peatland	3	4.0
Jack pine dominant on shallow peatland	3	4.4
Tamarack dominant on mineral	3	10.6
Tamarack- black spruce mixture on riparian peatland	4	4.6
Tamarack dominant on thin peatland	4	3.7
Black spruce mixedwood on shallow peatland	5	5.7
White birch mixedwood on all ecosites	5	8.7
Jack pine mixture on shallow peatland	5	10.5
Tamarack dominant on shallow peatland	6	3.9
Tall shrub on mineral	9	4.5
Black spruce mixedwood on thin peatland	9	9.9
White birch dominant on all ecosites	11	5.6
Jack pine mixedwood on thin peatland	20	7.8

Balsam poplar mixedwood on all ecosites, tamarack dominant on riparian peatland and tamarack dominant on shallow peatlands were the only three inland broad habitat types that were represented by less than 50 stands in Study Zone 4 but did not have stands in the Local Study Area (Table 2-33). Jack pine dominant on shallow peatland had only one stand mapped in the Local Study Area.

2.7.3.2.2 Priority Habitat Types

Table 2-33 lists the 43 native inland broad habitat types that met at least one of the priority habitat criteria and the reasons for including the broad habitat type as a priority habitat type. Of the 43 priority habitat types, 28 satisfied more than one priority habitat criterion. Appendix 2E provides descriptive statistics for each of the priority habitat types. A generalized description for groupings of similar broad habitat types was provided by the coarse habitat type descriptions in Section 2.3.4.

Table 2-33: Priority Habitat Types With Their Reasons for Inclusion, Historical and Current Areas and Habitat Composition Percentages[1] for the Regional and Local Study Areas

Priority Habitat Type	Priority Criteria[2]	Estimated Historical Area (ha)[3]	Estimated Current Area (ha)	% of Land in Regional Study Area	% of Land in Local Study Area
Balsam poplar dominant on all ecosites	RD	21	20	0.0	0.0
Trembling aspen dominant on all ecosites	RD	7,073	6,843	0.6	1.2
White birch dominant on all ecosites	RD	553	535	0.0	0.2
Balsam poplar mixedwood on all ecosites	RDS	12	11	0.0	-
Trembling aspen mixedwood on all ecosites	RDS	5,872	5,681	0.5	0.9
White birch mixedwood on all ecosites	R	446	432	0.0	0.3
Black spruce mixedwood on mineral	R	3,099	2,998	0.2	0.2
Black spruce mixedwood on thin peatland	RDS	885	856	0.1	0.0
Jack pine mixedwood on mineral	RD	2,166	2,095	0.2	0.3
Jack pine mixedwood on thin peatland	RDS	1,415	1,369	0.1	0.3
Jack pine dominant on mineral	UDS	15,584	15,077	1.2	1.3
Jack pine dominant on thin peatland	RDS	1,323	1,280	0.1	0.3
Jack pine mixture on thin peatland	R	5,255	5,084	0.4	1.3
Tamarack dominant on mineral	RDS	307	297	0.0	0.0
Tamarack mixture on mineral	RDS	1,067	1,033	0.1	0.3
Black spruce dominant on mineral	U	97,857	94,673	7.6	8.5
Black spruce mixture on mineral	RD	9,797	9,478	0.8	3.5
Black spruce mixture on thin peatland	R	8,132	7,868	0.6	1.9
Tamarack dominant on thin peatland	RDS	241	233	0.0	0.0
Tamarack mixture on thin peatland	RDS	3,029	2,930	0.2	0.7
Tall shrub on mineral	RD	490	474	0.0	0.1
Tall shrub on thin peatland	RDS	1,978	1,913	0.2	0.4
Low Vegetation on thin peatland	U	53,247	51,514	4.2	3.0
Jack pine dominant on shallow peatland	RS	137	132	0.0	0.0
Jack pine mixture on shallow peatland	RDS	526	509	0.0	0.2
Black spruce mixedwood on shallow peatland	RD	292	282	0.0	0.0
Jack pine mixedwood on shallow peatland	RS	103	100	0.0	0.0

Table 2-33: Priority Habitat Types With Their Reasons for Inclusion, Historical and Current Areas and Habitat Composition Percentages[1] for the Regional and Local Study Areas

Priority Habitat Type	Priority Criteria[2]	Estimated Historical Area (ha)[3]	Estimated Current Area (ha)	% of Land in Regional Study Area	% of Land in Local Study Area
Black spruce mixture on shallow peatland	RD	5,757	5,570	0.4	0.7
Black spruce dominant on wet peatland	UD	26,802	25,930	2.1	0.9
Black spruce mixture on wet peatland	R	1,759	1,702	0.1	0.1
Tamarack mixture on wet peatland	RD	9,648	9,334	0.8	0.2
Tamarack dominant on shallow peatland	R	440	426	0.0	-
Tamarack mixture on shallow peatland	RD	3,494	3,381	0.3	0.6
Tamarack dominant on wet peatland	R	2,048	1,982	0.2	0.0
Black spruce dominant on riparian peatland	RDS	8,522	8,245	0.7	0.4
Tamarack- black spruce mixture on riparian peatland	RD	435	421	0.0	0.0
Tamarack dominant on riparian peatland	R	82	79	0.0	-
Tall shrub on shallow peatland	RDS	3,351	3,242	0.3	0.2
Tall shrub on wet peatland	R	1,661	1,607	0.1	0.3
Low vegetation on shallow peatland	U	41,754	40,395	3.3	2.1
Low vegetation on wet peatland	U	20,026	19,374	1.6	1.1
Tall shrub on riparian peatland	R	7,606	7,358	0.6	1.8
Low vegetation on riparian peatland	U	23,495	22,731	1.8	1.7
Area of all types		*377,788*	*365,494*		
Study Areas				*1,239,328*	*13,043*

[1] Percentages of total land area.
[2] R = Rare, U = Uncommon, D = Diverse, S = High potential to support rare plant species.
[3] Historical areas estimated by multiplying the total Regional Study Area land area by the fraction of total native habitat area for each broad habitat type.

Seven broad habitat types were regionally uncommon and 36 were regionally rare (Table 2-33). The rarest habitat types were balsam poplar mixedwood and balsam poplar dominant on all ecosites. Each of these types covered less than 20 ha in the Regional Study Area. Balsam poplar mixedwood on all ecosites was not present in the Local Study Area. Some broad habitat types were uncommon or rare because they occurred on site conditions that were uncommon in the Regional Study Area (*e.g.*, mineral soils) or because their defining plant species occurred infrequently in the canopy for reasons other than the availability of suitable site conditions (*e.g.*, white spruce is limited by the fire cycle length).

Many of the regionally rare and uncommon habitat types were more abundant within the Local Study

Area than the rest of the Regional Study Area (Map 2-18), primarily because many of these habitat types were mineral or thin peatland types and these ecosite types were concentrated along the Nelson River and on the north esker. The influence of the Nelson River also accounted for the larger proportions of some of the riparian peatland types. Regionally rare and uncommon broad habitat types that were more abundant in the Local Study Area included black spruce mixture on mineral soil and on thin peatland, jack pine mixture on thin peatland, trembling aspen dominant on all ecosites, white birch types, and tall shrub types, particularly on wet peatlands, riparian peatlands, and shoreline wetlands.

Twenty-six broad habitat types were classified as highly diverse based on plant species density and/or structural complexity. Of this total, 21 types had a relatively high mean number of plant species (Table 2E-1) and 11 types had high structural complexity relative to all of the habitat types in the Regional Study Area (Table 2-33). The rare broad habitat types that had relatively high plant species density and structural complexity were tall shrub on shallow peatlands, tall shrub on thin peatland, all balsam poplar mixedwood on all ecosites trembling aspen mixedwood on all ecosites, black spruce mixedwood on thin peatland, jack pine dominant on mineral, jack pine dominant on thin peatland, jack pine mixedwood on thin peatland, jack pine mixture on shallow peatland, tamarack dominant on mineral, tamarack mixture on mineral, tamarack dominant on thin peatland and tamarack mixture on thin peatland. All of these broad habitat types were estimated to have at least 16 plant **taxa** per sampled location on average. Regardless of the ecosite type, the low vegetation broad habitat types generally had the lowest mean number of species.

Sixteen broad habitat types in the Regional Study Area had high potential to support regionally rare plant species (Appendix 2E). Jack pine habitat types generally had the highest potential to support rare species (Table 2E-1); each of these habitat types had more than three regionally rare and/or **sparse species** per location on average. Other priority habitat types with high regionally rare species potential were trembling aspen mixedwoods, balsam poplar mixedwoods, tamarack habitat on mineral and thin peatland, black spruce mixtures and mixedwoods on thin peatlands and tall shrub types.

2.7.3.3 Current Trends (no future climate change)

Past and existing human impacts and climate change are expected to continue to drive future habitat change in the Regional Study Area even if the Project does not proceed. Ongoing shoreline erosion will continue to remove and alter terrestrial habitat. For example, it is estimated that approximately 91 ha of inland habitat would be lost to ongoing mineral bank erosion in the Keeyask reach of the Nelson River between 2006 and 2047 (equivalent to 30 years post-Project; see Section 2.2.4). Due to the higher proportion of mineral ecosites along the Nelson River banks, and the disproportionate effects of shoreline erosion on mineral banks, it is predicted that mineral habitat types would make up a relatively high proportion of priority habitat lost to ongoing erosion. Black spruce dominant on mineral and tall shrub on riparian peatland would likely make up the highest proportions of priority habitat lost (19% and 14%, respectively), followed by black spruce mixture on mineral (6%; see Table 2C-1). While these ongoing adverse terrestrial habitat responses to past human developments are locally important, their magnitude at the regional scale is very small for the native broad habitat types. For example, the ongoing mineral bank erosion described above is expected to affect between nil and 0.2% of the historical area of the various native broad habitat types.

It was estimated that the ongoing effects of past climate change will convert at least one-quarter of the remaining peat plateau bog to open water and other peatland types by 2047. Since the ground ice peatland types were not included as priority habitat types, these changes should not decrease the areas of any priority habitat types but tend to increase the amounts of the wet peatland priority habitat types over time.

2.7.4 Project Effects, Mitigation and Monitoring

The potential Project effects pathways described for terrestrial habitat (Section 2.3.6) also apply to ecosystem diversity because ecosystem diversity indicators were measured using the terrestrial habitat mapping. Potential Project effects on ecosystem diversity include reducing the number of native ecosystem types, altering the distribution of area amongst the ecosystem types, reducing the total number of stands representing an ecosystem type and/or reducing the total area of a priority ecosystem type.

Better access brings more equipment, material and/or people into an area, which could lead to increased resource harvesting, invasive plant spread and human-caused fires, among other things. In extreme cases, a single accidental fire that is severe could alter ecosystem diversity, either by extirpating a habitat type or substantially reducing its abundance (by degrading site conditions and/or decimating the propagule bank). Invasive plants have the potential to crowd out native plant species and, in extreme cases, alter ecosystem diversity through changes to broad habitat composition.

2.7.4.1 Construction Period

2.7.4.1.1 Potential Project Effects

Overall Ecosystem Diversity Measures

Project construction is not expected to change the total number of native broad habitat types.

Project construction is not expected substantially change the proportions of any of the regionally common or uncommon native habitat types. The largest absolute percentage change is 0.2% (black spruce mixture on mineral increases from 20.3% to 20.5%) and most of the remaining changes are less than 0.1% (Table 2-34) Changes to the regionally rare habitat types are evaluated below.

Project construction is expected to reduce the total number of stands for eight out of the 14 native broad habitat types with 20 or less stands and six out of the 12 habitat types with less than 10 stands in Study Zone 4 (Table 2-35). Although white birch mixedwood on all ecosites and jack pine mixture on shallow peatland (2 out of 5 each) are the most affected, in both cases the removed stands are very small and represent less than 2% of the total area after mitigation. In addition, it is not known how many additional stands occur in the portion of the Regional Study Area that is outside of Study Zone 4. A simple area based extrapolation to provide a very crude estimate would increase the total number of stands for each type by approximately 7.5 times on average.

Table 2-34: Estimated Inland Broad Habitat Composition of the Existing Regional Study Area, Following Construction, and After 30 Years of Operation

Broad Habitat Type	Existing Regional Study Area	During Construction	Year 30 of Operation
Balsam poplar dominant on all ecosites	0.0	0.0	0.0
Trembling aspen dominant on all ecosites	0.6	0.5	0.5
White birch dominant on all ecosites	0.0	0.0	0.0
Balsam poplar mixedwood on all ecosites	0.0	0.0	0.0
Trembling aspen mixedwood on all ecosites	0.5	0.5	0.5
White birch mixedwood on all ecosites	0.0	0.0	0.0
Black spruce mixedwood on mineral	0.2	0.2	0.2
Black spruce mixedwood on thin peatland	0.1	0.1	0.1
Jack pine mixedwood on mineral	0.2	0.2	0.2
Jack pine mixedwood on thin peatland	0.1	0.1	0.1
Jack pine dominant on mineral	1.2	1.2	1.2
Jack pine dominant on thin peatland	0.1	0.1	0.1
Jack pine mixture on thin peatland	0.4	0.4	0.4
Tamarack dominant on mineral	0.0	0.0	0.0
Tamarack mixture on mineral	0.1	0.1	0.1
Black spruce dominant on mineral	7.6	7.6	7.6
Black spruce mixture on mineral	0.8	0.7	0.7
Black spruce dominant on thin peatland	32.3	32.1	32.1
Black spruce mixture on thin peatland	0.6	0.6	0.6
Tamarack dominant on thin peatland	0.0	0.0	0.0
Tamarack mixture on thin peatland	0.2	0.2	0.2
Tall shrub on mineral	0.0	0.0	0.0
Tall shrub on thin peatland	0.2	0.2	0.2
Low vegetation on mineral	0.4	0.4	0.4
Low Vegetation on thin peatland	4.2	4.1	4.1
Jack pine dominant on shallow peatland	0.0	0.0	0.0
Jack pine mixture on ground ice peatland	0.0	0.0	0.0
Jack pine mixture on shallow peatland	0.0	0.0	0.0
Black spruce mixedwood on shallow peatland	0.0	0.0	0.0
Jack pine mixedwood on shallow peatland	0.0	0.0	0.0
Black spruce dominant on ground ice peatland	11.9	11.9	11.8
Black spruce dominant on shallow peatland	20.3	20.2	20.2
Black spruce mixture on ground ice peatland	0.1	0.1	0.1
Black spruce mixture on shallow peatland	0.4	0.4	0.4
Black spruce dominant on wet peatland	2.1	2.1	2.1
Black spruce mixture on wet peatland	0.1	0.1	0.1

Table 2-34: Estimated Inland Broad Habitat Composition of the Existing Regional Study Area, Following Construction, and After 30 Years of Operation

Broad Habitat Type	Existing Regional Study Area	During Construction	Year 30 of Operation
Tamarack mixture on wet peatland	0.8	0.8	0.8
Tamarack dominant on ground ice peatland	0.0	0.0	0.0
Tamarack dominant on shallow peatland	0.0	0.0	0.0
Tamarack mixture on ground ice peatland	0.1	0.1	0.1
Tamarack mixture on shallow peatland	0.3	0.3	0.3
Tamarack dominant on wet peatland	0.2	0.2	0.2
Black spruce dominant on riparian peatland	0.7	0.7	0.7
Tamarack- black spruce mixture on riparian peatland	0.0	0.0	0.0
Tamarack dominant on riparian peatland	0.0	0.0	0.0
Tall shrub on ground ice peatland	0.1	0.1	0.1
Tall shrub on shallow peatland	0.3	0.3	0.3
Tall shrub on wet peatland	0.1	0.1	0.1
Low vegetation on ground ice peatland	3.7	3.7	3.7
Low vegetation on shallow peatland	3.3	3.2	3.2
Low vegetation on wet peatland	1.6	1.6	1.6
Tall shrub on riparian peatland	0.6	0.6	0.6
Low vegetation on riparian peatland	1.8	1.8	1.8
Total percentage of land area	*98.5*	*97.8*	*97.8*
Note: Percentages are of total land area including shoreline wetlands.			

Table 2-35: Number of Stands and Total Area of Broad Habitat Types with Less Than 20 Stands in Study Zone 4, and in the Project Footprint and Habitat Zone of Influence During Construction and During Operation

Broad Habitat Type	# in Study Zone 4 (*total area in ha*)	# in Construction Effects Area (*mean size in ha*)	# in Operation Effects Area at Year 30 (*mean size in ha*)
Tamarack dominant on riparian peatland	1 (2.3)	-	-
Jack pine mixedwood on shallow peatland	3 (11.9)	1 (2.0)	1 (2.0)
Jack pine dominant on shallow peatland	3 (13.1)	-	-
Tamarack dominant on mineral	3 (31.9)	-	-
Tamarack- black spruce mixture on riparian peatland	4 (18.3)	1 (2.3)	2 (13.5)
Tamarack dominant on thin peatland	4 (14.9)	-	-
Black spruce mixedwood on shallow peatland	5 (28.4)	-	-
White birch mixedwood on all ecosites	5 (43.7)	2 (31.0)	2 (31.0)
Jack pine mixture on shallow peatland	5 (52.7)	2 (30.8)	2 (30.8)
Tamarack dominant on shallow peatland	6 (23.4)	-	-
Tall shrub on mineral	9 (40.5)	2 (12.3)	2 (12.3)
Black spruce mixedwood on thin peatland	9 (88.7)	1 (2.3)	1 (2.3)
White birch dominant on all ecosites	11 (61.3)	4 (18.0)	4 (18.0)
Jack pine mixedwood on thin peatland	20 (156.3)	5 (28.3)	5 (28.3)

Priority Habitat Types

The Project design process considerably reduced Project effects on ecosystem diversity. During the early stages, a low head option that considerably reduced terrestrial flooding was selected based on feedback from the Cree Nation Partners (CNP; PD SV Section 6.0). Subsequently, a highly interactive collaboration between engineers, biologists and Project personnel further modified Project design so that a substantial amount of priority habitat was avoided. Examples of design changes resulting from the latter process include revising south access road routing, relocating some of the excavated material placement areas and refining the boundaries of the potential borrow areas and excavated material placement areas (see Section 4.2.3).

Before considering additional mitigation measures, it is predicted that the Project will not affect three of the 43 priority habitat types but could affect up to 3.8% of the area of all but one of the remaining priority habitat types (Table 2-36). The Project could affect up to 7.7% of white birch mixedwood on all ecosites area and the largest stand representing this type.

After considering the of the Project in combination with past and current projects, white birch mixedwood on all ecosites is anticipated to be the only priority habitat type that could have a high magnitude effect (Table 2-37). In descending order, the remaining priority habitat types with the highest effects before mitigation are black spruce mixture on mineral, white birch dominant on all ecosites, tall shrub on mineral, tall shrub on riparian peatland, tamarack mixture on mineral, tall shrub on thin peatland, tamarack mixture on thin peatland, black spruce mixture on thin peatland and jack pine mixture on thin peatland.

Table 2-36: Priority Habitat Affected During Construction and Operation as a Percentage of Area in Regional Study Area

Priority Habitat Type	*Total Estimated Regional Study Area (ha)*	Existing Percentage of Regional Study Area (%)	Construction Period			Operation Period	
			Project Footprint (%)	Habitat Zone of Influence (%)	After Mitigation (%)	Project Footprint at Year 30 (%)	Net Habitat Affected at Year 30[1] (%)
Balsam poplar dominant on all ecosites	*20*	0.0	0.4	1.9	1.9	0.7	4.9
Balsam poplar mixedwood on all ecosites	*11*	0.0	-	-	-	-	-
Black spruce dominant on mineral soil	*94,673*	7.6	0.5	0.7	0.7	0.4	0.7
Black spruce dominant on riparian peatland	*8,245*	0.7	0.3	0.4	0.4	0.3	0.4
Black spruce dominant on wet peatland	*25,930*	2.1	0.3	0.3	0.3	0.3	0.4
Black spruce mixedwood on mineral soil	*2,998*	0.2	0.3	0.6	0.6	0.3	0.6
Black spruce mixedwood on shallow peatland	*282*	0.0	0.7	0.7	0.7	0.6	0.7
Black spruce mixedwood on thin peatland	*856*	0.1	0.3	0.5	0.5	0.3	0.5
Black spruce mixture on mineral soil	*9,478*	0.8	3.2	3.8	3.8	3.2	3.9
Black spruce mixture on shallow peatland	*5,570*	0.4	0.9	1.2	1.2	1.0	1.3
Black spruce mixture on thin peatland	*7,868*	0.6	1.6	2.1	2.1	1.7	2.3
Black spruce mixture on wet peatland	*1,702*	0.1	0.2	0.3	0.3	0.2	0.3
Jack pine dominant on mineral soils	*15,077*	1.2	0.5	0.7	0.7	0.4	0.7
Jack pine dominant on shallow peatland	*132*	0.0	-	0.1	0.1	-	0.1
Jack pine dominant on thin peatland	*1,280*	0.1	0.5	1.1	1.1	0.5	1.0
Jack pine mixedwood on mineral soils	*2,095*	0.2	0.7	1.0	1.0	0.5	1.0
Jack pine mixedwood on shallow peatland	*100*	0.0	-	0.9	0.9	-	0.9
Jack pine mixedwood on thin peatland	*1,369*	0.1	0.8	1.6	1.6	0.8	1.6
Jack pine mixture on shallow peatland	*509*	0.0	0.0	1.1	1.1	0.0	1.1
Jack pine mixture on thin peatland	*5,084*	0.4	1.1	2.1	2.1	1.0	2.1
Low vegetation on riparian peatland	*22,731*	1.8	0.7	0.8	0.8	0.7	0.9
Low vegetation on shallow peatland	*40,395*	3.3	0.4	0.5	0.5	0.4	0.5
Low vegetation on thin peatland	*51,514*	4.2	0.4	0.5	0.5	0.3	0.5
Low vegetation on wet peatland	*19,374*	1.6	0.5	0.6	0.6	0.5	0.6
Tall shrub on mineral soil	*474*	0.0	2.3	3.3	3.3	1.4	3.2
Tall shrub on riparian peatland	*7,358*	0.6	2.8	2.9	2.9	2.9	3.0
Tall shrub on shallow peatland	*3,242*	0.3	0.3	0.6	0.6	0.4	0.6
Tall shrub on thin peatland	*1,913*	0.2	1.9	2.4	2.4	1.8	2.3
Tall shrub on wet peatland	*1,607*	0.1	1.6	1.8	1.8	1.8	1.9
Tamarack- black spruce mixture on riparian peatland	*421*	0.0	0.3	0.3	0.3	0.7	1.4
Tamarack dominant on mineral soil	*297*	0.0	1.2	1.3	1.3	1.2	1.3
Tamarack dominant on riparian peatland	*79*	0.0	-	-	-	-	-
Tamarack dominant on shallow peatland	*426*	0.0	-	-	-	-	-
Tamarack dominant on thin peatland	*233*	0.0	0.4	0.6	0.6	0.4	0.8
Tamarack dominant on wet peatland	*1,982*	0.2	0.1	0.1	0.1	0.1	0.1
Tamarack mixture on mineral soil	*1,033*	0.1	2.4	2.6	2.6	2.3	2.6
Tamarack mixture on shallow peatland	*3,381*	0.3	1.1	1.4	1.4	1.1	1.5
Tamarack mixture on thin peatland	*2,930*	0.2	1.7	2.3	2.3	1.7	2.6
Tamarack mixture on wet peatland	*9,334*	0.8	0.2	0.2	0.2	0.2	0.3
Trembling aspen dominant on all ecosites	*6,843*	0.6	1.5	1.9	1.8	1.1	1.8
Trembling aspen mixedwood on all ecosites	*5,681*	0.5	0.6	1.1	1.1	0.6	1.2
White birch dominant on all ecosites	*535*	0.0	3.2	3.3	1.1	1.2	2.2
White birch mixedwood on all ecosites	*432*	0.0	6.9	7.7	1.8	1.9	3.8
Number of priority habitat types with moderate degree effects relative to historical RSA area.			**14**	**20**	**20**	**13**	**20**

Notes: [1] Net habitat affected at Year 30 is after predicted reservoir expansion, Project-related indirect effects (*e.g.*, edge and groundwater effects) and habitat recovery from habitat rehabilitation and natural regeneration.

Table 2-37: Priority Habitat Affected During Construction and Operation Including Cumulative Historical Effects as a Percentage of Historical Area in Regional Study Area

Priority Habitat Type	*Total Estimated Historical Regional Study Area (ha)*	Estimated Percentage of Historical Regional Study Area (%)	Construction Period			Operation Period	
			Project Footprint (%)	Habitat Zone of Influence (%)	After Mitigation (%)	Project Footprint at Year 30 (%)	Net Habitat Affected at Year 30[1] (%)
Balsam poplar dominant on all ecosites	*21*	0.0	5.4	6.8	6.8	5.6	9.9

Priority Habitat Type	*Total Estimated Historical Regional Study Area (ha)*	Estimated Percentage of Historical Regional Study Area (%)	Construction Period			Operation Period	
			Project Footprint (%)	Habitat Zone of Influence (%)	After Mitigation (%)	Project Footprint at Year 30 (%)	Net Habitat Affected at Year 30[1] (%)
Balsam poplar mixedwood on all ecosites	*12*	0.0	n/a	n/a	n/a	n/a	n/a
Black spruce dominant on mineral soil	*97,857*	7.7	5.4	5.7	5.7	5.4	5.7
Black spruce dominant on riparian peatland	*8,522*	0.7	5.3	5.3	5.3	5.3	5.4
Black spruce dominant on wet peatland	*26,802*	2.1	5.2	5.3	5.3	5.3	5.3
Black spruce mixedwood on mineral soil	*3,099*	0.2	5.3	5.6	5.6	5.2	5.5
Black spruce mixedwood on shallow peatland	*292*	0.0	5.6	5.7	5.7	5.6	5.7
Black spruce mixedwood on thin peatland	*885*	0.1	5.3	5.4	5.4	5.3	5.4
Black spruce mixture on mineral soil	*9,797*	0.8	8.1	8.8	8.7	8.1	8.8
Black spruce mixture on shallow peatland	*5,757*	0.5	5.8	6.2	6.2	5.9	6.2
Black spruce mixture on thin peatland	*8,132*	0.6	6.5	7.0	7.0	6.6	7.2
Black spruce mixture on wet peatland	*1,759*	0.1	5.1	5.2	5.2	5.2	5.2
Jack pine dominant on mineral soils	*15,584*	1.2	5.4	5.6	5.6	5.4	5.6
Jack pine dominant on shallow peatland	*137*	0.0	5.0	5.0	5.0	5.0	5.0
Jack pine dominant on thin peatland	*1,323*	0.1	5.5	6.1	6.1	5.5	5.9
Jack pine mixedwood on mineral soils	*2,166*	0.2	5.7	5.9	5.9	5.5	5.9
Jack pine mixedwood on shallow peatland	*103*	0.0	5.0	5.9	5.9	5.0	5.9
Jack pine mixedwood on thin peatland	*1,415*	0.1	5.7	6.6	6.6	5.7	6.6
Jack pine mixture on shallow peatland	*526*	0.0	5.0	6.1	6.1	5.0	6.1
Jack pine mixture on thin peatland	*5,255*	0.4	6.1	7.0	7.0	5.9	7.0
Low vegetation on riparian peatland	*23,495*	1.9	5.7	5.8	5.8	5.7	5.8
Low vegetation on shallow peatland	*41,754*	3.3	5.3	5.4	5.4	5.3	5.4
Low vegetation on thin peatland	*53,247*	4.2	5.3	5.5	5.5	5.3	5.5
Low vegetation on wet peatland	*20,026*	1.6	5.4	5.5	5.5	5.5	5.6
Tall shrub on mineral soil	*490*	0.0	7.3	8.2	8.2	6.4	8.1
Tall shrub on riparian peatland	*7,606*	0.6	7.8	7.9	7.9	7.8	8.0
Tall shrub on shallow peatland	*3,351*	0.3	5.3	5.5	5.5	5.3	5.6
Tall shrub on thin peatland	*1,978*	0.2	6.9	7.3	7.3	6.7	7.3
Tall shrub on wet peatland	*1,661*	0.1	6.5	6.7	6.7	6.8	6.9
Tamarack- black spruce mixture on riparian peatland	*435*	0.0	5.2	5.3	5.3	5.6	6.4
Tamarack dominant on mineral soil	*307*	0.0	6.2	6.3	6.3	6.2	6.3
Tamarack dominant on riparian peatland	*82*	0.0	n/a	n/a	n/a	n/a	n/a
Tamarack dominant on shallow peatland	*440*	0.0	n/a	n/a	n/a	n/a	n/a
Tamarack dominant on thin peatland	*241*	0.0	5.3	5.5	5.5	5.4	5.8
Tamarack dominant on wet peatland	*2,048*	0.2	5.0	5.0	5.0	5.0	5.1
Tamarack mixture on mineral soil	*1,067*	0.1	7.3	7.6	7.6	7.2	7.6
Tamarack mixture on shallow peatland	*3,494*	0.3	6.0	6.4	6.4	6.1	6.5
Tamarack mixture on thin peatland	*3,029*	0.2	6.6	7.3	7.3	6.7	7.5
Tamarack mixture on wet peatland	*9,648*	0.8	5.1	5.2	5.2	5.2	5.2
Trembling aspen dominant on all ecosites	*7,073*	0.6	6.4	6.9	6.7	6.0	6.7
Trembling aspen mixedwood on all ecosites	*5,872*	0.5	5.6	6.1	6.1	5.6	6.1
White birch dominant on all ecosites	*553*	0.0	8.1	8.3	6.1	6.1	7.1
White birch mixedwood on all ecosites	*446*	0.0	11.9	12.7	6.8	6.9	8.8
Number of priority habitat types with moderate degree effects relative to historical RSA area.			**40**	**40**	**40**	**40**	**40**
Number of priority habitat types with high degree effects relative to historical RSA area.			**1**	**1**	-	-	-

Notes: [1] Net habitat affected at Year 30 is after predicted reservoir expansion, Project-related indirect effects (*e.g.*, edge and groundwater effects) and habitat recovery from habitat rehabilitation and natural regeneration. Habitat types with values of "n/a" are types with no expected project effects, and are not considered in the cumulative effects analysis.

For most of the priority habitat types, the majority of the affected area is in the Project Footprint rather than the terrestrial habitat zone of influence. Exceptions include jack pine mixture on shallow peatland, jack pine mixedwood on shallow peatland and balsam poplar dominant on all ecosites.

Reservoir clearing and borrow areas would make the largest contributions to potential priority habitat losses. EMPAs are the only other footprint type that has a greater than low degree effects on a priority habitat type, but this only affects the tall shrub on mineral soil priority habitat type. The priority habitat types most affected by the reservoir clearing and borrow area footprints include tall shrub on shallow peatland, tall shrub on wet peatland, tall shrub on riparian peatland and all of the broadleaf treed types except balsam poplar dominant on all ecosites. Jack pine dominant on mineral and on thin peatland, jack pine mixedwood on mineral an on thin peatland, black spruce dominant on mineral and black spruce mixedwood on mineral are also affected in these footprints. In general, mineral and thin peatland types would be most affected by these Project Footprint components.

If borrow area E-1 is used, area losses for 10 of the priority habitat types that already have moderate degree effects would increase but are expected to remain in the moderate magnitude range. None of the priority habitat types with low magnitude effects would have an increase to moderate magnitude effects.

Project-related use of the existing PR 280 could slightly increase indirect effects on priority habitats, primarily through increased road dust deposition and increased access related effects. These effects are expected to be limited because portions of this highway were used during the construction of two generating stations starting in 1971, with all portions in use after 1985. Additionally, this has been and continues to be the only highway to locations north of Thompson.

Most of the above estimates of potential construction effects are anticipated to be overestimates for the reasons described in Section 2.6.4.1.1.

2.7.4.1.2 Mitigation

Mitigation for ecosystem diversity effects in addition to that already incorporated into the Project design will include the following:

- The portion of borrow area N-6 identified as the N6 sensitive site in Map 2-19 will be avoided to reduce effects on the white birch priority habitat types, and protection measures will be implemented to ensure that soil alteration or accidental disturbance within this site does not occur;
- Clearing and disturbance within the Project Footprint will be minimized to the extent practicable;
- Disturbance of areas adjacent to the Project Footprint will be avoided to the extent practicable;
- A rehabilitation plan will be developed that gives preference to rehabilitating the most affected priority habitat types using approaches that “go with nature” (Keeyask JKDA Schedule 7-1); and,
- Except for existing resource-use trails (see Construction Access Management Plan), Project-related cutlines and trails will be blocked where they intersect the Project Footprint, and the portions of these features within 100 m of the Project Footprint will be revegetated to minimize the risk of habitat disturbance, invasive plant spreading, accidental fires and access-related effects.

Preference for rehabilitating the priority habitat types with the highest predicted residual effects is included as a mitigation measures even though predicted Project effects are moderate magnitude as a precautionary measure to address prediction uncertainties.

Mitigation implemented for wetland function as well as the disturbance and the clearing minimization measures in the EnvPPs (Manitoba Hydro 2012a) are expected to further reduce Project effects on ecosystem diversity. The EnvPPs will also include measures to minimize the risk that accidental spills will affect ecosystem diversity. The risk of accidental fires, or that the proposed Project will affect fire intensity and/or severity is considered low given the mitigation measures that are included for the fire regime supporting topic (Section 2.3.4). The risk of invasive plants affecting priority habitats is also expected to be low given the mitigation measures related to these species (Section 3.4.2).

2.7.4.1.3 Residual Effects

After considering mitigation, Project construction is not expected to create additional effects on three priority habitat types and is expected to affect between 0.1% and 3.8% of estimated area for the 40 remaining priority habitat types. After considering these remaining Project effects in combination with other past and current projects and activities, it is predicted that the residual effects of Project construction on ecosystem diversity would include affecting between 5.0% and 8.7% of estimated historical area for 40 priority habitat types, which are moderate magnitude effects.

Using the criteria established to determine the significance of Project effects for regulatory purposes (Section 2.2.5.2), the likely residual effects of Project construction on ecosystem diversity are expected to be adverse, medium in geographic extent, long term in duration and, depending on the ecosystem diversity indicator either nil, small or moderate in magnitude. The moderate magnitude residual effects are expected to be irreversible, continuous in frequency, and low in ecological context.

2.7.4.2 Operation Period

2.7.4.2.1 Potential Project Effects

Reservoir expansion, additional edge effects and groundwater-related habitat effects will be the primary pathways for adverse Project effects on ecosystem diversity during operation. These increases will be somewhat offset by elimination of temporary construction effects (see Section 2.3.6.3). The predicted net increase in the total amount of affected terrestrial habitat is relatively small throughout operation, increasing by 545 ha, or 0.04%, of Regional Study Area habitat by Year 30. Most of the reservoir-related habitat loss occurs during the first 15 years.

Overall, potential Project effects on ecosystem diversity are expected to increase during the first 30 years of Project operation. As described in Section 2.2.4.3, although initial flooding is contained within the construction footprint, habitat recovery over the first 30 years of operation is expected to be lower than reservoir expansion and other indirect reservoir effects during the same period.

Better access brings more equipment, material and/or people into an area, which could lead to increased resource harvesting, invasive plant spread and human-caused fires, among other things. In general, the risk of Project-related fire regime effects may decline or increase slightly during operation. Although Project activity in the area will be greatly reduced, better public access would increase the risk of human-caused wildfires.

Improved public access will be somewhat offset if and when Manitoba Infrastructure and Transportation closes PR 280 between its junctions with the north access road and PR 290.

Overall Ecosystem Diversity Measures

Project operation is not expected to change the total number of broad habitat types present in the Regional Study Area or the proportion of any common or uncommon habitat types because the increase in area affected is relatively small (Table 2-36). Changes to the regionally rare habitat types are evaluated below.

Before considering potential mitigation measures, Project operation would only increase the total number of stands affected for one broad habitat types that was already affected during the construction period (Tamarack- black spruce mixture on riparian peatland; Table 2-35). In descending order, the broad habitat types with the highest predicted potential effects during operation are white birch mixedwood on all ecosites, balsam poplar dominant on all ecosites, black spruce mixture on mineral, white birch dominant on all ecosites, tall shrub on mineral and on riparian peatland.

Priority Habitat Types

Potential Project effects on some priority habitat types could increase slightly during operation while effects on other types are expected to decline. Reservoir expansion during the first 30 years of operation would affect some additional priority habitat, but this would be somewhat offset by accounting for potential construction areas that were not used, natural regeneration and habitat rehabilitation elsewhere in the Local Study Area. Project-related changes to reservoir edge effects and elevated groundwater would affect an additional 480 ha of priority habitat. Despite this, on a net basis before additional operation phase mitigation is considered, the number of priority habitat types with moderate degree effects is predicted to remain at 20 (Table 2-36; see Section 2.3.6.3.1 for an explanation of how net habitat effects at year 30 were determined).

Balsam poplar dominant on all ecosites, white birch mixedwood on all ecosites, white birch dominant on all ecosites, tamarack- black spruce mixture on riparian peatland, tamarack mixture on thin peatland, tamarack dominant on thin peatland, black spruce mixture on thin peatland and tall shrub on wet peatlands are the only priority habitat types expected to have slight (> 0.1%) increases in the degree of Project effects during the first 30 years of operation (Table 2-36).

2.7.4.2.2 Mitigation

Mitigation during operation, in addition to that already incorporated into the Project design, will include the following:

- The portion of borrow area N-6 identified as the N6 sensitive site in Map 2-19 will be avoided to reduce effects on the white birch priority habitat types, and protection measures will be implemented to ensure that soil alteration or accidental disturbance within this site does not occur;
- The rehabilitation plan developed and initiated during construction will extend into the operation phase, and continue until all necessary rehabilitation is completed; and
- Except for existing resource-use trails (see Construction Access Management Plan), Project-related cutlines and trails will be blocked where they intersect the Project Footprint, and the portions of these

features within 100 m of the Project Footprint will be revegetated to minimize the risk of habitat disturbance, invasive plant spreading, accidental fires and access-related effects.

Mitigation implemented for wetland function is expected to further reduce Project effects on ecosystem diversity.

2.7.4.2.3 Residual Effects

After considering mitigation, Project operation is not expected to create additional effects on three priority habitat types and to affect between 0.1% and 4.9% of estimated area for the remaining 40 priority habitat types, depending on the type. After considering these remaining Project effects in combination with other past and current projects and activities, it is predicted that the residual effects of Project operation on ecosystem diversity would include affecting between 5.0% and 9.9% of estimated historical area for 40 priority habitat types, which are moderate magnitude effects. The rehabilitation plan is expected to reduce effects on some priority habitat types.

Using the criteria established to determine the significance of Project effects for regulatory purposes (Section 2.2.5.2), the likely residual effects of Project operation on ecosystem diversity are expected to be adverse, local in extent, long term in duration and, depending on the ecosystem diversity indicator either nil, small or moderate in magnitude. Residual effects are also expected to be irreversible, continuous in frequency, and low in ecological context.

2.7.4.3 Residual Effects Conclusion

Overall, the likely Project residual effects on ecosystem diversity are expected to be adverse but regionally acceptable because no stand level habitat types are lost, the distribution of area amongst the stand level habitat types is not expected to change substantially and the cumulative area losses for all of the priority habitat types remains below 10%.

Using the criteria established to determine the significance of Project effects for regulatory purposes (Section 2.2.5.2), the likely residual effects of Project operation on ecosystem diversity are expected to be adverse, medium in geographic extent, long term in duration and, depending on the ecosystem diversity indicator either nil, small or moderate in magnitude. The moderate magnitude residual effects are expected to be irreversible, continuous in frequency, and low in ecological context.

2.7.4.4 Uncertainty

Overall, the uncertainty related to the ecosystem diversity assessment is moderately low to moderate. The spatial extent of Project-related physical terrestrial loss as a percentage of the Regional Study Area can be predicted with relatively high accuracy. There is moderately low uncertainty as to the total area of terrestrial habitat that could be indirectly affected. Although the current amounts of the priority habitat types in Study Zone 4 can be mapped with relatively high accuracy, there is moderate uncertainty relating to the historical amounts of each priority habitat type in the Regional Study Area and the current amounts in the portions of the Regional Study Area that is outside of Study Zone 4.

2.7.4.5 Environmental Monitoring and Follow-up

Ecosystem diversity monitoring will include confirming that the identified white birch mixedwood priority habitat patch was avoided, rehabilitation to native broad habitat types was successful at identified locations and documenting the actual direct and indirect effects on each of the priority habitat types. Monitoring details are provided in the Terrestrial Environment Monitoring Plan (Manitoba Hydro 2012b).

2.8 WETLAND FUNCTION

2.8.1 Introduction

Wetland functions are the natural properties or processes that are associated with wetlands, independent of the benefits those functions provide to humans (Smith *et al.* 1995; Lynch-Stewart & Associates 2000; Hanson *et al.* 2008). Among other things, wetlands convert sunlight into biomass, store carbon, create soil, store and purify groundwater, protect shorelines, contribute to biodiversity and provide high quality habitat for some plant and animal species. Wetlands generally make high contributions to ecosystem function (Mitch and Gosselink 2000; Keddy 2010).

Wetlands also provide services to people such as recreational opportunities, hunting areas and drinking water purification. Several medicinal and country food plant species used by members of the KCNs are exclusively or most commonly found in wetlands (*e.g.*, sweet flag, tamarack).

The ecological and social importance of wetlands is recognized by Federal and Provincial policies relating to wetland conservation such as Manitoba's Water Policies (Sustainability Manitoba undated) and The Federal Policy on Wetland Conservation (Government of Canada 1991) and by guidelines for environmental assessments of projects affecting wetlands (*e.g.* Milko 1998b; Hanson *et al.* 2008).

2.8.1.1 Overall Approach

The overall goal of The Federal Policy on Wetland Conservation is: "to promote the conservation of Canada's wetlands to sustain their ecological and socio-economic functions, now and in the future". A subsidiary goal of the Federal Policy on Wetland Conservation is there be "no net loss of wetland functions on all Federal lands and waters".

What does no net loss of wetland function mean? Using the ecosystem health conceptual approach, it is possible for wetland functions to be maintained even when total wetland area declines. Not all of the biological elements (genes, species, populations, communities) or all of the interactions at a particular site are required to maintain its ecological functions (King 1993). In regions that are in a relatively pristine condition, it is anticipated some degree of area loss can be absorbed without adversely affecting ecosystem functions (Miller and Ehnes 2000). This is the practical implementation of the range of natural variability approach. Karr (undated) illustrates this overall approach when applied to communities with the diagram reproduced in Figure 2-38.

Shoreline wetlands are highly dynamic systems (Keddy 2010) so that the total areas of various wetland typesarea fluctuates naturally within a range while maintaining ecosystem functions. Wetland functions are adversely affected when total wetland area or the areas of certain wetland types fall below threshold values or when particularly important wetlands are altered.

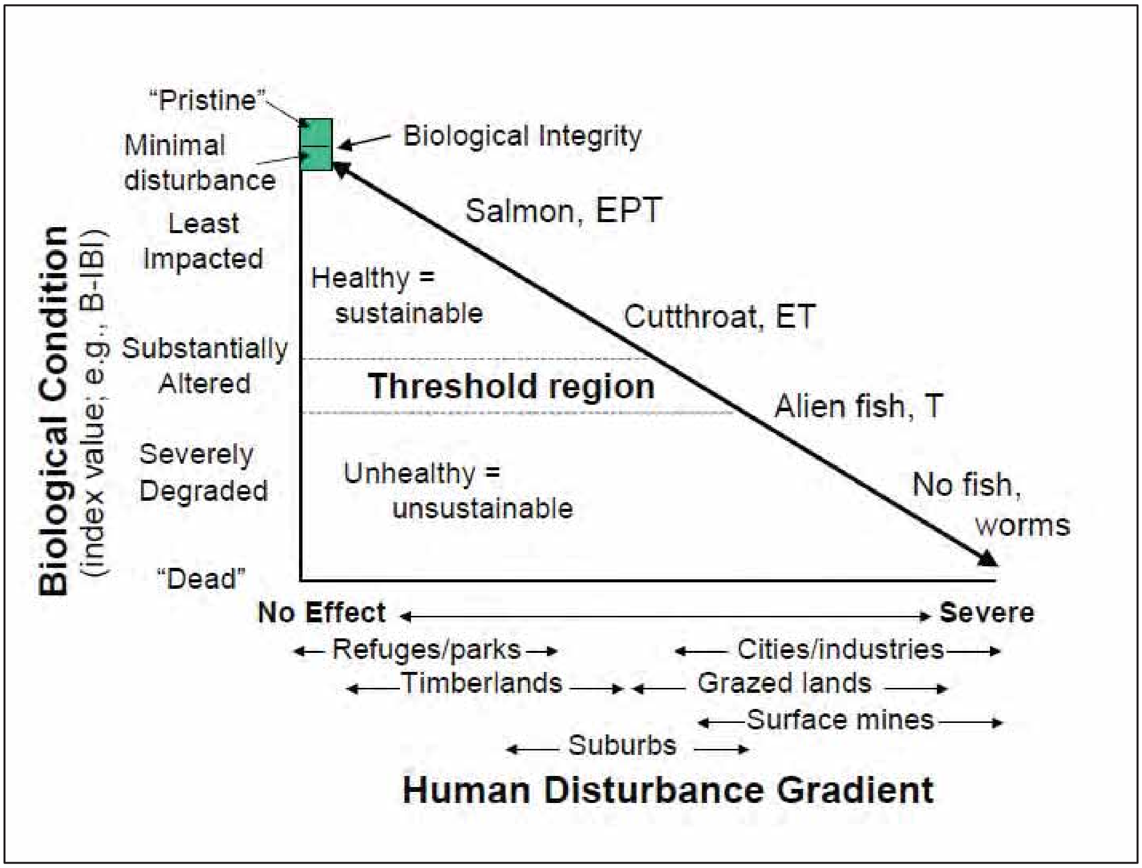


Figure 2-38: Relationship Between Biological Condition and a Hypothetical, Synthetic Measure of Human Activity, With Examples (from Karr Undated).

Two key factors in selecting an assessment approach to determine when wetland function is reduced to unacceptable levels are the regional context (Lynch-Stewart 1992) and the appropriate spatial scale to conduct the assessment (Miller and Ehnes 2000). In areas where a high proportion of wetland area has already been lost, it is presumed that there have been substantial effects on wetland function without directly measuring the functions performed by those wetlands. In some regions of Canada, further wetland area loss should be avoided because wetland area losses have already been severe (Government of Canada 1991).

As described above, it is anticipated some degree of area loss can be absorbed without adversely affecting wetland function in regions where wetlands are abundant and remain in a relatively pristine condition. Focusing on particularly important wetlands for evaluation and mitigation is an appropriate approach for a region with extensive wetlands that are in a relatively pristine condition.

In regions with extensive natural wetlands, the particularly important wetlands are critical habitats (*e.g.*, RAMSAR sites, waterfowl staging areas identified by North American Waterfowl Management Plan) or regionally rare wetland types. This appears to be the approach taken by the Northern Ontario

Wetland Evaluation System (Anonymous 2012), which uses the process for creating protected areas as the appropriate mechanism for evaluating wetlands in remote regions with extensive wetlands. For these remote areas, a screening system is used to identify wetlands that have the potential to be provincially significant so that priorities can be set for identifying which wetlands will undergo a detailed wetland evaluation. That is, there seems to be an implicit acknowledgement that some wetland area loss is acceptable given the regional context of extensive naturally functioning wetlands.

Focusing on particularly important wetlands for evaluation and mitigation is an appropriate approach for this Project assessment since the Project is located in a region with extensive wetlands that are in a relatively pristine condition except along the Nelson River. The approach of focusing on particularly important wetlands for evaluation and mitigation is appropriate for the Project assessment since the Project is located in a region with extensive wetlands that are in a relatively pristine condition. Wetlands cover approximately 90% of the land area in the Keeyask region. Historical wetland losses and alterations in the Keeyask region have been modest, estimated as having been less than 5% of historical land area. The vast majority of the affected wetlands are on the Nelson River. Consequently, a wetland function assessment approach that places greatest emphasis on the particularly important wetland types is appropriate.

The regional ecosystem is the appropriate ecosystem level to assess the effects of development on wetland function in a naturally functioning ecosystem (Miller and Ehnes 2000).

2.8.1.2 Assessment Techniques

Numerous techniques for evaluating wetland function have been proposed and tested. Several reviews have concluded that no single technique is best for all regions or all situations (Bartoldus 2000; Kusler 2006; Hanson *et al.* 2008). Technique selection must be based on the wetland types and questions to be addressed by the wetland functions assessment (Hanson *et al.* 2008). Given the severe wetland losses that have occurred in most of North America south of the boreal forest, most of the existing wetland evaluation techniques focus on rating wetland condition (Fennesey *et al.* 2007), which is the degree to which a wetland's function has been altered in a developed setting (Smith *et al.* 1995).

In contrast, an evaluation technique that compares the functions performed by various wetland types is appropriate for the Project context. Such a comparative technique would identify the particularly important wetlands in a region with extensive, natural wetlands. Examples of evaluation techniques that rate or rank the degrees to which different wetland types perform various wetland functions include the Northern Ontario Wetland Evaluation System (Anonymous 2012) and The Washington State Wetland Rating system for Western Washington (Hruby 2004).

A key decision when selecting a comparative evaluation technique is the appropriate level of effort. As Kusler (2006) points out "Wetlands are complex systems . . . developing a detailed and accurate understanding of the hydrology, soils, water chemistry, plants, animals for even a single wetland can require hundreds or thousands of hours of investigation". For this reason, rapid assessment techniques such as and Bond *et al.* (1992) were developed. These techniques have fallen out of favour unless they are backed by empirical data from the area (Hanson *et al.* 2008).

Even though the Northern Ontario Wetland Evaluation System involves a high level of effort (Chisholm *et al.* 1997), the technique's approach is still useful for assessments of developments in northern regions.

The Northern Ontario Wetland Evaluation System (Anonymous 2012) is the most relevant wetland function evaluation technique for the Project region since it was developed for the boreal zone. The Ontario Wetland Evaluation System (OWES) is a science-based ranking system that provides a standardized approach to determining the relative value of wetlands (Ontario Ministry of Natural Resources 2012).

In the Northern Ontario Wetland Evaluation System, wetland values for four principal components (biological, social, hydrological and special features) are scored and then summed to provide an overall score for an individual wetland (the components and attributes that are wetland services rather than wetland functions can be ignored without comprising the overall approach). Component scores are calculated by ascribing points to a variety of wetland attributes that are relevant to the component. This approach of scoring individual attributes, summing attribute scores into a component score and then summing component scores into an overall individual wetland score is analogous to the Washington State Wetland Rating system for Western Washington (Hruby 2004).

A field visit to each individual wetland is required to score some of the attributes in the Northern Ontario Wetland Evaluation System, which is why it is not applied to regions with extensive wetlands. Given the large area involved in a region level assessment of wetland function effects, it is neither feasible nor necessary to conduct a field assessment of each individual wetland. In most cases, a development will affect a very small proportion of regional wetland area so the focus is on a screening technique that identifies wetlands that are particularly important for the region level ecosystem.

2.8.2 Assessment Approach and Methods

2.8.2.1 Overview

The wetland function VEC provides an assessment of Project effects on wetland functions, focusing on the particularly important wetlands in the Keeyask region. Table 1A-1 provides additional details explaining why wetland function was selected as a VEC.

Wetland quality was the indicator used to evaluate wetland function. Wetland quality is a combined rating of wetland condition and the anticipated degree to which a particular wetland type normally performs various wetland functions. Wetland condition is the degree to which the functions normally performed by a wetland have been adversely affected by human development and activities.

Measured indicator attributes included the total area of each wetland type ranked according to wetland quality.

The general assessment approach and methods for wetland function were the same as those used for all of the key topics (see Sections 1.3, 1.4 and 2.2). Details specific to the wetland function assessment are provided below.

2.8.2.2 Study Areas

The Wetland Function Local and Regional Study Areas were Study Zones 2 and 5 in Map 2-1, respectively. The 18,689 ha Local Study Area is the area where direct and indirect Project effects on individual wetlands and wetland complexes may occur. Since the Regional Study Area boundaries closely approximated watershed boundaries, Study Zone 5 was used for easy comparability with other key topics. In addition, the peatland types that account for the majority of wetland area are more influenced by the fire regime than by watershed level drainage patterns (Section 2.3.2).

The 1,420,000 ha Regional Study Area was large enough to represent a region level ecosystem, an ecologically homogenous area capable of supporting the key boreal processes (*e.g.*, fire regime) and populations of most resident wildlife species (Section 1.3.5).

Due to the dramatic water regime differences in the Nelson River and off-system waterbodies, as well as between segments of the Nelson River (Section 4.3), the Regional Study Area was subdivided into the Nelson River and off-system zones and the Nelson River was subdivided into the shoreline wetland study zones shown in Map 2-20.

Proxy areas included Stephens Lake, Long Spruce reservoir, Notigi reservoir and Wuskwatim Lake. Off-system lakes and a portion of the Fox River were used as benchmark areas (Map 2-2).

2.8.2.3 Information Sources

Sections 1.4.6 and 2.2.4 describe the information sources generally used in the assessment. The detailed habitat mapping and habitat relationships analyses were the primary data sources used to evaluated wetland quality status and trends and to identify particularly important wetlands. Information sources used to produce the terrestrial habitat mapping and habitat relationships analyses are described in Section 2.2.4. Additional data sources were the mapped caribou calving and rearing complexes (Section 7.4.6.2).

2.8.2.4 Methods

Important factors that influenced the approach used to assess potential Project effects on wetland function were:

- The detailed wetland mapping area is over 221,509 ha in size;
- Wetlands cover approximately 90% of terrestrial area in the Regional Study Area;
- Most of the wetlands in the Regional Study Area have not been altered by human development and activities. The primary exception is that wetlands along the Nelson River have been highly disrupted by hydroelectric development;
- Every wetland performs multiple functions to varying degrees;
- It is impractical to complete a detailed wetland function field evaluation for each individual wetland given the amount of wetland in the Regional Study Area; and,
- A wetland classification system can incorporate the information needed to rank the degree to which various wetland functions are performed by each wetland type.

Since wetlands account most of the terrestrial area in the Local and Regional Study Areas and both study areas were large, it was neither necessary nor practicable to undertake a field evaluation of each individual wetland. Wetland function was evaluated by assigning an overall wetland quality score to each mapped wetland based on its wetland type.

This overall wetland quality score is a combined rating of wetland condition and the anticipated degree to which a particular wetland type normally performs various wetland functions. Wetland condition is the degree to which the functions normally performed by a wetland have been adversely affected by human development and activities. Wetland quality scoring reduces the standard wetland function rating for wetlands along Nelson River shorelines as a reflection that they were highly disrupted in terms of a number of attributes such as native species diversity and peat volume.

A number of attributes contribute to wetland function. A particular wetland possesses a subset of these attributes to varying degrees. The wetland function component of the wetland quality score reflects the anticipated degree to which a particular wetland performs biogeochemical, hydrological, and biodiversity functions on a per hectare basis. The broad and specific functions used to score each of these broad wetland functions were:

- Biogeochemical functions:
  - Carbon storage;
  - Nutrient and organic export; and,
  - Water quality treatment.
- Hydrological functions:
  - Climate regulation;
  - Groundwater recharge;
  - Shoreline and erosion protection; and,
  - Water flow moderation.
- Biodiversity functions:
  - Degree of regional rarity for the wetland type;
  - Diversity of vegetation types within the wetland;
  - Plant species richness;
  - Habitat for focal wetland wildlife species (waterfowl, muskrat, caribou, moose, olive-sided flycatcher); and,
  - High quality habitat for species of concern (caribou, olive-sided flycatcher).

Each individual wetland in the terrestrial habitat map (Section 2.2.4.4) was assigned a standard score for each of the above functional attributes based on its wetland type. The individual scores were derived from Hanson *et al.* (2008), information from Project studies and the scientific literature. For each individual mapped wetland, the individual scores were summed to produce an overall wetland quality score. Since caribou select calving and rearing habitat at the wetland complex rather than the individual wetland level (Section 7.3.6.3), individual wetlands that were part of a potential caribou calving and rearing complex received an increment to their overall wetland quality score.

The following steps were taken to assess potential Project effects on wetland function:

1. Classify wetlands using the Canadian Wetland Classification System (CWCS; National Wetlands Working Group 1997) with enhancements to reflect regional conditions, Nelson River water regulation and water depth duration zones in shoreline (*i.e.*, littogenous) wetlands;
2. Complete detailed wetland mapping for the study area;
3. Assign a standard wetland quality score to each wetland type based on its condition and its expected degree of contribution to biogeochemical, hydrological, habitat and ecosystem functions under natural conditions;
4. Apply the standard wetland quality score to each of the mapped wetland patches based on its wetland type;
5. Increase the score of wetland patches that are components of a wetland complex that provides high quality habitat for priority wildlife species that select habitat at the wetland complex rather than the individual wetland level;
6. Modify Project design to avoid any globally, nationally or provincially significant wetlands;
7. Quantify the regional percentage of each wetland type that could potentially be affected by the Project;
8. Identify mitigation to reduce Project effects to achieve no net area loss of particularly important wetlands; and,
9. Identify mitigation to reduce Project effects on the remaining wetlands so that cumulative wetland area losses remain below 10% of the historical area for the wetland type.

Further details regarding wetland classification and wetland quality scoring are provided below.

Since wetlands are a type of terrestrial habitat, the terrestrial habitat effects predictions (Section 2.3.6) were the basis for predicting potential Project effects on wetland function.

The acceptability of residual Project effects on wetland function was evaluated based on how the particularly important wetlands would be affected and the cumulative historical area losses for each of the remaining native wetland types. Subtantial effects on any existing globally, nationally and/or provincially significant wetland would be an unacceptable effect. For the other particularly important wetland types, a net area loss would be an unacceptable effect. For the remaining native wetland types, effects that are small to moderate in magnitude would generally be acceptable regardless of their duration or geographic extent because this degree of change is expected to fall within the range of natural variability. Exceptions to this generalization could occur for a moderate magnitude residual effect if there was a substantial ongoing adverse trend in the amount of a wetland type being considered.

The magnitude of residual Project effects on those native wetland types not classified as being particularly important was measured as the cumulative percentage of area affected by human development and activities in the Regional Study Area. Percentage change benchmarks were as follows: percentage changes below 1% are small magnitude; percentage changes between 1% and 10% are moderate magnitude; and, percentage changes greater than 10% are high magnitude (Hegmann et al. 1999; Salmo et al. 2004 for the 10% value).

2.8.2.4.1 Wetland Mapping

As described in Section 2.2.4.4, the CWCS (National Wetlands Working Group 1997) is a hierarchical classification system comprised of wetland class, form and type. Wetland classes reflect the overall genetic origin of the wetland ecosystem and the nature of the wetland environment Bog, fen, swamp, marsh and shallow water are the five wetland classes. Wetland forms are subdivisions of each wetland class based on surface morphology, surface pattern, water type and morphological characteristics of the underlying mineral soil. Many of the wetland forms are applied to more than one wetland class (e.g., riparian fen and riparian bog). Some forms can be further subdivided into subforms. Wetland types are subdivisions of the wetland forms and subforms based on physiognomic characteristics of the vegetation communities. Due to the limitations of mapping wetlands from 1:15,000 photography, the forb, graminoid, lichen, moss and low shrub types were grouped into a broader category called low vegetation in the terrestrial habitat mapping. The term wetland type in this document refers to a CWCS subform enhanced to capture shoreline wetland water depth duration zones and the differing water regimes found on the Nelson River and off-system waterbodies.

The CWCS recognizes three distinct zones in marshes that relate to the durations of water depths. Keddy (2010) and Hellsten (2000) have formalized these zones for natural and regulated shoreline wetlands to aid in understanding and predicting the effects of hydroelectric development on shoreline wetlands. Their approaches were applied when incorporating Project water and ice regimes into the shoreline wetland classification.

2.8.2.4.2 Wetland Quality

As described above, the anticipated degree of contribution to wetland function provided by each wetland type on a per hectare basis was assigned using relevant wetland literature and wetland data collected in the Regional Study Area.

Appendix B table in Hanson *et al.* (2008) classifies each of the wetland subforms defined by the CWCS into a low, moderate, high or variable function level for various wetland functions based on the degree to which the wetland subform typically performs each function:

- water flow moderation;
- groundwater recharge;
- shoreline erosion and protection;
- water quality treatment;
- climate regulation;
- nutrient and organic export;
- carbon sequestration and storage; and,
- biological productivity and support for biodiversity.

The qualitative functional rankings (i.e., low, moderate, high) from Appendix B in Hanson et al. (2008; this table is reproduced in a restructured format as Appendix 2F, Table 2 83) were used to assign the standard wetland function score for each broad wetland function except for biological productivity and support for biodiversity.

Function level scores for biological productivity and support for biodiversity functions were assigned based on regional conditions. The specific attributes included were the wetland's degree of rarity in the Regional Study Area, typical vegetation diversity, number of plant species typically occurring in the type and habitat quality for key priority wildlife species that use wetlands. From an ecosystem diversity perspective, rare and uncommon wetland types contribute highly to the biodiversity component of wetland function. The key priority wildlife species were waterfowl, olive-sided flycatcher, moose, caribou, and muskrat. High quality habitat for other plant and wildlife species is considered in the plant and wildlife sections.

In general, the standard function level score assigned to each wetland function ranking was as follows: low=1; moderate=3; high= 5 and variable=3. Wetland quality scores for regional rarity and habitat quality for species at risk received higher moderate and high scores (moderate=9; high= 15 and variable=9) to provide higher weighting for this attribute in the overall wetland score.

Since the overall wetland scores are approximations due to their derivation from qualitative ranks, minor differences between overall scores for wetland types should not be used to rank wetland types with similar overall wetland quality scores. In other words, overall wetland quality scores that are within 5 points of each other should be interpreted as not being different. The purpose of these scores is to elucidate broad differences in the relative contributions of various wetland types to wetland function. The component scores are being refined using a multivariate statistical habitat relationships model, which is expected to maintain the overall ranking of the wetland types.

Caribou was the key priority wildlife species in the Regional Study Area that selects wetland mosaics rather than individual wetland patches to meet a life requisite (Section 7.3.6.3). A wetland patch that was part of a mapped potential caribou calving and rearing peatland complex received a five point increment to its overall wetland quality score.

2.8.3 Environmental setting

2.8.3.1 Historical Conditions

As described in Section 2.3.3.2, climate change over the past 150 years and the cumulative human footprint have affected wetlands. The overall patterns follow those described in Section 2.3.3. Hydroelectric and public infrastructure development have reduced total wetland area as well as the amounts of moderate and high quality wetlands. Wetland composition was also altered by those roads and other infrastructure that changed hydrology. All of the natural Nelson River shoreline wetlands in the Regional Study Area were either lost to flooding or have been altered by modified water and ice regimes. Off-system wetlands with hydrological connections from the Nelson River to the wetlands may have been affected by flooding and hydrological changes related to Nelson River water regulation.

2.8.3.2 Current Conditions

2.8.3.2.1 Wetland Composition and Distribution

Wetlands accounted for approximately 90% of the land area in the Regional Study Area in 2010. The Regional Study Area is essentially one large wetland complex that is dotted with mineral-capped ridges and hills (Map 2-21). Bog accounted for approximately 91% of the wetland area in 2010, followed by fen (8% of wetland area) and marsh (1% of wetland area). Swamp was virtually absent, with none occurring in the Local Study Area.

In descending order, the most abundant wetland forms were veneer bog, blanket bog and the various permafrost bog wetland forms (Table 2-38). The relatively abundant fen wetland forms were horizontal fen and riparian fen. Swamp is not considered further since it was virtually absent in patches large enough to map and none of the mapped patches were within the Local Study Area.

Marsh wetland forms included lacustrine marsh, stream marsh, riparian fen, riparian bog and shallow water (shallow water was only mapped for the Keeyask reach of the Nelson River where bathymetry data were available to separate shallow from deep water). As noted in Section 2.3.4.1.3, the nature and composition of Nelson River and off-system shoreline wetlands were considerably different. Nelson River shoreline wetlands were highly disrupted by water regulation and associated ice scouring, which presumably is why vegetation and plant species diversity in these wetlands were lower than in comparable environmental conditions in off-system wetlands. Virtually all of the littoral and lower beach marsh was in off-system waterbodies. Emergent vegetation islands were frequent in off-system waterbodies (Map 2-29 to Map 2-40) but were not observed in patches large enough to map in the Keeyask shoreline wetland study zone

Focusing on shoreline wetlands, fen was by far the most abundant off-system vegetated wetland class, accounting for approximately 74% of shoreline wetland area (Table 2-39), followed by marsh (22%) and bog (4%). The shallow water wetland class, which is not included in the shoreline wetland land type, was only mapped for the Keeyask shoreline wetland study zone (Map 2-20) where it accounted for 83% of the total wetland area. There was no natural marsh in the Nelson River, presumably due to the high degree of water fluctuations and ice scouring (Keddy 2010).

On a lineal km of shoreline basis, the open water side of the shoreline is predominantly shallow water, with marsh occurring along only 3% of the shoreline. Marsh was less frequent in the Keeyask shoreline wetland study zone (Map 2-20), occurring along 1% of Keeyask shoreline versus nearly 8% of the classified Stephens Lake shoreline (Table 2-40). This may reflect the fact that Stephens Lake shorelines are still undergoing peatland disintegration from Kettle reservoir flooding whereas increased water levels in the Keeyask shoreline wetland study zone were within the historical range of variability (PE SV Section 6.3.1.4). Most of the marsh in the Stephens Lake shoreline wetland study zone was shrub and/or low vegetation on sunken peat, primarily originating from disintegrating peatlands.

Tall shrub on riparian peatland and low vegetation on wet peatland were scattered in sheltered bays and at stream outlets along the Nelson River. Wetland classes other than shallow water were virtually confined to inlets and sheltered bays (Map 2-28 to Map 2-40).

Large herb and/or tall shrub meadows appeared during low to intermediate water levels in the shoreline wetlands found in several bays. A tall shrub band was present at upper elevations along approximately 59% of the classified shoreline, becoming wide along about 21% of the shoreline. Most of the tall shrub vegetation occurred on peat banks. Willows were the most abundant tall shrubs by far. In Stephens Lake, marsh and fen were the only vegetated wetland classes occurring in the remainder of the classified shoreline.

Emergent vegetation was more common in Stephens Lake, particularly in the bays. Although shoreline tall shrub vegetation occurred on a higher proportion of the classified shoreline, wide tall shrub bands were less common. Floating peat islands produced by peatland disintegration occurred in Stephens Lake.

With respect to area, regulated marsh made up two-thirds of the shoreline wetlands (Table 2-41). These marshes occurred on the upper and lower beach water depth duration zones along the Nelson River, however due to water fluctuation and ice scour, these did not resemble off-system marshes. Most of the marsh area in Keeyask was lacustrine shore marsh on upper beach (41%), and lacustrine bay marsh on upper beach (12%). The 13% that included upper beach shore and bay marsh on sunken, disintegrated peatland was primarily found in Stephens Lake. Most of the remaining shoreline area (33%) was comprised of riparian fens, which were generally scattered in sheltered bays and at stream outlets (Map 2-21).

On a lineal km of shoreline basis, shallow water was the most frequent wetland type on the water side of the off-system shoreline, with marsh occurring along 15% of the shoreline. These marshes were occurring within shallow lacustrine environments and along the sunken margins of floating peatlands. On the inland side of the shoreline, riparian fens were most common, comprising 57% of the classified length, while riparian bogs comprised only 3%. The remaining shoreline occurred along inland uplands and wetlands (Map 2-28 to Map 2-40).

Most of the vegetated off-system shoreline wetland area was comprised of riparian fen (90%) followed by riparian bog (6%), with marsh making up the remaining area (Table 2-42). Approximately 75% of the 193 ha of off-system marsh in Study Zone 4 was lacustrine bay marsh while the rest was riparian stream marsh. This off-system marsh was predominantly located in the littoral rather than the lower beach water depth zone, typically growing as a narrow band along the shoreline. Off-shore marsh islands and patches of floating-leaved plants tended to occur in the littoral zone. Most of the remaining marsh was growing on the sunken fringes of floating riparian fens and bogs. Photo 2-7 and Photo 2-8 are photos of typical off-system marshes growing on the lake bottom.

Off-system waterbodies with relatively high amounts of marsh were located along waterways and tended to be situated in the valleys formed by pronounced drumlins, presumably receiving nutrient inputs captured by surface and groundwater flow from these landforms.

Photo 2-7: Aerial View of Off-System Marsh Growing on the Lake Bottom Next to a Riparian Peatland

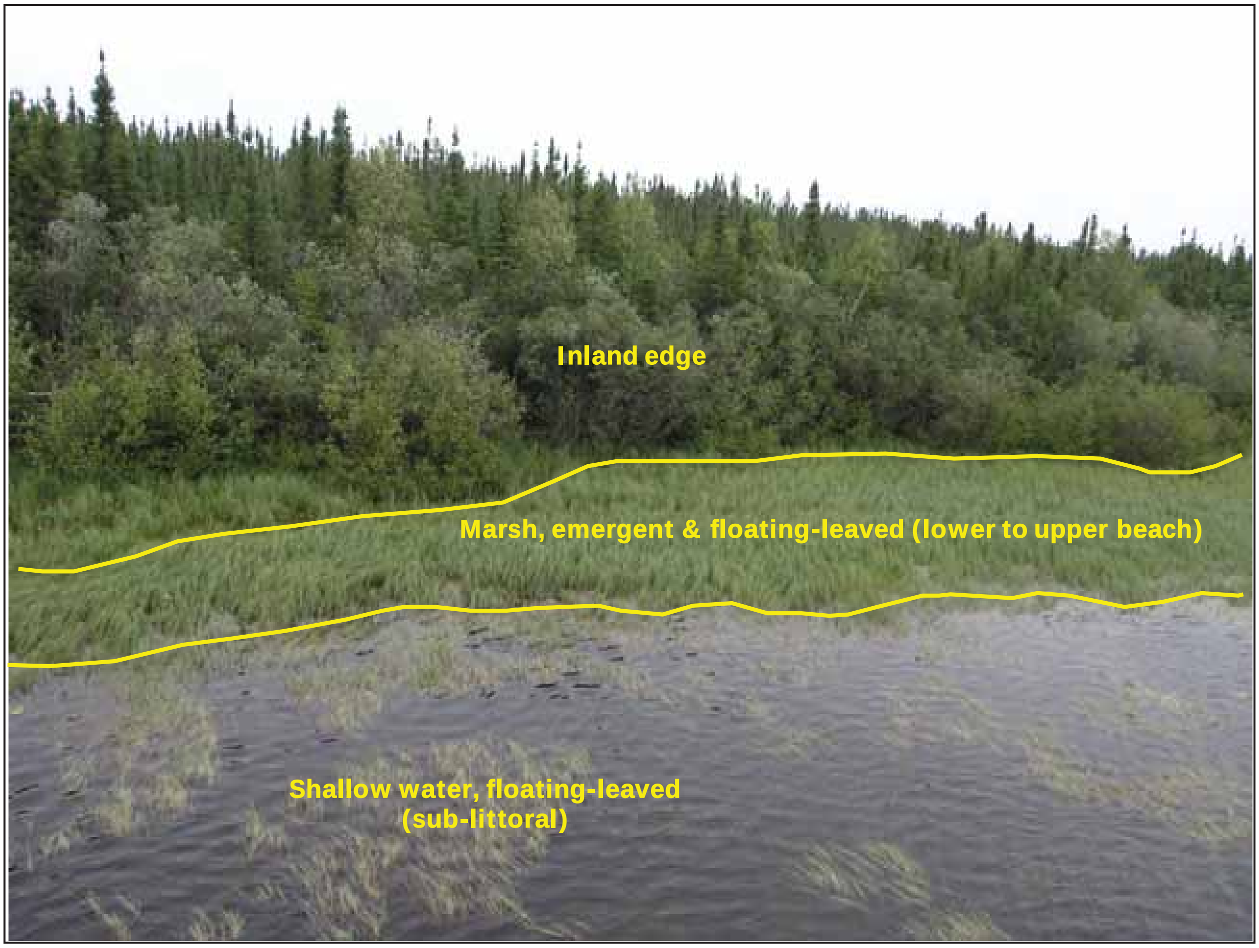


Photo 2-8: Close-up View of Off-System Marsh and Floating-leaved Vegetation Growing on the Lake Bottom

Table 2-38: Composition of Existing Wetlands by Wetland Class and Form

Wetland Class	Wetland Form	Study Zone 4	Wetland Function Local Study Area
Swamp	Flat	0.0	-
Bog	Veneer	46.9	50.9
	Slope	1.6	0.6
	Blanket	23.3	22.7
	Peat plateau	5.5	5.0
	Collapse scar	0.2	0.3
	Peat plateau bog/collapse scar mixture	11.0	9.6
	Blanket bog/collapse scar mixture	1.6	-
	Flat	0.7	0.6
	Riparian	0.2	0.1
Fen	Basin	0.0	-
	Slope	0.2	0.2
	Collapse scar	0.0	0.1
	Horizontal	4.4	2.3
	String	0.0	-
	Riparian	3.3	4.9
Fen/Bog mixture	Horizontal fen and blanket bog	0.2	-
Marsh	Lacustrine and stream	1.0	2.8
All		100.0	100.0
Total Area (ha)		**147,566**	**10,461**

Note: Reported areas are land area only.

Table 2-39: Overall Composition of Existing Shoreline Wetlands in the Nelson River and Off-system Waterbodies

Water Regime	Wetland Class	Wetland Form	Wetland Subform	Water Depth Duration Zone	Study Zone 4	Local Study Area
Off-system	Bog	Riparian	Shore and floating		4.1	1.4
	Fen	Riparian	Shore and floating		64.1	35.4
	Marsh	Lacustrine	Bay	Littoral	1.2	0.1
				Lower beach	0.3	0.3
				Upper beach on sunken peat	0.8	0.6
		Riparian	Stream	Lower beach	0.0	
				Upper beach on sunken peat	0.6	0.4
Nelson River	Bog	Riparian	Shore and floating		0.0	0.1
	Fen	Riparian	Shore and floating		9.7	26.9
	Marsh	Lacustrine	Bay	Lower beach	0.2	1.3
				Upper beach	3.6	7.3
			Shore	Lower beach	0.0	
				Upper beach	11.8	15.5
			Shore and Bay	Upper beach on sunken, disintegrated peatland	3.7	10.5
Both	All				100.0	100.0

Table 2-40: Composition of Open Water Side of Nelson River of Classified Shoreline Wetlands as a Proportion of Lineal Shoreline Length by Reach

Wetland	Keeyask Reach	Stephens Reach	All
Marsh	1.1	7.6	3.2
Bog	0.0	0.1	0.0
Fen	10.0	27.2	15.5
Shrub Meadow	4.4	7.9	5.6
Wet Meadow	4.8	0.0	3.3
Shallow Water	79.7	57.2	72.4
Total classified shoreline length (km)	*254*	*121*	*374*

Table 2-41: Composition of Existing Shoreline Wetlands in the Nelson River

<table>
<tr><th>Wetland Class</th><th>Wetland Form</th><th>Wetland Subform</th><th>Water Depth Duration Zone</th><th>Study Zone 4</th><th>Local Study Area</th></tr>
<tr><td>Bog</td><td>Riparian</td><td>Shore and floating</td><td></td><td>0.1</td><td>0.1</td></tr>
<tr><td>Fen</td><td>Riparian</td><td>Shore and floating</td><td></td><td>33.5</td><td>43.7</td></tr>
<tr><td rowspan="5">Marsh</td><td rowspan="5">Lacustrine</td><td rowspan="2">Bay</td><td>Lower beach</td><td>0.6</td><td>2.2</td></tr>
<tr><td>Upper beach</td><td>12.3</td><td>11.9</td></tr>
<tr><td rowspan="2">Shore</td><td>Lower beach</td><td>0.0</td><td>-</td></tr>
<tr><td>Upper beach</td><td>40.7</td><td>25.2</td></tr>
<tr><td>Shore and Bay</td><td>Upper beach on sunken, disintegrated peatland</td><td>12.9</td><td>17.0</td></tr>
<tr><td colspan="4">Total Nelson River wetland area (ha)</td><td>1,920</td><td>502</td></tr>
</table>

Table 2-42: Composition of Existing Shoreline Wetlands in the Off-System Waterbodies

Wetland Class	Wetland Form	Wetland Subform	Water Depth Duration Zone	Study Zone 4	Local Study Area
Bog	Riparian	Shore and floating		5.8	3.7
Fen	Riparian	Shore and floating		90.1	92.4
Marsh	Lacustrine	Bay	Littoral	1.7	0.4
			Lower beach	0.4	0.8
			Upper beach on sunken peat	1.2	1.6
	Riparian	Stream	Lower beach	0.0	-
			Upper beach on sunken peat	0.8	1.0
Total off-system wetland area (ha)				*4,723*	*312*

2.8.3.2.2 Shoreline Wetland Habitat Type Descriptions

This section provides an overview characterizations of the common shoreline wetland habitat types by water depth duration zone. Section 2.3.4.2 provides descriptions of the inland wetland habitat types.

As noted above, water depth duration zones typically organize plant species into a sequence of vegetation and habitat types at a particular shoreline location. Water horsetail and viscid great bulrush were the most common shoreline habitat types in the shallow water depth zone of the Nelson River and off-system waterbodies, followed by small yellow pond-lily and creeping spike-rush. The only shallow water habitat type found in the Nelson River was water horsetail, most of which was in the Keeyask reach.

The water horsetail and viscid great bulrush habitat types were emergent, or marsh, habitat types. The water horsetail habitat type usually occurred on mineral substrates with bottle sedge and water smartweed in the Nelson River and on a mixture of mineral and organic substrates with narrow-leaved bur-reed and small yellow pond-lily in the off-system waterbodies (Table 2-43). The viscid great bulrush habitat type, which included viscid great bulrush as its sole species, was associated with fine mineral substrates. These habitat types represent marsh habitat in the off-system and Nelson River waterbodies. Generally, off-system marsh habitat tended to be more species-rich, had a wider range of marsh habitat types, and had a higher abundance of floating-leaved species (Table 2-43).

In the lower to middle beach water depth zone, small bedstraw /creeping spike-rush/water smartweed was the most common habitat type, followed by the bottle sedge/bladderwort type, green reindeer lichen (*Cladina mitis*)/bladderwort type, and marsh five-finger /sedge type. The small bedstraw/creeping spike-rush/water smartweed habitat type was the most common lower to middle beach habitat type in the Nelson River but was not found in the off-system lakes. It primarily on organic substrates and often included water parsnip (*Sium suave*), smooth beggar-ticks and water sedge. In contrast, the bottle sedge/bladderwort habitat type was one of the most common in the off-system lakes but was not found in the Nelson River. It typically occurred on organic substrates and often included marsh reed-grass and water horsetail.

In the upper beach and inland edge water depth zone, flat-leaved willow/marsh reed-grass was the most common habitat type, followed by the water sedge/marsh reed grass and silverweed/narrow reed-grass types. The former two habitat types were encountered in both the Nelson River and off-system waterbodies, while the latter was only found in the Nelson River. The flat-leaved willow/marsh reed-grass habitat type typically occurred on organic substrates and often included peat moss, common horsetail (*Equisetum arvense*), three-leaved Solomon's-seal, dewberry and water sedge. Bog bilberry also occurred in the Nelson River occurrences of this habitat type.

Table 2-43: Typical species composition of off-system and Nelson River shallow water (marsh) habitat

Off-System Marsh		Nelson River Marsh	
Habitat Types	**Typical Species**	**Habitat Types**	**Typical Species**
Water horsetail Viscid great bulrush Small yellow pond-lily Creeping spike-rush	Mineral substrates: Various-leaved pondweed (*Potamogeton gramineus*), Viscid great-bulrush (*Schoenoplectus tabernaemontani*), creeping spike-rush (*Eleocharis palustris*), water horsetail (*Equisetum fluviatile*) Organic substrates: Spiked water-milfoil (*Myriophyllum sibiricum*), Richardson's pondweed (*Potamogeton richardsonii*), narrow-leaved bur-reed (*Sparganium angustifolium*), needle spike-rush (*Eleocharis acicularis*), small yellow pond-lily (*Nuphar variegata*)	Water horsetail	Mineral substrates: Water horsetail (*Equisetum fluviatile*), bottle sedge (*Carex utriculata*), water smartweed (*Persicaria amphibia*)

2.8.3.2.3 Wetland Quality

As described above, scores that provided combined ratings for individual wetland functions, as adjusted for wetland condition, were summed to obtain an overall wetland quality score for each wetland type. Standard wetland quality scores for each combination of wetland subform and water regime type are provided in Table 2-44.

The off-system marsh wetland types attained the highest overall standard wetland quality scores before making an increment for potential caribou calving and rearing habitat (score equals 60 to 62; Table 2-44). Although the off-system riparian fen types had the next highest overall wetland quality scores (score equals 51), their scores were substantially lower than the off-system marsh scores. Inland swamp types were the the next highest scoring wetland types (score equals 47).

The off-system marsh types were considered to be particularly important wetland types because their overall wetland quality scores were substantially higher than all of the other wetland types, the off-system marsh wetland class was rare in the Regional Study Area and these wetland types were highly ranked for the biodiversity and habitat attributes.

Approximately 163 ha of Nelson River marsh, which consisted of disturbed, non-native wetland types, were mapped in the Keeyask shoreline wetland study zone during the 2003 to 2005 period. All of the Nelson River marsh types received relatively low wetland quality scores (*i.e.*, less than 20) due to the influences of water regulation on their ability to perform wetland functions. It appeared that extremely high flows and water levels on the Nelson River from 2005 to 2011 eliminated marsh in the Keeyask shoreline wetland study zone. Because shoreline wetlands are highly dynamic ecosystems, marsh is expected to redevelop over time once water levels drop and remain below median levels for several growing seasons (Keddy and Fraser 2000).

Table 2-44: Anticipated Degree of Contribution to Wetland Function for the Wetland Classes Occurring in the Regional Study Area

Canadian System of Wetland Classification			Hydrodynamics Class	EcoSite Fine Type	Wetland Quality Score
Class	**Form**	**SubForm**			
Marsh	Riparian	Stream	Stream	Lower beach	62
Marsh	Lacustrine	Bay	Lake	Lower beach	62
Marsh	Riparian	Stream	Stream	Littoral	62
Marsh	Lacustrine	Bay	Bay	Littoral	62
Marsh	Lacustrine	Bay	OffSystem	Upper beach on sunken, riparian peatland	60
Marsh	Riparian	Stream	Stream	Upper beach on sunken peat	60
Marsh	Riparian	Bay	Bay	Upper beach on sunken peat	60
Fen	Riparian	Shore and floating	Stream	Riparian fen	51
Fen	Riparian	Shore and floating	Lake	Riparian fen	51
Fen	Riparian	Stream and floating	Stream	Riparian fen	51
Swamp	Riparian		Inland	Swamp	47
Swamp	Flat		Inland	Deep wet mineral	43

Table 2-44: Anticipated Degree of Contribution to Wetland Function for the Wetland Classes Occurring in the Regional Study Area

Canadian System of Wetland Classification			Hydrodynamics Class	EcoSite Fine Type	Wetland Quality Score
Class	**Form**	**SubForm**			
Fen	String	Northern ribbed, ladder or net	Groundwater flow	String fen	39
Fen	Feather		Groundwater flow	Feather fen	39
Bog	Riparian	Shore and floating	Stream	Riparian bog	39
Bog	Riparian	Shore and floating	Lake	Riparian bog	39
Fen	Basin		Inland	Basin fen	37
Peatland	Slope		Inland	Slope peatland	35
Fen	Slope		Inland	Slope fen	35
Fen/ Bog mixture	Horizontal and blanket mixture		Inland	Horizontal fen/ blanket bog mosaic	35
Fen	Horizontal		Inland	Horizontal fen	33
Fen	Horizontal		Inland	Horizontal fen/ flat bog mosaic	33
Bog	Flat		Inland	Flat bog	29
Bog	Slope		Inland	Slope bog	27
Bog	Peat plateau		Inland	Peat plateau bog	27
Bog	Polygonal peat plateau		Inland	Polygonal peat plateau bog	27
Fen	Collapse scar		Inland	Collapse scar fen	27
Bog	Peat plateau		Inland	Peat plateau bog transitional stage	23
Bog	PPB/ CS mixture		Inland	Peat plateau bog/ collapse scar peatland mosaic	23
Bog	BB/ CS Mixture		Inland	Blanket bog/ collapse scar peatland mosaic	23
Bog	Collapse scar		Inland	Collapse scar bog	23
Shallow water	Lacustrine	Shore	OffSystem	Shallow water	22
Bog	Veneer or Blanket		Inland	Veneer or blanket bog	21
Bog	Veneer		Inland	Veneer bog	21
Shallow water	Lacustrine	Bay	OffSystem	Shallow water	20
Bog	Veneer	Strongly sloped	Inland	Veneer bog on slope	19
Bog	Riparian	Shore and floating	Nelson River	Riparian bog	18
Fen	Riparian	Shore and floating	Nelson River	Riparian fen	18
Bog	Blanket	0	Inland	Blanket bog	17
Marsh	Lacustrine	Shore	Nelson River	Lower beach	17
Marsh	Lacustrine	Bay	Nelson River	Lower beach	17

Table 2-44: Anticipated Degree of Contribution to Wetland Function for the Wetland Classes Occurring in the Regional Study Area

Canadian System of Wetland Classification			Hydrodynamics Class	EcoSite Fine Type	Wetland Quality Score
Class	**Form**	**SubForm**			
Marsh	Lacustrine	Bay	Nelson River	Lower beach on sunken, disintegrated peatland	17
Marsh	Lacustrine	Bay	Nelson River	Upper beach on sunken, disintegrated peatland	16
Marsh	Lacustrine	Shore	Nelson River	Upper beach-regulated	15
Marsh	Lacustrine	Bay	Nelson River	Upper beach-regulated	15
Marsh	Lacustrine	Bay	Nelson River	Littoral- regulated	14

Note: These are the wetland quality scores for the wetland type before incrementing for potential caribou calving and rearing habitat.

Based on the overall wetland quality scores after adjustments for potential caribou calving and rearing habitat, Study Zone 4 included 193 ha of wetlands scoring at least 60, 12 ha of which were situated in the Local Study Area (Table 2-45). Over 100,000 ha, or 68% of wetlands had wetland quality scores that were less than 20, primarily due to the high contribution of inland bog types to total wetland area (Table 2-38).

The distribution of the highest wetland quality score class within Study Zone 4 is the same as that described for off-system marsh in the previous section since this was the only wetland type falling into the highest score class even after adjustments for potential caribou calving and rearing habitat. Of the remaining wetlands, those scoring between 42 and 51 (classes 40-49 and 50-59 in Table 2-38) were associated with riparian areas, along streams, and were most frequent north and south of Gull Lake and south of Stephens Lake (Map 2-22). Class 30-39 wetlands were distributed throughout Study Zone 4, but the most extensive areas occurred around the Long Spruce reservoir, and one large area near PR 280 in the northwest portion of Study Zone 4.

Table 2-45: Existing Wetland Area by Wetland Quality Score Class

Wetland Quality Score Class	Area (ha)		Percentage of Wetland Area	
	Study Zone 4	Local Study Area	Study Zone 4	Local Study Area
60	193	12	0.1	0.1
50	4,255	288	2.9	2.8
40	168	-	0.1	-
30	7,387	290	5.0	2.8
20	34,615	1,826	23.5	17.5
10	100,947	8,045	68.4	76.9
All	147,566	10,461	100.0	100.0

2.8.3.3 Current Trends (no future climate change)

Past and existing human impacts and climate change are expected to continue to drive future changes in wetland function and wetland condition in the Regional Study Area even if the Project does not proceed. Ongoing shoreline erosion (Section 2.2.4) will continue to remove and alter off-system wetlands. There may also be lagged effects on wetlands where permanent human infrastructure has altered hydrology. While these ongoing adverse wetland area responses to past human developments are locally important, their magnitude at the regional scale is very small since the amounts of area affected are relatively small.

Future adjustments in response to past climate changes are expected to lead to the disappearance of the ground ice peatland types, which are likely to be replaced by wet peatland types and open water. While effects on overall wetland function could be relatively low since these types typically make similar degrees of contribution to total wetland function (Table 2-44), there may be changes to total contributions for specific types of wetland functions.

2.8.4Project Effects, Mitigation And Monitoring

Potential Project effects on wetland function and condition include wetland loss and alteration in the Project Footprint and surrounding areas through pathways such as physical disturbance, altered depth to groundwater or changes to the flows and/or nutrient status of surface and groundwater. Project-related wetland loss and alteration would affect wetland function, with the degree of these effects depending on the types of wetlands that are affected. The Project could also affect the globally, nationally and/or provincially significant wetlands that have been identified by Ramsar, the North American Waterfowl Management Plan, Ducks Unlimited and/or the Manitoba Heritage Marsh Program.

Better access brings more equipment, material and/or people into an area, which could lead to increased resource harvesting, invasive plant spread and human-caused fires, among other things. In extreme cases, a single accidental fire that is severe could alter wetland function by altering wetland composition, either by extirpating a habitat type or substantially reducing its abundance (by degrading site conditions and/or decimating the propagule bank). Invasive plants have the potential to crowd out native plant species and, in extreme cases, alter wetland composition through changes to broad habitat composition (see Section 3). The measures included in the EnvPPs (Manitoba Hydro 2012a) are expected to be effective at minimizing the risks of that these effects will occur.

2.8.4.1 Construction Period

2.8.4.1.1 Potential Project Effects

There are no globally, nationally or provincially significant wetlands in the Regional Study Area.

The Project Footprint could potentially remove or alter up to 6,161 ha, or 0.6% of the Regional Study Area vegetated wetland area (Table 2-46). An additional 1,604 ha could be indirectly affected in the wetland zone of influence, which could increase the total Project effects to 0.7% of wetland habitat in the Regional Study Area. Approximately 76% of the wetland area affected was scored as low quality (<20), mostly made up of strongly sloped veneer bog (47%) and blanket bog (23%; Table 2-46). In the unlikely event that borrow area E-1 is used, the total area of habitat directly and indirectly affected could increase to 7,868 ha, with nearly all of the increases occurring in areas with a quality score of 20 or less.

The Project Footprint during construction includes approximately 5,785 ha of off-system inland wetlands. The majority of inland wetland area in the Project Footprint and the wetland zone of influence is comprised of wetland types that are common and/or of relatively low quality. As described in Section 2.6.4.1.1, these estimates for inland wetland habitat loss in the Project Footprint are cautious because it is expected that portions of the Project Footprint will not be used, and measures to minimize clearing and disturbance outside of the project components will be employed (EnvPPs; Section 8.3.2).

The effect of Project construction on Nelson River shoreline wetlands is uncertain. As noted in the previous section, prolonged high water levels have apparently removed all shoreline wetlands in the Keeyask shoreline wetland study zone. If water levels tend to remain above median levels, then construction effects on Nelson River shoreline wetlands may be negligible. Additionally, even though potential Nelson River wetland area would still be affected during construction, this could be offset by wetland development along the reservoir shoreline during operation (see next section).

The off-system marsh wetland types were considered to be particularly important wetland types (Section 2.8.2.4.2). Before considering mitigation, Project construction is predicted to affect up to nine ha of mapped off-system marsh in the locations shown in Map 2-23. The total amount of affected off-system marsh does not include emergent vegetation patches that are too small to map, the inclusion of which could increase the amount of affected off-system marsh to 12 ha.

Table 2-46. Potential wetlands directly and indirectly affected by the Project during construction by wetland type and wetland quality class

Wetland Quality Score Class	Wetland Type	Area (ha)			Percentage of Wetland Area		
		Footprint	Zone of Influence	Total	Footprint	Zone of Influence	Total
60	Bay Lacustrine Marsh	6	0	7	0	0	0
	Stream Riparian Marsh	2	1	3	0	0	0
50	Shore and floating Riparian Fen	208	25	233	3	2	3
30	Flat Bog	1	1	2	0	0	0
	Horizontal Fen	148	31	179	2	2	2
	Peat plateau Bog	4	2	7	0	0	0
	Slope Bog	-	0	0	-	0	0
	Slope Fen	12	2	14	0	0	0
	Shore and floating Riparian Bog	11	0	11	0	0	0
20	Blanket Bog	3	1	4	0	0	0
	Collapse scar Bog	22	1	24	0	0	0
	Collapse scar Fen	9	-	9	0	-	0
	Flat Bog	45	3	48	1	0	1
	Peat plateau Bog	352	52	404	6	3	5
	PPB/ CS mixture Bog	609	144	753	10	9	10
	Slope Bog	28	9	37	0	1	0
	Veneer Bog	108	19	127	2	1	2
10	Blanket Bog	1,420	359	1,780	23	22	23
	Bay Lacustrine Marsh	62	4	66	1	0	1
	Shore and Bay Lacustrine Marsh	23	28	51	0	2	1
	Shore and floating Riparian Bog	1	-	1	0	-	0
	Shore and floating Riparian Fen	208	6	214	3	0	3
	Shore Lacustrine Marsh	96	15	110	2	1	1
	Strongly sloped Veneer Bog	2,783	900	3,684	45	56	47
Total wetland area		*6,161*	*1,604*	*7,965*	*100*	*100*	*100*
Off-system marsh in patches that are too small to map				*3*			
Total wetland area including small patches of off-system marsh				*7,968*			

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Table 2-47: Wetland Quality Types Affected During Construction and Operation as a Percentage of Area in Regional Study Area

Wetland Quality Score Class	*Total Estimated Regional Study Area (ha)*	Existing Percentage of Regional Study Area (%)	Construction Period			Operation Period	
			Project Footprint (%)	Habitat Local Study Area (%)	After Mitigation	Year 30 After Construction Mitigation, Reservoir Expansion and Habitat Recovery	Habitat Local Study Area, Reservoir Expansion and Habitat Recovery
60	*534*	0.0	1.6	1.7	1.7	1.5	1.7
50	*32,033*	2.9	1.2	1.3	1.3	1.2	1.4
40	*1,268*	0.1	0.6	0.6	0.6	0.6	0.6
30	*55,434*	5.1	0.7	0.7	0.7	0.7	0.8
20	*259,412*	23.6	0.7	0.8	0.8	0.7	0.9
10	*748,345*	68.2	0.9	1.0	1.0	0.9	1.1

Note: Reported areas are land area only.

2.8.4.1.2 Mitigation

Mitigation to replace Nelson River wetland types is not proposed for the possible circumstance that shoreline wetlands reappear in the Keeyask shoreline wetland study zone by the time construction commences. These are non-native wetland types. In addition, it is anticipated that similar wetlands will eventually develop along the reservoir shoreline during the operation phase.

Some mitigation for the remaining wetland types was already incorporated into the Project design. Choosing a low-head option considerably reduced the amount of wetland loss. Examples of other design measures are avoiding some wetland patches with high and moderate wetland quality scores through south access road routing, relocating some of the excavated material placement areas and refining the boundaries of the potential borrow areas and excavated material placement areas (Response to EIS Guidelines Chapter 4 Section 4.2.3).

Additional mitigation to reduce Project effects on wetland function during construction will include the following:

- Measures to protect against erosion, siltation and hydrological alteration will be implemented in utilized construction areas that are within 50 m of any off-system marsh that is outside of the Project Footprint; and,
- 12 ha of the off-system marsh wetland type will be developed within or near the Local Study Area.

2.8.4.1.3 Residual Effects

After considering mitigation, Project construction is expected to result in the temporary loss of most of the Nelson River shoreline wetlands in the Local Study Area, create no net area loss for off-system marsh, have no effects on five wetland types and, depending on the wetland type, remove or alter between 0.2% and 2.4% of estimated historical area for the remaining wetland types. After these remaining Project effects in combination with the effects of other past and current projects and activities, it is predicted that the Project would not increase historical effects on Nelson River wetlands, off-system marsh or several of the other wetland types but would increase historical effects on the remaining wetland types to between 3.0% and 6.2% of estimated historical area, which is considered to be moderate magnitude effects.

Using the criteria established to determine the significance of Project effects for regulatory purposes (Section 2.2.5.2), the likely residual effects of Project construction on wetland function are expected to be adverse, medium in geographic extent, long term in duration and, depending on the wetland type, nil to moderate in magnitude. The moderate magnitude residual effects are expected to be irreversible, continuous in frequency and low in ecological context.

2.8.4.2 Operation Period

2.8.4.2.1 Potential Project Effects

Reservoir expansion, additional edge effects and groundwater-related habitat effects will be the primary pathways for Project effects on wetlands during operation. All of the flooding that initiates Project operation would occur within areas already that were already affected during construction. As described in Section 2.3.6.3, terrestrial habitat that recovers from temporary construction effects (*e.g.*, potential construction areas that were not actually disturbed, rehabilitation of temporarily cleared areas) will reduce the total amount of affected wetland area.

Areas generally slope towards the Nelson River. Reservoir creation would essentially widen the river and Gull Lake into a larger lake. Flooding would not alter surface or surficial aquifer or groundwater hydrology except along reservoir shorelines (PE SV Section 8.4.2). Over the first 30 years of operation, it is predicted that the total shoreline length will increase from 205 km to 264 km after initial flooding, then decrease to 244 km following the first 30 years of reservoir expansion (PE SV Section 6.4.2.1). The decrease in length over the expansion period would be due to decreased shoreline shape complexity.

After considering habitat recovery but before considering mitigation, the first 30 years of Project operation are predicted to increase the amount of affected wetland to 8,288 ha (Table 2-48) in the locations shown in Map 2-23. The wetland quality composition of these wetlands is 12 ha of off-system marsh; up to 2,086 ha wetlands with wetland quality scores ranging from 20 to 56 and up to 6,190 ha of wetlands with wetland quality scores lower than 20.

Additional reservoir expansion after Year 30 would likely be confined to the wetlands already affected by groundwater changes so that the amount of wetland area affected would not change. These subsequent wetland losses would consist of peatlands converting to aquatic areas.

Based on observations from Stephens Lake (*i.e.*, the Kettle GS reservoir), it is expected that Nelson River shoreline wetlands that were removed or altered by the Project would be replaced by wetlands that develop along the reservoir shoreline during the operation phase. The Project would reduce the existing high monthly and annual variability in water elevations in the Keeyask segment of the Nelson River (PE SV Section 4.3.1.1), which would facilitate the development of marsh and riparian fen. A longer shoreline would further contribute to increasing the total area of Nelson River shoreline wetlands (see above).

As described in Section 2.3.6.3.1 and shown in Map 2-11, some of the effects on wetlands are predicted to be permanent while others represent areas that are either undergoing rehabilitation or were not actually altered during construction. The permanent components of the Project Footprint including reservoir expansion produce approximately 4,974 ha of permanent wetland loss (Table 2-48). Most of the wetlands (70%) in the permanent footprint were scored as low quality.

Before considering mitigation, flooding, reservoir expansion and groundwater changes during Project operation are predicted to be less than 2% for all wetland quality classes (Table 2-47). Slight increases (0.1% of Regional Study Area cover) in the second highest and lowest quality wetland classes are predicted during the first 30 years of operation.

In the unlikely event that borrow area E-1 was used during construction, wetland loss and alteration during operation would be approximately 8,391 ha. Approximately 75% of this wetland area was scored as low quality (<20), most of which would be comprised of sloped veneer bog (46%) and blanket bog (23%).

Table 2-48: Potential Wetlands Directly and Indirectly Affected by the Project During the First 30 Years of Operation by Wetland Type and Wetland Quality Class

Wetland Quality	Wetland Type	Permanent habitat loss			Permanent habitat alteration		Temporary habitat Alteration	Total Area
		Infra-structure	Initial Flooding	Reservoir Expansion	Indirect reservoir effects	Other long term indirect effects	Undisturbed potential construction areas and regenerating construction areas	
60	Bay Lacustrine Marsh	0.0	0.2	0.0	0.0	0.1	0.0	0.1
	Stream Riparian Marsh	-	0.1	-	-	0.0	-	0.0
50	Shore and floating Riparian Fen	1.0	4.8	3.2	2.5	2.5	0.3	3.2
30	Flat Bog	0.1	-	-	-	0.1	-	0.0
	Horizontal Fen	2.5	3.3	3.1	2.1	2.1	0.0	2.4
	Peat plateau Bog	0.0	0.1	0.5	0.0	0.1	0.0	0.1
	Slope Bog	-	-	-	-	0.0	-	0.0
	Slope Fen	0.0	0.3	0.4	0.3	0.1	-	0.2
	Shore and floating Riparian Bog	-	0.3	0.0	0.0	-	-	0.1
20	Blanket Bog	0.0	0.1	-	-	0.1	0.0	0.0
	Collapse scar Bog	0.0	0.6	0.6	0.4	0.0	0.0	0.4
	Collapse scar Fen	-	0.1	-	-	-	0.5	0.1
	Flat Bog	0.1	1.1	0.8	0.0	0.1	-	0.6
	Peat plateau Bog	2.7	7.3	6.0	6.4	4.2	2.2	5.6
	PPB/ CS mixture Bog	6.4	10.9	16.6	12.1	9.6	7.4	10.4
	Slope Bog	0.5	0.5	0.7	0.7	0.5	0.3	0.5
	Veneer Bog	0.9	2.1	1.1	1.6	1.2	0.8	1.5
10	Blanket Bog	19.7	25.6	25.4	19.5	21.9	18.1	22.9
	Bay Lacustrine Marsh	-	1.6	0.4	-	0.3	0.0	0.8
	Shore and Bay Lacustrine Marsh	0.1	-	-	-	2.5	1.6	0.6
	Shore and floating Riparian Bog	-	0.0	-	-	-	-	0.0
	Shore and floating Riparian Fen	0.5	5.2	2.1	0.3	0.3	0.0	2.6
	Shore Lacustrine Marsh	0.4	2.0	1.4	1.4	0.7	0.3	1.4
	Strongly sloped Veneer Bog	65.0	34.0	37.7	52.7	53.7	68.5	46.5
Total wetland area (ha)		*623*	*3,769*	*581*	*918*	*1,203*	*1,190*	*8,285*
Off-system marsh in patches that are too small to map								*3*
Total wetland area including small patches of off-system marsh								*8,288*

Note: Reported areas are land area only.

2.8.4.2.2 Mitigation

Mitigation during operation, in addition to that already incorporated into the Project design, will include the following:

- Implement additional wetland development to the extent practicable if monitoring determines that further measures are needed to achieve successful development of 12 ha of the off-system marsh wetland type.

2.8.4.2.3 Residual Effects

After considering mitigation, Project operation is expected to increase the amount of Nelson River shoreline wetlands in the Local Study Area relative to what is typically there now, create no net area loss for off-system marsh, have no effects for five wetland types and, depending on the wetland type, remove or alter between 0.2% and 1.6% of historical wetland area for the remaining wetland types. After considering these remaining Project effects in combination with the effects of other past and current projects and activities, it is predicted that the Project would not increase historical effects on Nelson River wetlands, off-system marsh or five wetland types but would increase historical effects on the remaining wetland types to between 1.7% and 6.5% of estimated historical area, which is considered to be moderate magnitude effects.

Using the criteria established to determine the significance of Project effects for regulatory purposes (Section 2.2.5.2), the likely residual effects of Project operation on wetland function are expected to be adverse, medium in geographic extent, long term in duration and, depending on the wetland type, nil to moderate in magnitude. The moderate magnitude rresidual effects are expected to be irreversible, continuous in frequency and low in ecological context.

2.8.4.3 Residual Effects Conclusion

Overall, the likely residual Project effects on wetland function are expected to be adverse but regionally acceptable because globally, nationally and/or provincially significant wetlands are not affected, there is no net area loss for off-system marsh and the cumulative area losses for all of the remaining native wetland types is below 10% of historical area. For those native wetland types with moderate magnitude effects, these effects are regionally acceptable because wetlands off the Nelson River are widespread, abundant and relatively pristine. As described in Section 2.8.3.3, the ecological context does not include substantial ongoing adverse trends that would alter the overall conclusion for any of the native wetland types with moderate magnitude effects.

2.8.4.4 Uncertainty

Overall, the uncertainty related to the wetland function assessment is moderately low to moderate. Existing wetlands can be mapped with relatively high accuracy. The spatial extent of Project-related physical wetland loss as a percentage of the Regional Study Area can also be predicted with relatively high accuracy. There is moderate uncertainty as to the total area of wetlands that could be indirectly affected, primarily because there may be inland groundwater effects in areas where there are connections between the surface and deep groundwater layers. There is moderate uncertainty that the development of 12 ha of marsh will be completely successful since there is limited experience developing wetlands in the Boreal Shield.

2.8.4.5 Environmental Monitoring and Follow-up

Wetland monitoring provides an effective means to monitor a wide array of terrestrial ecosystem effects because wetland composition and distribution are easily monitored with accuracy, these are indicators for other ecosystem components and wetland composition changes are a key driver for effects on other ecosystem components such as wildlife habitat.

Wetland monitoring will include documenting the actual direct and indirect effects on wetland habitat as well as monitoring the success of wetland mitigation. Monitoring details are provided in the Terrestrial Environment Monitoring Plan (Manitoba Hydro 2012b).

2.9 SOIL QUANTITY AND QUALITY

2.9.1 Introduction

Soil sustains plant productivity and other ecosystem functions through its ability to hold and supply water and nutrients, store organic matter and provide suitable habitat for plant roots and a wide range of organisms. Soil functions listed by USDA Natural Resources Conservation Service (2008) include:

- sustaining biological diversity, activity, and productivity;
- regulating and partitioning water and solute flow;
- filtering, buffering, degrading, immobilizing and detoxifying organic and inorganic materials;
- storing and cycling nutrients and carbon; and,
- providing physical stability and support for plants or socio-economic structures or protection for archaeological treasures associated with human habitation.

Soil quantity and quality is a key indicator for sustainability reporting in Canada (CCFM 1995) and the U.S. (USDA Natural Resources Conservation Service 2008). Soil quantity is simply the amount of each mapped soil type using a soil classification that is relevant to the issues of interest.

Soil quality is often viewed as the capability of soil to perform functions. Soil quality cannot be measured directly, but must be inferred by measuring soil attributes or properties that serve as proxies. The proxies that are commonly used at the plot, field or local levels are difficult and expensive to monitor at the regional level. To meet the practical needs of promoting and monitoring sustainable land use management, jurisdictions have enacted policies, guidelines and standards: (a) to provide for the protection of sensitive sites; (b) for soil disturbance; and, (c) for road construction, stream crossing and riparian zone management. These standards typically relate to compaction, erosion and area loss by soil type.

2.9.2 Assessment Approach and Methods

2.9.2.1 Overview

Soil quantity and quality was selected as a VEC to provide information on potential Project effects on soil quantity and quality, which is of interest in its own right, and as a proxy for indirect effects on other ecosystem components. Table 1A-1 provides additional details explaining why soil quantity and quality was selected as a supporting topic.

Fine ecosite composition was the indicator for soil quantity and quality. The fine ecosite classes reflect ecologically important differences in soil attributes such as soil organic matter, soil texture, drainage, moisture regime and nutrient regime. The fine ecosite classes were expected to coincide with substantial differences in more than one of: vegetation composition, nutrient storage and cycling, carbon storage and cycling, primary productivity, water regulation and physical stability and support for plants or human structures.

The general assessment approach and methods for soil quantity and quality were the same as those used for all of the key topics (see Sections 1.3, 1.4 and 2.2). Details specific to soil quantity and quality were as follows.

2.9.2.2 Study Areas

The Soil Quantity and Quality Local and Regional Study Areas were Study Zones 2 and 5 in Map 2-1, respectively. The 18,689 ha Local Study Area is the area where direct and indirect Project effects on fine ecosite composition may occur. The 1,420,000 ha Regional Study Area was large enough to represent a region level ecosystem, an ecologically homogenous area capable of supporting the key boreal processes (*e.g.*, fire regime) and populations of most resident wildlife species (Section 1.3.5).

Proxy and benchmark areas in addition to those used in Section 2.2 were not required.

2.9.2.3 Information Sources

Published information regarding soil quantity and quality in the Regional Study Area was not discovered. Agriculture and Agri-Food Canada (1996) provides small scale soil complex mapping for the Regional Study Area. Beke *et al.* (1973) provide soil profile data for a small number of locations in the Regional Study Area.

Since ecosite is a component of habitat type, fine ecosite composition was measured from the terrestrial habitat mapping and terrestrial habitat relationships field studies (Sections 2.2.4.4 and 2.2.4.5). The fine ecosite composition of Study Zone 4 was assumed to be representative of the Regional Study Area based on results from less detailed information available for the entire Regional Study Area (see Section 2.2.4.4).

Field studies that measured soil stratigraphy also contributed essential information for mapping and ecosite type characterization (Section 2.2.4.5). An overview description of soils and ecosites is provided in the Physiography Section of the PE SV (Section 5.3).

2.9.2.4 Methods

The soil quantity and quality supporting topic included the inland fine ecosite types. Given the complexities of shoreline wetland drivers, shoreline wetland ecosite types were addressed by the wetland function VEC.

Existing fine ecosite composition was measured from the terrestrial habitat map (see Section 2.2). Collapse scar fens and bogs were combined with the peat plateau bog/collapse mosaic ecosite type to eliminate a localized mapping bias for these ecosite types. Collapse scar peatlands were generally only mapped in the potential reservoir area for use in the peatland disintegration predictions provided in PE SV Section 6.

Field data were used to characterize the soil and site attributes of each fine ecosite type.

Historical ecosite composition was derived from the historical condition described in Section 2.3.3. Future changes to fine ecosite composition, with and without the Project, were obtained from the habitat predictions provided in Section 2.3.5.

Potential Project effects on soil quantity and quality were assessed based on area changes in fine ecosite composition.

The benchmark values used to evaluate residual effects on soil quantity and quality were Hegmann *et al.*'s (1999) rules of thumb for measurable indicator attributes for which accepted thresholds or benchmarks do not exist. The benchmark values for evaluating the magnitude of adverse residual effects of the Project in combination with past and current projects on the fine ecosite types were as follows: small magnitude for area losses below 1% of regional historical area; moderate magnitude for area losses between 1% and 10% of regional historical area; and, high magnitude for area losses greater than 10% of regional historical area.

2.9.3 Environmental Setting

2.9.3.1 Historical Conditions

As described in the terrestrial habitat section, recent climate change and the cumulative human footprint have altered habitat composition, which means that fine ecosite composition and soil quantity and quality have also been altered. Cumulative historical change is estimated to have removed or altered approximately 5% of the total historical area of terrestrial habitat, which likely has reduced the total area of most, if not all, fine ecosite types.

Area losses have been relatively high for mineral ecosite types, as these are the typical locations for roads, settlements and other infrastructure. Fine ecosite types that tend to occur along the Nelson River were also disproportionately affected by hydroelectric development, due to flooding in some reaches of the Nelson River and altered water regimes along its remaining length.

Throughout much of the boreal forest, past climate change has altered the fire regime such that fire activity has increased (Section 2.5.3.1). These past climate and fire regime changes are thought to have shifted habitat composition towards reduced proportions of the permafrost peatland types (Section 2.3.3).

2.9.3.2 Current Conditions

Section 2.3.4.1 provided land, coarse ecosite and fine ecosite type descriptions as well as representative photos for some of the fine ecosite types.

The Regional Study Area includes 20 fine ecosite types that qualified for inclusion in the soil quantity and quality assessment. Of these, five were upland/thin feathermoss peatland types, eight were shallow peatland types and seven were wet peatland types (Table 2-49). Peatlands covered over 88% of the Regional Study Area, the majority of which were veneer bog ecosite types.

Veneer bog on slope was the most common and widely distributed fine ecosite type in the Regional Study Area (Map 2-24), comprising nearly 39% of the land area. Deep dry mineral, the other common upland/thin feathermoss peatland ecosite type, was primarily associated with ridges, crests and upper slopes, which were most frequent nearer the Nelson River and along eskers in the Local Study Area.

Table 2-49: Coarse and Fine Ecosite Composition of Study Zones 4 and 2, as a Percentage of Land Area

Coarse Ecosite Type	Fine Ecosite Type	Study Zone 4	Local Study Area
Mineral Land Type		**11.7**	**18.7**
Mineral	Deep dry mineral	11.5	17.5
	Deep wet mineral	0.0	-
	Outcrop	0.0	-
	Shallow/ thin mineral	0.2	1.2
Thin Peatland Land Type		**38.8**	**39.7**
Thin Peatland	Veneer bog on slope or crest	38.8	39.7
Other Peatlands Land Type		**45.5**	**34.3**
Shallow Peatland	Blanket bog	20.6	18.2
	Slope bog	1.4	0.5
	Slope fen	0.2	0.2
	Veneer bog not on slope or crest	2.5	1.1
Ground Ice Peatland	Blanket bog/ collapse scar peatland mosaic	1.4	-
	Peat plateau bog	0.4	0.7
	Peat plateau bog transitional	4.4	3.3
	Peat plateau bog/ collapse scar peatland mosaic	9.9	8.0
Other Permafrost Peatland	Horizontal fen/ blanket bog mosaic	0.2	-
Deep Peatland	Basin fen	0.0	-
	Flat bog	0.6	0.4
	Horizontal fen	3.8	1.9
Wet Deep Peatland	String fen	0.0	-
Shore Zone Peatland Land Type		**3.1**	**4.0**
Riparian Peatland	Riparian bog	0.2	0.1
	Riparian fen	2.9	3.9
Total Inland Area (ha)		*165,628*	*12,620*

Note: Reported areas are land area only without shoreline wetlands.
Cells with “0.0” values are areas that round to 0, while “-“ indicates that the type is absent.

Blanket bog was the most common shallow peatland ecosite type, and the second-most common fine ecosite in the Regional Study Area. Blanket bog was also widely distributed (Map 2-24), and associated primarily with horizontal topography, as well as some lower slopes.

Each of the remaining fine ecosite types comprised less than 10% of the Regional Study Area land area. For the remaining shallow peatlands, uncommon ecosites included peat plateau bog/ collapse scar mosaics, transitional peat plateau bogs, veneer bogs, slope bogs, and blanket bog/ collapse scar peatland mosaics.

Horizontal and riparian fens, the most abundant wet peatland ecosite types, were uncommon. Riparian fens were widely distributed throughout the Regional Study Area (Map 2-24), generally along shorelines. Horizontal fens were somewhat more frequent in inland portions of the Regional Study Area, and were associated with horizontal and depressed topography.

Together, the common and uncommon fine ecosite types comprised nearly 98% of the land area. Some of the rarest ecosite types included rock outcrops and wet mineral soils, string fens, wet deep peatlands and disturbed **lacustrine peatland**s.

Descriptions of the coarse ecosite types, which are groupings of similar fine ecosite types, are provided in Section 2.3.4.1.2.

2.9.3.3 Current Trends (no future climate change)

Past and existing human impacts and climate change are expected to continue to drive future changes in fine ecosite composition and soil quantity and quality in the Regional Study Area even if the Project does not proceed. Ongoing shoreline erosion (Section 2.2.4) will continue to remove and alter terrestrial areas, which will remove soils. There may also be lagged effects on wetland ecosite types where permanent human infrastructure has altered hydrology. Future adjustments in response to past climate changes are expected to lead to the disappearance of the ground ice peatland fine ecosite types, which are likely to be replaced by wet peatland fine ecosite types and open water.

2.9.4 Project Effects, Mitigation and Monitoring

Potential Project effects on soil quantity and quality include the loss and alteration of fine ecosites in the Project Footprint and surrounding areas through pathways such as physical disturbance, altered depth to groundwater or changes to the flows and/or nutrient status of surface and groundwater. Some potential Project effects on soil quality may not lead to conversion to a different fine ecosite type. The Project could alter soil quality through soil compaction, rutting, puddling, altered surface and groundwater flows, and altered depth to water table. For the purposes of the assessment, soil quantity and quality was assumed to be affected within the entire soil quantity and quality zone of influence (Section 2.3.6.1).

Better access brings more equipment, material and/or people into an area, which could lead to increased human-caused fires, among other things. In extreme cases, a single accidental fire that is severe could alter soil quantity and quality, either by substantially reducing the abundance of a fine ecosite type or by degrading site conditions.

2.9.4.1 Construction Period

2.9.4.1.1 Potential Project Effects

During construction, the Project Footprint is predicted to affect more than 1% of the area of four of the 20 fine ecosite types, in the unlikely outcome that the full extent of the borrow areas are used (Table 2-50). Additional indirect effects in the soil quantity and quality zone of influence could increase the number of affected fine ecosite types to five (Table 2-50). In the unlikely event that Borrow Area E-1 is used, no additional types would be affected but there would be a slight increase in effects on 10 types.

Reservoir clearing and borrow areas are the largest contributors to fine ecosite area losses. Since ecosite is a component of habitat type, the patterns of Project-related ecosite effects during construction would be similar to those described for terrestrial habitat in Section 2.3.6.2.

Table 2-50: Estimated Percentages of Fine Ecosite Area in the Regional Study Area Affected During Construction and Operation

Fine Ecosite Type	*Total Estimated Regional Study Area (ha)*	Construction Period			Operation Period	
		Project Footprint (%)	Project Footprint and Terrestrial Habitat Zone of Influence (%)	After Mitigation (%)	Project Footprint at Year 30 After Mitigation, Reservoir Expansion and Habitat Recovery (%)	Project Footprint and Habitat Zone of Influence at Year 30 (%)
Outcrop	*24*	-	-	-	-	-
Shallow/ thin mineral	*2,262*	2.5	4.3	4.3	2.3	4.3
Deep dry mineral	*139,735*	0.9	1.2	1.2	0.8	1.2
Deep wet mineral	*4*	-	-	-	-	-
Veneer bog on slope	*485,138*	0.6	0.7	0.7	0.5	0.8
Veneer bog	*31,596*	0.3	0.4	0.4	0.3	0.4
Blanket bog	*258,612*	0.5	0.7	0.7	0.5	0.7
Slope bog	*18,041*	0.2	0.2	0.2	0.2	0.2
Slope fen	*2,106*	0.5	0.6	0.6	0.6	0.8
Peat plateau bog	*4,843*	1.3	1.5	1.5	1.4	1.7
Peat plateau bog transitional stage	*56,108*	0.5	0.6	0.6	0.5	0.7
Peat plateau bog/ collapse scar peatland mosaic	*124,139*	0.5	0.6	0.6	0.5	0.7
Blanket bog/ collapse scar peatland mosaic	*17,188*	-	-	-	-	-
Horizontal fen/ blanket bog mosaic	*2,549*	-	-	-	-	-
Basin fen	*12*	-	-	-	-	-
Flat bog	*7,526*	0.6	0.6	0.6	0.6	0.6
Horizontal fen	*48,260*	0.3	0.4	0.4	0.3	0.4
String fen	*155*	-	-	-	-	-
Riparian bog	*2,083*	0.5	0.5	0.5	0.5	0.5
Riparian fen	*36,889*	1.1	1.2	1.2	1.1	1.3

2.9.4.1.2 Mitigation

Mitigation of Project effects on soil quantity and quality already achieved through avoidance during Project design includes selecting a low-head option that considerably reduced Project-related flooding, reducing the total size the borrow area and EMPA footprints and reducing effects on fine ecosite types associated with regionally rare habitat types through south access road routing, relocating some of the excavated material placement areas and refining the boundaries of the potential borrow areas and excavated material placement areas.

Additional mitigation for soil quantity and quality effects during construction will include the following:

- Disturbance of areas adjacent to the Project Footprint will be avoided to the extent practicable;
- Stripped topsoil will be stockpiled for later use in site rehabilitation;
- Staging areas will be sited to the extent practicable on soils with a high weight bearing capacity and low permeability to minimize rutting and soil compaction; and,
- To the extent practicable, traversing across known wetland areas outside of the Project Footprint will not be done until the ground is frozen solid to minimize rutting and soil compaction.

Mitigation implemented for ecosystem diversity and wetland function (Sections 2.7.4 and 2.8.4) are expected to further reduce Project effects on terrestrial habitat. The EnvPPs will also include measures to minimize the risk that there will be Project-related accidental fires, accidental spills and altered hydrology (Manitoba Hydro 2012a).

2.9.4.1.3 Residual Effects

After considering mitigation, residual Project effects on soil quantity and quality during construction are expected to include no effects on six fine ecosite types and, depending on the fine ecosite type, affecting between 0.2% and 4.3% of estimated area for 14 of the 20 fine ecosite types. After considering the remaining Project effects in combination with other past and current projects and activities, it is predicted that the residual effects of Project construction on soil quantity and quality would include no effects on six fine ecosite types and, depending on the fine ecosite type, affecting between 1.3% and 7.6% of estimated historical area for 14 fine ecosite types, which are moderate magnitude effects.

2.9.4.2 Operation Period

2.9.4.2.1 Potential Project Effects

Project effects during operation remain similar to construction for most fine ecosite types. Initially, Project operation would not increase effects on any ecosite types because flooding is contained within areas that were affected during construction. Reservoir expansion during the first 30 years of operation would increase the amount of affected area for a number of fine ecosite types but this would be offset to various degrees by habitat recovery elsewhere in the Local Study Area (Table 2-50). The number of fine ecosite types with more than 1% of their Regional Study Area affected total could be reduced in the likely outcome that portions of the borrow areas are not used.

Since ecosite is a component of habitat type, the patterns of Project-related ecosite effects during operation would be similar to those described for terrestrial habitat in Section 2.3.6.3.

2.9.4.2.2 Mitigation

Mitigation during operation, in addition to that already incorporated into the Project design and the EnvPPs (Manitoba Hydro 2012a), is not proposed.

2.9.4.2.3 Residual Effects

After considering mitigation, residual Project effects on soil quantity and quality during operation are expected to include no effects on six fine ecosite types and affecting between 0.2% and 4.3% of estimated area for 14 of the 20 fine ecosite types, depending on the type. After considering these remaining Project effects in combination with other past and current projects and activities, it is predicted that the residual effects of Project operation on soil quantity and quality would include no effects on six fine ecosite types and, depending on the fine ecosite type, affecting between 1.3% and 7.5% of estimated historical area for 14 fine ecosite types, which are moderate magnitude effects.

2.9.4.3 Residual Effects Conclusion

Overall, the likely Project residual effects on soil quantity and quality are expected to be adverse but within an acceptable range because the small Project-related incremental addition to the amounts affected maintains the magnitude of cumulative effects well within the moderate range (*i.e.*, below 10% of historical area) for all of the fine ecosite types. As described in Section 2.9.3.3, the ecological context is that none of the fine ecosite types considered in the soil quantity and quality assessment except for the ground ice peatland types are experiencing substantial ongoing adverse changes in response to past human development and climate change.

2.9.4.4 Uncertainty

Overall, the uncertainty related to the soil quantity and quality assessment is moderately low to moderate. The spatial extent of Project-related physical terrestrial loss as a percentage of the Regional Study Area can be predicted with relatively high accuracy. There is moderately low uncertainty as to the total area of fine ecosites that could be indirectly affected. Although the current amounts of the fine ecosite types in Study Zone 4 can be mapped with relatively high accuracy, there is moderate uncertainty relating to the historical amounts of each type in the Regional Study Area and the current amounts in the portion of the Regional Study Area that is outside of Study Zone 4.

2.9.4.5 Environmental Monitoring and Follow-up

Soil quantity and quality monitoring will include documenting the actual direct and indirect effects on each of the fine ecosite types, which will be accomplished through the terrestrial habitat monitoring. Monitoring details are provided in the Terrestrial Environment Monitoring Plan (Manitoba Hydro 2012b).

2.10 CUMULATIVE EFFECTS WITH FUTURE PROJECTS

2.10.1 Introduction

As described in the Response to the EIS Guidelines Section 7.2, VECs with adverse residual effects were evaluated for cumulative effects with reasonably foreseeable future projects and human activities. This section provides that assessment. The effects past and current projects and activities was described in the preceding sections as a component of the residual effects assessment for each VEC. The reasonably foreseeable future projects and activities considered for the cumulative effects assessment were Bipole III Transmission Project, Keeyask Transmission Project, Gillam Redevelopment and Conawapa Generation Project. See Response to the EIS Guidelines Chapter 7 (Section 7.2) for a description of the approach used for the assessment of cumulative effects of the Project with future projects and activities.

By focusing on individual environmental components, the VEC approach does not capture the broader concept of the Cree worldview, which emphasizes that all things are interconnected and should be viewed as a whole. An understanding of this worldview, as expressed by the KCN is provided in Response to the EIS Guidelines Chapter 2, Partners' Context, Worldviews and Evaluation Process (Response to the EIS Guidelines Section 2.2), and in the KCNs Environmental Evaluation Reports. However, where ATK of specific environmental components was incorporated into the assessment, this is reflected in the CEA results.

2.10.2 Intactness

Effects from Gillam Redevelopment and all of the transmission projects would overlap spatially and temporally with residual Project effects on intactness.

Based on the anticipated locations of the reasonably foreseeable overlapping future projects, the transmission line projects would increase total linear feature density from 1.23 km/km^2 to 1.27 km/km^2 in the Local Study Area. Total linear feature density would increase from 0.44 km/km^2 to 0.48 km/km^2 in the Regional Study Area, and from 0.31 km/km^2 to 0.36 km/km^2 in the portion of the Regional Study Area outside of the Thompson area, which is still in the lower half of the moderate magnitude effects range (between 0.40 km/km^2 and 0.60 km/km^2) and within the small magnitude range for the Regional Study Area outside of the Thompson area.

Based on their anticipated locations, reasonably foreseeable future projects would increase cumulative effects on core areas. Total core area would decline by up to 13,335 ha while increased fragmentation would increase the number of core areas by approximately 10 and reduce mean core area size by up to 2,710 ha (Table 2-51). The two largest core areas would be fragmented into four core areas. The percentage of the Regional Study Area in core area is expected to remain over 80% during the first 30 years of operation (Table 2-51), which is well within the range for small magnitude core area effects (*i.e.*, 66% to 100% of land area). Natural regeneration on portions of existing, disused cutlines would increase core area over time.

Table 2-51: Number, Percentage of Regional Study Area and Mean Size of Core Areas During Project Operation With Reasonably Foreseeable Future Projects, by Minimum Core Area Size

Core Area Minimum size	Core Area Percentage of RSA			Number			Mean size (ha)		
	Operation	With Future Projects	Change	Operation	With Future Projects	Change	Operation	With Future Projects	Change
200 ha	84	83	-1	111	121	10	9,346	8,474	-872
1,000 ha	82	81	-1	56	65	9	18,090	15,380	-2,710

2.10.3 Ecosystem Diversity

Effects from Gillam Redevelopment and all of the transmission projects would overlap spatially and temporally with residual Project effects on ecosystem diversity.

Based on the anticipated locations of the Gillam Redevelopment and the transmission projects (footprints plus 50 m buffer), these projects could affect an estimated 1,170 ha of terrestrial habitat in addition to that already affected by the Project. Regionally common habitat types comprise approximately half of this area. For all of the priority habitat types, the amounts of additional habitat affected are relatively small so that increases in the percentages of habitat area affected could remain below 10% of historical area for all affected priority habitat types, depending on the final locations of the transmission ROWs.

Based on its anticipated location, Bipole III could affect approximately 3,700 of terrestrial habitat. Since detailed habitat mapping was not available for the Bipole III footprint, the composition of the affected habitat was assumed to be similar to that of Zone 4. On this basis, approximately 70% of the affected habitat is not priority habitat. Although the increased amounts of additional habitat affected would be relatively high for some of the priority habitat types using this assumption, the increases in the percentage of affected habitat area could remain below 10% of historical area for all priority habitat types, depending on the final location of the ROW.

Based on the anticipated locations of the future projects, cumulative future effects could remain at the low end of the moderate range for total habitat area affected and the common habitat types and within the small to moderate range for all of the priority habitat types.

2.10.4 Wetland Function

Effects from Gillam Redevelopment and all of the transmission projects would overlap spatially and temporally with residual Project effects on wetland.

Based on the anticipated locations of the future projects, the Gillam Redevelopment and the transmission projects (footprints plus 50 m buffer) would affect an estimated 990 ha of wetlands in addition to that already affected by the Project. Regionally common wetland types account for more than half of the affected wetland area (since detailed habitat mapping was not available for the Bipole III footprint, the composition of this portion of the affected habitat was assumed to be similar to that of Study Zone 4).

Detailed habitat mapping indicates that Gillam Redevelopment and the Keeyask Transmission Project are not expected to affect any particularly important wetland areas (*i.e.*, off-system marsh). The affected areas of the remaining wetland types are expected to be relatively small.

For Bipole III, even if the route overlaps off-system marsh, effects are likely to be negligible since clearing occurs in winter, clearing is minimised in riparian zones and buffers are typically maintained where transmission rights-of-way overlap riparian zones. The affected areas of the remaining wetland types are expected to be relatively small, depending on the final locations of the transmission ROWs.

Based on their anticipated locations, the future projects are not expected to affect any particularly important wetland areas (i.e. off-system marsh). Wetland mapping demonstrates that Gillam Redevelopment and the Keeyask Transmission Project would not overlap off-system marsh. Although detailed wetland mapping was not available for the Bipole III route, even if it does overlap off-system marsh, effects are likely to be negligible given that clearing occurs in winter, clearing is minimised in riparian zones and buffers are typically maintained where transmission rights-of-way overlap riparian zones. For the remaining native wetland types, the additional affected areas are expected to range from nil to relatively small so that cumulative area losses could remain in the small to moderate magnitude range, depending on the final locations of the transmission ROWs.

2.11 SENSITIVITY OF PREDICTIONS TO FUTURE CLIMATE CHANGE

2.11.1 Background

As described in the TE SV Section 2.3.2, climate change scenarios, on average, project increasing temperatures and precipitation in the Project area. Winter is projected to experience the greatest change with annual temperature and precipitation changes increasing between the 2020s and the 2080s. A smaller subset of climate change scenarios also project increasing evapotranspiration for the same time periods, although climate modeling uncertainty is not well captured in the limited subset of scenarios.

Potential effects of future climate change on the physical environment residual Project effects predictions that are relevant for the terrestrial habitat and ecosystems assessment are a possible increase in reservoir area and the rate at which the reservoir expands after the fifth year of operation (PE SV Section 11.4). These changes would create relatively small increases in the amounts of peatland loss. A longer reservoir shoreline could increase the amount of Nelson River shoreline wetland.

The predicted future changes to climate could also alter the terrestrial habitat and ecosystems residual effects predictions through the following anticipated changes to terrestrial ecosystem drivers:

- Longer growing season.
- Higher evapotranspiration.
- Droughts, especially in the fall, may be more frequent and more severe.
- Extreme weather events may be more frequent and more severe.
- Heat waves may be more frequent and more severe;
- Large fires could become more frequent and possibly more severe; and,
- Accelerated permafrost melting.

The remainder of this section describes potential effects for each of the supporting topics and VECs.

2.11.2 Terrestrial Habitat

Almost 80% of the terrestrial habitat affected by the Project is within the Project Footprint and this would not change with future climate change. The terrestrial habitat zone of influence could vary somewhat through climate change induced alterations to terrestrial ecosystem drivers. While the nature of these potential changes is uncertain, they would have to be very large to increase effects on total habitat area or the areas of the common broad habitat types from moderate to high magnitude. For example, the size of the terrestrial habitat zone of influence would have to increase by three times for the magnitude of effects on total terrestrial habitat to increase from moderate to large magnitude.

2.11.3 Intactness

Potential pathways for future climate change to alter the linear feature density residual Project effects predictions are through increases to the lengths of Project linear features or by reducing vegetation regeneration in cutlines. Future climate change would not alter the length of Project linear features. Since potential cutline regeneration was considered after determining the magnitude of linear feature density effects, poorer cutline regeneration would not alter the residual effects predictions.

Potential pathways for future climate change to alter core area predictions are through increases to the size of the terrestrial habitat zone of influence or by reducing habitat regeneration in the temporarily cleared areas. As described for terrestrial habitat, potential increases to the area of affected habitat are expected to be relatively small. In addition, post-Project core area percentage is considerably higher than the benchmark value that indicates the transition from moderate to high magnitude effects.

2.11.4 Fire Regime

Potential ways for future climate change to alter fire regime residual Project effects predictions relate to the risk that the Project could start an accidental fire and/or alter the attributes of a naturally occurring wildfire. Climate change may increase the risk that an accidental fire will become a large fire before it can be suppressed and that Project-related fire effects result in more severe burns. It is possible that this risk of increased Project-related fire regime effects could be managed through more stringent application of EnvPP measures already in place to minimize the risk of Project-related fire regime effects.

2.11.5 Ecosystem Diversity

Potential increases to terrestrial habitat loss and alteration through interactions between future climate change and residual Project effects that were described in Section 2.11.2 are not expected to lead to the extirpation of any of the native broad habitat types. These changes could slightly alter the proportions of the common and uncommon habitat types. The increased amount of terrestrial habitat loss could increase effects on some of the regionally rare habitat types. For many of these types, the increases would need to be quite large to increase effects from moderate to high magnitude, especially considering that the most highly affected types will be given preference in the rehabilitation plan.

2.11.6 Wetland Function

Potential pathways for future climate change to alter the wetland function residual Project effects predictions are through a reduced ability to develop 12 ha of the off-system wetland marsh type, increased amounts of wetland area losses or conversions of some moderate quality wetland types to lower quality types. Regarding off-system marsh mitigation, a potential response to poorer success than expected is the implementation of additional and/or different measures. Higher reservoir expansion would predominantly affect the very wet peatland types, which to some extent would be offset by development of Nelson River shoreline wetland area that was not considered in the calculation of net effects on priority habitats. For the remaining wetland types, as described for terrestrial habitat in Section 2.11.2, any increased area losses would have to very large before the magnitude of effects could increase from moderate to high.

2.11.7 Soil Quantity and Quality

The primary potential pathway for future climate change to alter the soil quantity and quality residual Project effects predictions is through the potential increases to terrestrial habitat loss and alteration described in Section 2.11.2. The predicted magnitude of residual Project effects on each of the fine ecosite types is well below the 10% of historical area benchmark used to distinguish between moderate and high magnitude effects. Consequently, climate change-related increases in the amounts of fine ecosite loss and alteration would need to be quite large to change the residual effects conclusion.

2.12 ENVIRONMENTAL MONITORING AND FOLLOW-UP

Monitoring will be required to verify the short and long-term effects of the Project on terrestrial habitat and ecosystems. The recommended monitoring and follow-up includes both VECs and some supporting topics during construction and operation phases (Table 2-52). While this table provides a summary of the topics and species requiring monitoring, information on the methods and procedures are outlined in the Terrestrial Effects Monitoring Program and will be provided in further detail as the Monitoring and Follow-up Plans are developed during the review process. Monitoring is planned for situations where the ATK and technical assessments differ, where a prediction has substantial uncertainty or a difference between predicted and actual residual effects could substantially alter the effects assessment.

Table 2-52: Monitoring and Follow-Up Program for Terrestrial Habitat and Ecosystems

Supporting Topic/ VEC	Issue/Rationale	Monitoring	Timelines
Terrestrial Habitat (Supporting Topic)	• To verify the predicted amounts and composition of direct and indirect habitat loss, alteration and disturbance during construction and operation.	• Measure direct habitat loss and disturbance, by habitat type, in the Project Footprint. • Measure indirect habitat loss and change, by habitat type, in areas where indirect effects are predicted to occur.	Once at the end of construction. Periodically during first 30 years of operation, with frequency decreasing over time.

Table 2-52: Monitoring and Follow-Up Program for Terrestrial Habitat and Ecosystems

Supporting Topic/ VEC	Issue/Rationale	Monitoring	Timelines
		• Monitor under storey vegetation and soil effects in areas where indirect effects are predicted to occur.	Periodically during first 30 years of operation, with frequency decreasing over time.
	• To verify the effectiveness of rehabilitation efforts in temporarily cleared or modified areas.	• Collect vegetation and soils data in the rehabilitated areas to assess degree of habitat recovery.	Periodically after regeneration is implemented, until vegetation is successfully established.
Ecosystem Diversity (VEC)	• To verify that the priority habitat patches that are to be avoided are not disturbed.	• Monitor to confirm avoidance of priority habitat patches.	Regularly during clearing activities.
Fire Regime (Supporting Topic)	• To confirm the Project does not create large accidental fires.	• In the event that any accidental Project-related fires occur, document the amount and composition of affected habitat and subsequent regeneration.	Contingent upon the nature of the event, if it occurs.
Intactness (VEC)	• To confirm that portions of trails that are blocked and revegetated are successfully regenerating.	• Collect vegetation data in the rehabilitated portions of linear features to assess degree of vegetation regeneration.	Periodically after regeneration is implemented.
	• To verify Project effects on linear feature density and core area abundance.	• Measure linear features associated with Project development.	Once at end of construction.
		• Monitor the contribution of habitat recovery to increased core area using terrestrial habitat monitoring data.	Once after revegetation is successfully established.

Table 2-52: Monitoring and Follow-Up Program for Terrestrial Habitat and Ecosystems

Supporting Topic/ VEC	Issue/Rationale	Monitoring	Timelines
Wetland Function (VEC)	• To verify predicted Project effects on wetlands.	• Monitor the amount and composition of inland wetland loss and alteration.	See Terrestrial Habitat Monitoring Section.
		• Sample shoreline wetlands in areas that may be indirectly affected by groundwater changes and edge effects.	Periodically during first 30 years of operation, with frequency declining as reservoir expansion slows.
	• To verify effectiveness of wetland mitigation measures.	• Collect vegetation, soils and other environmental data in the wetland mitigation areas to assess degree of wetland development.	Periodically after measures are implemented, as needed to assess success of wetland establishment.
Terrestrial Plants			
Priority Plants (VEC)	• To verify that the priority plant patches that are to be avoided are not disturbed.	• Monitor to confirm avoidance of priority plant patches.	Regularly during clearing activities.
	• To verify predicted effects on priority plant species.	• Monitor effects on priority plants and their habitat using terrestrial habitat monitoring data.	See Terrestrial Habitat Monitoring Section.
Invasive Plants (Supporting Topic)	• To verify that mitigation measures limit the further introduction and spreading of invasive non-native plants.	• Conduct invasive plant surveys within and near to the Project Footprint.	Periodically during construction and first five years of operation.

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APPENDIX 2A
ASSESSMENT METHODS

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2.14 APPENDIX 2A: ASSESSMENT METHODS

2.14.1 Project Linkages

Figure 2A-1 shows the web of linkages between vegetation clearing and terrestrial plants.

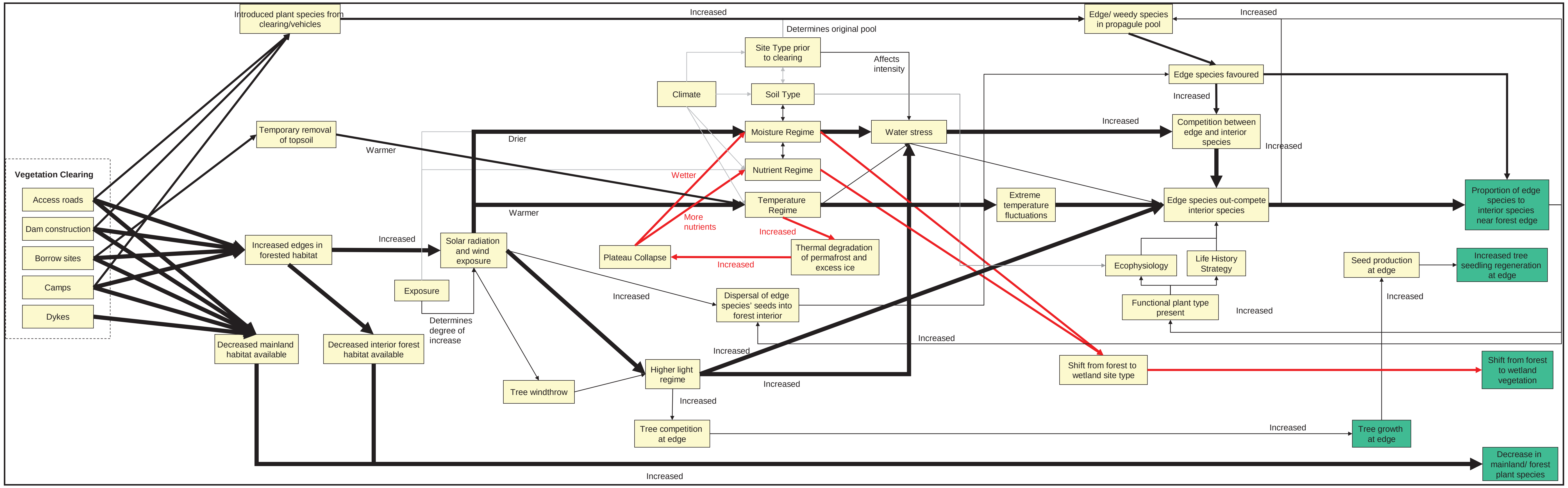

Figure 2A-1: Web of Linkages Between Physical Changes Caused by a Generating Station and Terrestrial Plants

2.14.2 Study Area Delineation

2.14.2.1 Methodology

This section describes the study area delineation methodology.

As described in Section 1.3.4 and Appendix 1A, the terrestrial environment assessment evaluates how the Project is expected to affect terrestrial ecosystem health, as represented by the VECs and supporting topics.

Two of the key questions to be answered when terrestrial ecosystem health is the primary focus of the terrestrial assessment are:

1. What is the appropriate ecosystem level to evaluate ecosystem health?
2. How are the spatial boundaries for the ecosystem level appropriate for ecosystem health evaluation delineated for a specific project?

Ecosystems generally do not have well-defined, tangible boundaries. Nevertheless, causal linkages between ecological states and factors lead to natural functional breaks in spatial and temporal scales that facilitate the identification of an ecologically meaningful nested hierarchy of ecosystem levels (Allan and Starr 1982, King 1993 and Rowe 1961 for components or Ehnes 1998 and Waltner-Toews *et al*. 2008 for a synthesis). For example, sites form stands, stands form landscapes, landscapes form subregions, subregions form regions and so on up to the biosphere (*e.g.*, Bailey 2009; Ehnes 2011). Figure 2.14-2 provides an example of a classification of hierarchical ecosystem levels.

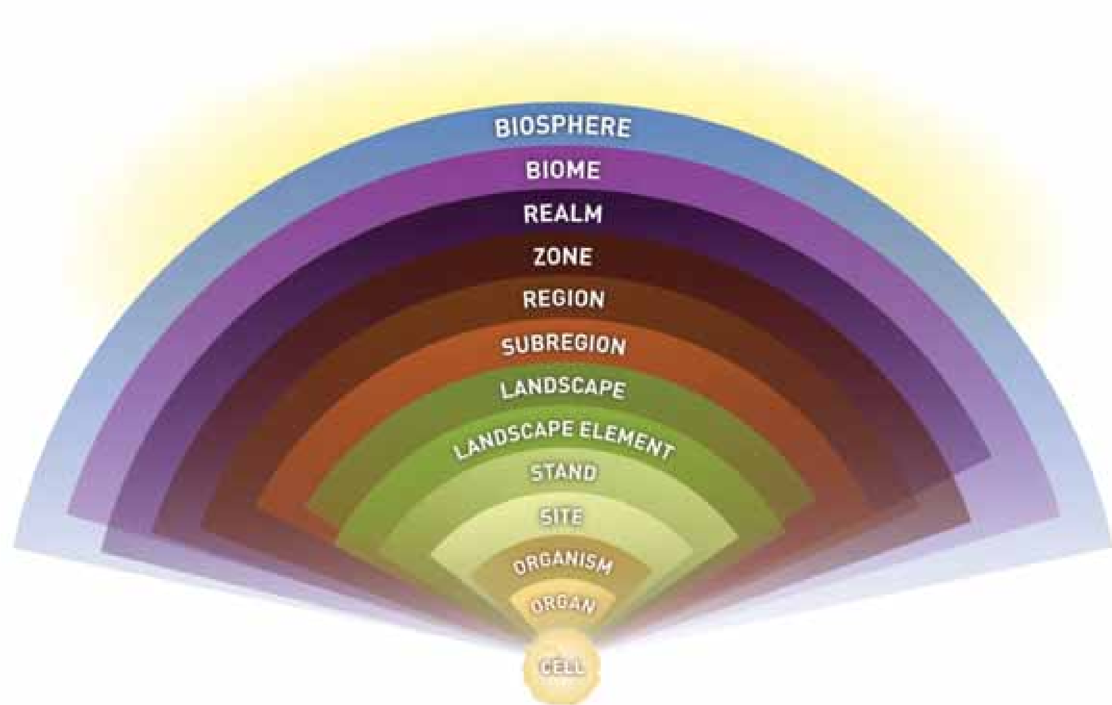

Figure 2A-2: Hierarchical ecosystems levels

Source: Pimachiowin Aki Corporation (2012).

The region ecosystem level (Figure 2.14-2) is the appropriate level to evaluate ecosystem health (Miller and Ehnes 2000). This is the ecosystem level that is large enough to capture the characteristic ecological patterns and processes for the ecological zone (Figure 2.14-2) the project is located in. In a relatively pristine area, process rates and ecosystem functions in the regional ecosystem are presumed to be occurring within their ranges of natural variability. Human projects and activities are ecologically sustainable, when ecosystem functions maintained within those ranges of natural variability. This conceptual approach is illustrated in Figure 2.8-1.

Study area delineation for the terrestrial ecosystem assessment began by identifying the boundaries of the Keeyask region level ecosystem (*i.e.*, the regional ecosystem). Since wildfire and climate are the keystone drivers for variability in region level ecosystem functions in the central Canadian boreal ecological zone over the century time frame, the first step was to determine the size and boundaries for an area surrounding the Project that was sufficiently large to support the regional fire regime.

A noteworthy characteristic of an area that is sufficiently large to support the regional fire regime would be the maintenance of relatively stable inland habitat composition in a shifting habitat mosaic over the century time frame (*i.e.*, period relevant for the life spans of species and where climate change is relatively small). In other words, the region should be sufficiently large so that one fire would not dramatically alter the proportions of any habitat type or the age class distribution of inland vegetation. Exceptions could occur if a fire larger than previously experienced were to occur or if a single fire or successive fires coincidentally extirpated a regionally rare habitat type. Another noteworthy characteristic of such a region is that it should be sufficiently large to support populations for most of the resident wildlife species (some species such as wolverine have extremely large population home ranges) since the resident species are adapted to cope with frequent large fires through strategies such as regenerating in situ. For example, plants sprouting from roots or animals moving to other places in the region (*e.g.*, an animal species that uses mature forest moving from a recently burned area to another area where the forest has shifted from the young to the mature age class).

Two possible approaches to establishing region size using the wildfire regime are statistical fire frequency distributions and rules of thumb. In the statistical fire frequency distribution approach, the region size is expanded until the age class distribution of the forest approximates a Weibull or a negative exponential distribution. In theory, the general shape of an age class distribution for the final geographic extents will be relatively stable over time, all other things being equal. A drawback of the statistical fire frequency distribution approach is that it requires age data for a very large geographic area. Since these data were not available for the study area, this approach was not pursued.

The rule of thumb approach uses an area that is much larger than the size of the largest known wildfire. That is, an area sufficiently large that a single wildfire would not substantially alter the habitat composition of the region. There is no generally accepted rule of thumb for what constitutes an area that is much larger than the size of the largest known fire. An important consideration for region size determination given that the region is used to assess the significance of Project effects is that the region not be so large that it is impossible or very difficult for a significant effect to occur. For this reason, a region size criterion was to select the minimum size required to support a relatively stable shifting habitat mosaic.

The objective when determining study region size is analogous to that used to establish ecological reserves designed to maintain natural ecosystems. Baker (1992) argues that reserves should be at least several times larger than the maximum disturbance size typical of the region. However, Johnson and Gutsell

(1994) state that an area three times larger than the largest historic fire is of limited use for charactering the wildfire regime. Mathematically, an area ten times larger than the largest fire should be adequate to absorb the effects of the largest fire in the sense that the proportions of the habitat types and age classes would generally not change dramatically. An exception would be the situation where all of a particular habitat type is concentrated in one location, all of which is burned in a wildfire.

The region size rule of thumb selected for the Project assessment was that the Keeyask region should be approximately ten times larger than the largest historic fire during the last century, recognizing that the application of this rule would be limited by available fire history data. In a region of this size, it is anticipated that it is unlikely that all occurrences of a particular plant species or habitat type would be burned even by the largest historic fire.

As a cross-check against the region size derived from this approach, studies addressing one or more aspects of how minimum size contributes to ecosystem functioning or minimum ecological reserve size have derived values that range from approximately 2,000 km^2 to over 20,000 km^2, with most including ranges that exceed 10,000 square kilometers (e.g. Baker 1992; Gurd *et al*. 2001; Ehnes 2000; Miller and Ehnes 2000; Rodrigues and Gaston 2001; Leroux *et al*. 2007) Minimum values vary with location in the boreal biome and the ecological attribute or attributes used to determine minimum size. The literature suggests that 10,000 km^2 is probably the minimum area needed to support a natural, boreal wildfire disturbance regime throughout much of the North American boreal shield.

2.14.2.2 Methods

Fire history data to determine the largest historic fire for the Keeyask Generation Project Area (Map 2.2-1) were compiled from several sources including government datasets, terrestrial habitat mapping and satellite imagery.

Manitoba Conservation (Manitoba Conservation 2010) has created a fire history dataset for all of Manitoba in GIS format. The Canadian Forest Service has created the Canadian large fire database (Stocks *et al.* 2003), which consists of database records with coordinates for a single point in each burn. At the time the region delineation analysis was completed, these records were available for the 1960 to 1999 period from the Canadian large fire database and for the 1976 to 2006 period from Manitoba Conservation.

Environmental impact assessment studies contributed additional, and in some cases, more detailed information. Recent fire history for Study Zone 4 was mapped as a component of the terrestrial habitat mapping. For areas outside of Study Zone 4 and for older burns, composites created from Landsat 5 and Landsat 7 satellite imagery were used to verify the presence of a burn and its boundaries. Although coarser resolution, the Landsat 5 were helpful confirming older burns since they were available from 1984 onward. Due to the mapping scale and the nature of the satellite data, they were only adequate to map coarse boundaries and large skips (*i.e.*, areas skipped over and left unburned).

Burns were dated using a combination of stereophotos and satellite imagery from multiple years and the Manitoba Conservation fire database (Manitoba Conservation 2010).

Fire history records indicated that the largest fire in the Keeyask Generation Project Area for the 1960 and 2006 period was 116,000 ha. On this basis, the Keeyask region should be approximately 1,200,000 ha (keeping in mind the limitations of the data which include missing burned area and missing burns for the earlier portion of the study period). This size was within the range reported in the literature (see previous section).

Once the approximate Keeyask region size was determined from the largest historic burn, Keeyask region boundaries were delineated by expanding outward from the Project Footprint over an ecologically homogenous area until the target region size was reached. The criteria for defining ecological homogeneity were the key controlling factors for the natural wildfire regime, which are climate and landscape level manifestations of surface materials, groundwater, surface water and topography (see Section 2.5.1). Different wildfire regimes are expected for large areas that have substantially different climate, dominant surface materials (*e.g.*, bedrock versus fen) or proportions of large waterbodies.

The polygons from Soil Landscapes of Canada (SLC polygons; Ecological Stratification Working Group 1996) were used as the building blocks to create the Keeyask region. Soil Landscapes of Canada uses climate and landscape level manifestations of surface materials, groundwater, surface water and topography to subdivide Manitoba into relatively homogenous ecological units. To guide the selection of adjacent SLC polygons, the Local Study Area and PR 280 were buffered to produce a polygon that was approximately 1,200,000 ha in area, which was the target region size. The Keeyask region was formed by starting with the SLC polygons that overlapped the Terrestrial Habitat Local Study Area and PR 280 between Thompson and Gillam (although this portion of PR 280 has traffic effects, it was not included in the Terrestrial Habitat Local Study Area because those effects were anticipated to be minimal). Adjacent SLC polygons to these ones were added iteratively until the total area was large enough to meet the target size. For SLC polygons that were much too large to be included in their entirety, watershed and surface material polygon boundaries were used to truncate distant portions of these SLC polygons. The result was the geographic area shown as Study Zone 5 in Map 2.2-1, which is the Keeyask region.

APPENDIX 2B
FIELD STUDY AND ANALYSIS METHODS

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2.15 APPENDIX 2B: FIELD STUDY AND ANALYSIS METHODS

2.15.1 Habitat Mapping

2.15.1.1 Photo-Interpretation and GIS Mapping

Habitat was initially photo-interpreted from 1:15,000 scale black and white stereo air photos taken on July 8, 2003. Stereo photography from 1999 (1:20,000), 1991 (1:12,000) and 1986 (1:20,000) was used where 2003 photo coverage was not available. Polygon boundaries were traced on the air photos and then heads-up digitized on DOIs or scanned photos that were georeferenced to the DOIs. Updates for areas near the Nelson River were subsequently made using black and white stereo photos taken in 2006 (1:15,000).

Photo-interpreted habitat attributes included vegetation structure, upper canopy species composition, lower canopy species composition, upper canopy closure, lower canopy closure (if visible), canopy complexity, burn extent, disturbed since 2003, fine ecosite type and topographic position. Definitions for these attributes, and mapping criteria are provided in Table 2B-1.

The minimum mappable polygon area for habitat attributes was generally 5,000 m^2. A 1,000 m^2 cutoff was used for patches containing canopy species other than black spruce since these conditions were uncommon to rare in the Study Zone 4. The minimum polygon size was 400 m^2 for water since this feature is important for distinguishing certain wetland types and could be extracted with high accuracy rate using an automated digitization process (see below).

A 20,000 m^2 (2 ha) minimum mappable polygon area was used for ecosite and topography with two exceptions. First, a 1,000 m^2 cutoff was used for collapse scars and peat plateau bogs in the potential Project reservoir area because these ecosite types play key roles in peatland disintegration (peatland disintegration is the largest indirect Project effect; see PE SV Section 6 for details). Second, certain distinct ecosite types such as narrow runnels were usually smaller than 2 ha so the standard minimum mappable area was used for these features.

It should be noted that polygons slightly smaller than the stated minimum area are present in the final habitat map since the polygon areas were usually judged visually while tracing and digitizing. Additionally, a polygon initially digitized for vegetation attributes may be split into a smaller polygon when ecosite was added.

A mirror stereoscope was generally used to photo-interpret ecosite and topography. An Abrams stereoscope was also used for ecosite and topography in locations where interpretation was uncertain. An Abrams stereoscope was used to photo-interpret all other habitat attributes.

GIS polygons for the photo-interpreted attributes were generated in several steps. The initial polygons were generated through a proprietary automated digitization computer program developed by ECOSTEM Ltd.. The computer program generates preliminary vegetation structure polygons and assigns a structure type to each polygon. The auto-digitization computer program processed the 1999 DOIs provided by Manitoba Hydro. The auto-digitized polygons were overlaid on the DOIs in MapInfo (initially Version 7.5 and then Version 8.5). Errors in the automated typing of vegetation structure were corrected and missing polygons were digitized. Erroneous boundaries in polygons were heads-up digitized on the DOIs and corrected at a standard viewing scale of 1 cm = 30 m in MapInfo. Photo-interpreted boundaries traced on photos and not already incorporated by the auto-digitized polygons (i.e., ecosite type, topography, canopy species other than black spruce, recent disturbance boundaries) were heads-up digitized on the 1999 DOIs. Photo-interpretations of attributes were reviewed by a second interpreter and further adjustments were made as necessary. Whenever possible, the same interpreter was used for review in order to maintain consistency throughout the mapping region.

After the habitat attributes were mapped as of 2003 (*i.e.*, photography year), fires occurring after 2003 were incorporated using either 2006 stereo photography or still camera photos acquired from a helicopter. An attribute was added to indicate that the polygon was burned since the 2003 photography; polygons were split into burned an unburned sections as needed. Two versions of the interpreted and derived variables were maintained in the habitat dataset, one as of 2003 and the other as of 2010. The former dataset represents conditions prior to the large 2005 burn on the south side of the Nelson River, which was maintained because most field data was collected prior to the 2005 burn. The 2010 version represents the existing environment for the EIS.

Several additional attributes were then added to the habitat dataset by inheriting them from other GIS datasets (i.e., year of origin, study zone, Forest Management Unit).

A number of additional attributes were derived from the photo-interpreted and inherited attributes (Table 2B-5). In general, derived attributes were broader categorizations of photo-interpreted attributes derived from direct manipulations of photo-interpreted attribute classes. For example, fine habitat type represents broad groupings of species composition and coarse ecosite type. Other derived attributes were mathematical calculations. For example, age at 2010 was 2010 minus year of polygon origin.

2.15.1.2 Validation

The photo-interpreted habitat mapping was validated using a combination of directed aerial validation surveys, ground data and still photos taken from a helicopter.

Directed aerial and ground validation surveys were completed for the uncommon to rare mapped habitat types. Location waypoints were generated from these map polygons and uploaded into a handheld GPS unit. The waypoints were visited in the field and the actual canopy species composition and site conditions were recorded on a map. Additionally, waypoints were acquired in the field for any priority habitat types that were observed from the helicopter but not already in the habitat map. In the lab, mapped versus actual typing was compared and accuracy rates were calculated. Validated habitat attributes were adjusted if necessary in the GIS database, and any new priority habitat locations were incorporated.

A geo-referenced database of oblique photos acquired from a helicopter was compiled to support photo-interpretation and to validate the habitat mapping. Still photos were taken from a helicopter during the 2001 – 2011 field seasons. Some photos were taken opportunistically while flying between ground sample locations; others were intentionally located in areas of high interest. In addition, oblique, overlapping photos of stands and the landscape were taken along a series of flight lines in the LNR region, at an altitude of approximately 150 metres.

Ecosite mapping was validated using soil profile data from the habitat plots, soil sample locations and the

Manitoba Hydro borehole database. These datasets provided stratigraphy information for over 4,000 locations.

2.15.1.3 Habitat Attributes

Table 2B-1 provides a summary description of each photo-interpreted habitat attribute. Where needed, further descriptions of the classes included within some of the attributes are provided in Table 2B-2 and Table 2B-4. Further details for interpreted attributes are provided below.

Table 2B-1: Habitat Attributes in the GIS Database Acquired Through Photo-Interpretation.

Attribute Name	Description	Values
Veg_Structure	Current vegetation structure type: The growth form of the highest vegetation layer having at least 25% total cover.	F = Forest; D = Woodland; S = Sparsely Treed; M = Heterogeneous; TS = Tall Shrub; L = Low Vegetation; E = Emergent; R = Young Regeneration
Veg_Structure_2003	Veg_Structure as of year 2003.	
Species_Upper	Species composition of canopy layer: All species with a minimum proportion of 10%, in 10% classes (e.g., BS6JP4 = 60% black spruce and 40% jack pine).	BS = Black Spruce, TL = Tamarack, JP = Jack Pine, TA = Trembling Aspen, BA = Balsam Poplar, WB = White Birch
Species_Upper_2003	Species composition of canopy layer as of year 2003.	
Species_Upper_Historical	Species composition of canopy layer prior to conversion to human infrastructure, if available.	
Species_Lower	Species composition of above-ground understorey layer (cannot be typed in polygons where understorey is obscured by canopy. i.e., forest or some woodland). Must be a distinct vegetation layer with at least 5m height difference between layers.	See Species_Upper
Species_Lower_2003	Species_Lower as of year 2003.	
Closure_Upper	Percent closure class of upper canopy layer: Classes are 10% increments where black spruce < 100%. Where black spruce = 100% there are 4 classes because of wide range of tree heights often in these stands (no true upper canopy).	0, 1, 2 . . . to 9 (1 = 10-19%; 2 = 20-29%; 3 = 30-39%;…; 9 = 90-100%)
Closure_Upper_2003	Closure_Upper as of year 2003.	
Closure_Lower	Percent closure of lower tree layer if present: Classes are 10% increments where lower canopy closure > 10%. Only applies to polygons where Species_Upper black spruce < 100%. Lower layer closure more difficult to interpret or underestimated with increasing upper canopy closure.	See Closure_Upper
Closure_Lower_2003	Closure_Lower as of year 2003.	

Table 2B-1: Habitat Attributes in the GIS Database Acquired Through Photo-Interpretation.

Attribute Name	Description	Values
Canopy_Complexity	Indicates a complex canopy where there is a wide range of tree heights with no defined layer.	1 = Range of tree heights; 0 = Other
Canopy_Complexity_2003	Canopy_Complexity as of year 2003.	
Year_Origin*	Most recent year of stand-replacing disturbance in polygon (where information is available).	Year
Year_Origin_2003*	Most recent year of stand-replacing disturbance in polygon up to 2003 (where information is available).	
Feature_Name	Identifies disturbance type if present.	Fire; Clearing- Linear, TLine, Railway etc.
EcoSite_Fine_Code	Fine ecosite type code.	See legend Table 2-19
Topography	Topographic form: Combines surface shape and topographic position.	See legend

Table 2B-2: Vegetation Structure Classes.

Vegetation Structure Type	Code	Percent Cover
Forest	F	61% - 100% trees
Forest/ Tall Shrub	F/ TS	61% - 100% trees in upper canopy/ > 25% tall shrubs in lower canopy
Woodland	D	26% - 60% trees
Woodland/ Tall Shrub	D/ TS	26% - 60% trees in upper canopy / > 25% tall shrubs in lower canopy
Sparsely Treed	S	10% - 25% trees
Sparsely Treed/ Tall Shrub	S/ TS	10% - 25% trees in upper canopy / > 25% tall shrubs in lower canopy
Heterogeneous mixture of woodland and sparsely treed	M	Mixture of woodland and sparsely treed

Table 2B-2: Vegetation Structure Classes.

Vegetation Structure Type	Code	Percent Cover
Heterogeneous mixture of woodland and sparsely treed/ Tall Shrub	M/ TS	Mixture of woodland and sparsely treed with TS lower canopy
Tall Shrub	TS	<10% tree cover and > 25% tall shrub cover
Low Shrub and/or Graminoid and/ or Bryoid	L	<10% trees and < 25% tall shrub and > 10% ground cover
Emergent	E	> 25% emergent vegetation cover
Barren	B	< 10% vegetation cover
Unclassified Young Regeneration	R	Burned after 1992, insufficient information to classify into vegetation structure type

Table 2B-3: Fine Ecosite Types and Criteria.

Name	Code	Criteria*
Mineral types		
Outcrop	1	Surface organic layer < 20 cm thick, and mineral soil < 4 cm thick.
Shallow/ thin mineral	2	Surface organic layer < 20 cm thick, and mineral soil ≥ 4 cm and < 100 cm thick.
Deep dry mineral	4	Surface organic layer < 20 cm thick; mineral soil >100 cm thick; moisture regime very fresh or drier. Vegetation indicative of the moisture regime is present.
Deep wet mineral	5	Surface organic layer < 20 cm thick; mineral soil >100 cm thick; moisture regime moderately moist or wetter. Vegetation indicative of the moisture regime is present.
Thin peatland types		
Veneer bog on slope	15	Surface organic layer ≥ 20cm and < 100 cm. Occurs on ridges and crests or sloped topography.
Organic or Mineral types		
Swamp	10	Mineral or organic soil; Moisture regime is wet. Water table usually >20 cm below surface; periodically flooded; woody vegetation cover ≥ 25%.
Shallow peatland types		
Veneer bog	21	Surface organic layer ≥ 20cm and < 100 cm, not occurring on crests, ridges or slopes
Blanket bog	22	Surface organic layer > 100 and ≤ 200 cm; Surface is level and featureless; Patchy ground ice may be present but does not form hummocks or banks taller than 1m.

Table 2B-3: Fine Ecosite Types and Criteria.

Name	Code	Criteria*
Slope bog	24	Surface organic layer > 20 cm thick and mineral soil >100 cm thick; Surface sloped. moisture regime moderately moist or wetter. On slopes. Usually in runnels. Slope and bog indicators.
Slope fen	25	Surface organic layer > 20 cm thick and mineral soil >100 cm thick; Surface sloped. Moisture regime moderately moist or wetter. On a slope. Usually in runnels. Vegetation indicative of mesotrophic or eutrophic conditions. Fen indicators. All polygons that could be slope swamps are included in this type.
Peat plateau bog	31	Surface organic layer ≥ 20cm: Massive ground ice at least 1m thick; Surface level. Banks obvious.
Peat plateau bog transitional stage	32	Surface organic layer ≥ 20cm: Massive ground ice patchy forming large, obvious hummocks and/ or banks shorter than 1m. Peat plateau bog in the formation or disintegration stage (build-up or melting of ground ice).
Peat plateau bog/ collapse scar peatland mosaic	33	Mixture of peat plateau bog and collapse scar peatlands.
Blanket bog/ collapse scar peatland mosaic	35	Mixture of blanket bog and collapse scar peatlands.
Wet peatland types		
Collapse scar bog	43	Thermokarst feature. Surface organic layer ≥ 20cm, in a depression within a peat plateau bog. Bog indicators. Peat mat usually floating. Often a narrow band of water on the perimeter.
Collapse scar fen	44	Thermokarst feature. Surface organic layer ≥ 20cm, in a depression within a peat plateau bog. Fen indicators. Peat mat usually floating. Often a narrow band of water on the perimeter.
Horizontal fen/ blanket bog mosaic	45	Mixture of horizontal fen (see type 55) and blanket bogs (see type 22).
Basin fen	52	Surface organic layer ≥ 20 cm, situated in a basin that has an essentially closed drainage, receiving water from the immediate surroundings. May have outlets but no inlets. Vegetation indicative of mesotrophic or eutrophic conditions.
Flat bog	54	Surface organic layer ≥ 20 cm. Depth to mineral material or bedrock typically greater than 2 m. Surface flat. Occurring in broad, poorly defined depressions. Open water absent or as small pools. Bog vegetation only.
Horizontal fen	55	Surface organic layer >= 20cm, open water absent or as small pools; Buried water layer usually present. Distinct water flow or vegetation indicative of mesotrophic or eutrophic conditions present. Patterning not visible.
String fen	62	Surface organic layer > 20 cm. Narrow, peaty ridges ("strings") that enclose open water pools or depressions of open water ("flarks") or wet fen surfaces. Strings are at right angles to the direction of surface water flow. Vegetation indicative of mesotrophic or eutrophic conditions.
Shore zone peatland types		
Riparian bog	67	Surface organic layer >= 20cm: Floating; open water present. No visible evidence of flowing water. Bog indicators.
Riparian fen	68	Surface organic layer >= 20cm: Floating; open water present, along lakes and waterways. Visible evidence of flowing water and/or fen indicator vegetation.

Table 2B-3: Fine Ecosite Types and Criteria.

Name	Code	Criteria*
Shore zone types		
Ice scour on mineral above wet meadow zone	70	Along Nelson River banks above the shoreline wetland zone, disturbed by ice movement. Usually a terrace or steeply sloped mineral/ bedrock area.
Upper beach- regulated	72	Nelson River shoreline wetland. In mainstem. Infrequent to frequent flooding. Sloped transition between open water and upland. Herbaceous and/or tall shrub vegetation.
Upper beach- regulated	75	Nelson River shoreline wetland. In a shallow bay. Sloped transition between open water and upland. Herbaceous and/or tall shrub vegetation.
Upper beach on sunken, disintegrated peatland	74	Wet meadow on sunken, disintegrated peatland that is under water. Sloped transition between open water and upland. Herbaceous and/or tall shrub vegetation, snags often present in water.
Lower beach	76	Shallow water with emergent vegetation present adjacent to shoreline, usually above waterline in low water years.
Upper beach on sunken peat	77	Marsh on sunken fringes of floating peatlands. Generally along edges of lakes and streams.
Littoral	79	Marsh island, floating-leaved patch in permanently submerged of the shallow water zone.
Other types		
Shallow water	80-85	Water covering at least 400 m^2 area and shallower than 2 m.
Deep water	88	Water covering at least 400 m^2 area and deeper than 2 m.
Nelson River deep water	89	Water covering at least 400 m^2 area and deeper than 2 m.
Human	90	Human structures or semi-permanent clearings (e.g., borrow areas that are not regenerating).

* Criteria refer to dominant conditions throughout the polygon.

Table 2B-4: Topographic form classes and criteria.

Topographic Form	Criteria*
Ridge/ Crest	Long, narrow elevation of the surface, usually sharp crested with steep sides. The ridges may be parallel, subparallel, or intersecting.
Slope	Sloping, unidirectional surface with a generally constant slope not broken by marked irregularities. Slopes are 2-70% (1-35°).
Bank	Erosional slopes, greater than 70% (35°), on both consolidated and unconsolidated materials.
Beach	Open water zone shallower than 2 m.
Horizontal	Flat or very gently sloping (i.e., < 2%), unidirectional surface with a generally constant slope not broken by marked elevations and depressions.
Horizontal- raised	Horizontal areas that are higher than the surrounding areas and have banks or very steep slopes (e.g., peat plateau bog)
Hummocky	Very complex sequence of slopes extending from somewhat rounded depressions or kettles of various sizes to irregular to conical knolls or knobs. The surface generally lacks concordance between knolls or depressions. Slopes are generally 9-70% (5-35°)
Dissected	Many crevices or small runnels interspersed throughout
Ravine	Band formed by steep, high banks on both sides; Feature may or may not be distinctly sloped
Runnel	Narrow band formed by (a) moderately to very short steep slopes on either sides, or (b) large gentle slopes (e.g., two veneer bogs meeting); Feature is often distinctly sloped.
Depression	Area is generally lower than all of the surrounding area but there may be surface water inlets and outlets.
Basin	Area is lower than all of the surrounding area.

* Criteria refer to dominant conditions throughout the polygon.

Table 2B-5: Habitat Attributes Inherited from Another GIS Dataset

Reach*	Nelson River shoreline wetland study zone.	See Section 2.8.2.2
FMU*	Forest Management Unit (Provincial boundaries)	FMU ID
Study_Area_ID*	Project Study Zone.	See Section 1.3.5
Impact_Construction	Project impact (footprint) type during construction period.	e.g. "Infrastructure" See PD SV Section 2
Impact_Name	Name of specific footprint component.	e.g. "Powerhouse" See PD SV Section 2
Impact_Operation	Project impact (footprint) type at beginning of operation period.	e.g. "Reservoir" See PD SV Section 2
Impact_Operation_Y30	Project impact (footprint) type at year 30 of operation period.	e.g. "Reservoir expansion" See Section 2.3.6.3 & PD SV Section 2

Table 2B-6: Habitat attributes in the GIS database derived from photo-interpreted and inherited attributes.

Attribute Name	Description	Example Values
Priority_Concern	Indicates priority habitat criteria met, if any.	R; D; RD See Section 2.7.3.2.2
Land_Cover	Coarsest class in hierarchical ecological land classification. Generally a combination of Veg_Class and Land_Type for inland habitat.	Needleleaf treed on other peatlands; Nelson River shore zone
Land_Cover_2003	Land_Cover in 2003.	See Land_Cover
Coarse_Habitat	Second-coarsest class in hierarchical habitat classification. Identifies dominant conifer tree species; combination with ecosite types.	Black spruce treed on shallow peatland; Nelson River shrub and/or low vegetation on upper beach
Coarse_Habitat_2003	Coarse_Habitat in 2003	See Coarse_Habitat
Broad_Habitat	Second-finest class in hierarchical habitat classification. Priority habitat identified at this level. Identifies all dominant tree species and their degree of mixture in combination with ecosite.	Black spruce mixture on ground ice peatland; Tall shrub on upper beach-regulated
Broad_Habitat_2003	Broad_Habitat in 2003	See Broad_Habitat
Fine_Habitat	Finest class in hierarchical habitat classification. Identifies all dominant tree species and their degree of mixture and tall shrub layer if present. Generally a combination of Veg_Broad and Broad_Ecosite.	BS Mixture/ Tall Shrub on Wet Peatland; Emergent on Sunken Peat
Fine_Habitat_2003	Fine_Habitat in 2003	See Fine_Habitat
Veg_Composition	Species composition of upper and lower strata. Combination of Species_Upper / Species_Lower.	JP8BS2/ BS10; TA10/ TS Unknown
Veg_Composition_2003	Veg_Composition as of year 2003.	See Veg_Composition.
Veg_Class	Aggregation of Veg_Broad classes into a small number of general types.	Needleleaf Treed; Broadleaf Treed
Veg_Class_2003	Veg_Class in 2003.	See Veg_Class
Veg_Broad	Leading species and degree of mixture with other types. Rules are: Needle mixedwood if broadleaf component >= 30% and <= 40%. Needle mixture if broadleaf component >= 10% and <= 20%. Broadleaf mixedwood if needle component >= 30% and <= 50%. Broadleaf mixture if needle component >= 10% and <= 20%. If there is a tie for leading species, then the following rules apply: BS always loses; Where there are ties that involve a needle and a broadleaf species, the broadleaf species always wins; and, Where there are ties that involve two broadleaf species, TA always loses.	BS Pure; TA Mixture
Veg_Broad_2003	Veg_Broad in 2003	See Veg_broad
Age_At_2003	Vegetation age in 2003. Equals 2003 minus "Year_Origin" where "Year_Origin" > 0.	Age (years)
Age_At_2010	Vegetation age in 2010. Equals 2010 minus "Year_Origin" where "Year_Origin" > 0.	Age (years)

Table 2B-6: Habitat attributes in the GIS database derived from photo-interpreted and inherited attributes.

Attribute Name	Description	Example Values
Balsam_Fir, Balsam_Poplar, Black_Spruce, Jack_Pine, Tamarack, Trembling_Aspen, White_Birch, White_Spruce	Percentage of Closure_Upper contributed by the species. Information also available as of year 2003 (e.g. Balsam_Fir_2003)	1 to 10 (10% to 100%)
Ecosite_Fine_Form	Adds a modifier to EcoSite_Fine_Code to distinguish between different wetland sub-forms and hydrodynamics within a fine ecosite type.	See Hydrodynamics and Wetland_Subform below.
EcoSite_Fine	Name of fine ecosite type, associated with EcoSite_Fine_Code.	See Table 2-19
EcoSite_Coarse_Code	Coarse ecosite type code. A more general grouping of EcoSite_Fine_Code.	See Table 2-22
EcoSite_Coarse	Name of coarse ecosite type, associated with EcoSite_Coarse_Code.	See Table 2-22
EcoSite_Broad	Broad ecosite type name. More general than coarse ecosite type for inland habitat.	See Table 2-22
Land_Type	Land type. The most general ecosite type classification.	See Table 2-22
Surface_Permafrost	Surface permafrost distribution in the polygon.	Continuous; Extensive Discontinuous; Sporadic Discontinuous; Isolated Patches; None
Hydrodynamics	Identifies hydrological influences within the polygon. Applies to wetlands and shore zone, otherwise "None".	None; Nelson River; Lake; Stream; Groundwater flow
Water_Depth_Zone	Water depth duration zone: A generalized classification of shore zone polygons according to the amount of time spent submerged annually. See Section 2.3.2.2.	Littoral; Lower beach; Upper beach; Inland ice scour; None
Regulated	Indicates if shore zone wetland polygon is influenced by Nelson River regulation.	Yes; No
Wetland_Class	Wetland class. Coarsest wetland classification, based on Canadian Wetland Classification System (CWCS; National Wetlands Working Group 1997).	Bog; Fen; Marsh; Swamp; Shallow Water
Wetland_Form	Wetland form: subdivisions of each wetland class based on surface morphology, surface pattern, water type, vegetation and ecosite.	Riparian; Lacustrine
Wetland_Subform	Wetland sub-form: a finer subdivision of wetland form reflecting more detailed site and water conditions.	Shore; Bay; Stream; Shore and floating; Shore and bay
Wetland_Quality	Wetland quality score. See Section 2.8.2.4.2.	17; 65
ID	Unique identifying number for individual polygons. Integer.	1, 2, etc.
Area	Spherical area of polygon in square meters. Calculated by MapInfo.	Area (m^2)

Table 2B-7: Coarse and broad ecosite classes and criteria.

Broad Ecosite	Coarse Ecosite	Coarse Ecosite Code	Criteria*
Mineral land types			
Mineral Soil	Mineral Soil	1	Surface organic layer < 20 cm thick. Fine_EcoSite_Code: 1 – 5)
Thin peatland land types			
Thin Peatland	Thin Peatland	15	Surface organic layer >= 20cm and < 100 cm. Occurs on ridges and crests or sloped topography. (Fine_EcoSite_Code: 15)
Peatland land types			
Shallow Peatland	Shallow Peatland	20	Surface organic layer > 20 cm and ≤ 200 cm thick. (Fine_EcoSite_Code: 21 – 25)
Ground Ice Peatland	Ground Ice Peatland	30	Surface organic layer ≥ 20 cm; excess ice continuous. Level surface. (Fine_EcoSite_Code: 31 – 35)
Wet Peatland	Other Permafrost Peatland	40	Surface organic layer ≥ 20 cm; evidence of excess ice actively forming or melting (e.g., collapse scar peatlands). Hummocky surface due to patchy excess ice. (Fine_EcoSite_Code: 41 – 47)
	Deep Peatland	50	Surface organic layer > 200 cm; surface level and featureless. Excess ice usually absent and not confined by bedrock or mineral terrain. (Fine_EcoSite_Code: 51 – 57)
	Wet Deep Peatland	60	Surface organic layer > 200 cm; surface level and featureless. Evidence of very high water table. Excess ice usually absent and not confined by bedrock or mineral terrain. (Fine_EcoSite_Code: 62 – 65)
Shore zone peatland land types			
Riparian Peatland	Riparian Peatland	66	Surface organic layer ≥ 20 cm, floating. Open water present. (Fine_EcoSite_Code: 67 – 68)
Shore zone- regulated land types			
Ice Scoured Upland	Ice Scoured Upland	70	Along Nelson River banks, disturbed by ice movement. Usually a terrace or steeply sloped mineral/ bedrock area. (Fine_EcoSite_Code: 70)
Upper beach- regulated Sunken peat- regulated Lower beach- regulated	Shoreline Wetland- regulated	75	Wet meadow, sloped transition between open water and upland. Herbaceous and/or tall shrub vegetation. (Fine_EcoSite_Code: 71 – 79)
Shore zone marsh land types			
Upper beach Lower beach Littoral	Shoreline Wetland	75	Wet meadow, sloped transition between open water and upland or along finges of floating peat. Emergent, Herbaceous and/or tall shrub vegetation. (Fine_EcoSite_Code: 71 – 79)

* Criteria refer to dominant conditions throughout the polygon.

2.15.1.3.1 Vegetation Structure

Vegetation structure (Veg_Structure attribute in the database) identifies the tallest growth form that has at least 25% total cover. The four treed classes were forest, woodland, sparsely treed, or heterogeneous woodland and sparsely treed mixtures. The treed classes were determined according to the average estimated percent cover. To be considered a treed polygon, a minimum 10% cover of trees taller than two metres was needed. Woodland and sparsely treed mixtures referred to areas with variable structure that was too complex to be subdivided. Other areas were typed simply as "treed". These were either woodland or sparsely treed areas located at the fringes of the Study Zone 4 where less detailed mapping was conducted, and/or appropriate aerial photography was not available.

The untreed classes were tall shrub, low vegetation, emergent and non-vegetated (H = human; W = water) class. Young regenerating burns were assigned to the recent burn class if information regarding the current dominant growth form was unavailable through photo-interpretation (i.e., often a mixture of shrubs and tree saplings) or other sources. For a polygon to be assigned to the burned structure class, the fire must have been estimated to occur after 1992. Table 2B-2 provides the photo-interpretation criteria for each vegetation structure class.

For the polygons with a treed vegetation structure type, if a tall shrub understory was visible in the photos then a modifier was added to the type (*e.g.*, F/TS). This modifier is generally useful for the sparsely treed polygons since the overstorey typically obscured the tall shrub layer in forest polygons.

2.15.1.3.2 Vegetation Composition

Upper canopy species composition of treed polygons (Species_Upper attribute) was classified through photo-interpretation. Polygons containing tree species other than black spruce, with at least 10% cover, were traced on the stereo photos and then digitized. All other treed areas were classified as 100% black spruce.

If a secondary or lower tree or tall shrub canopy layer was distinguishable, the species composition of that layer was recorded separately (Species_Lower attribute). The lower tall shrub layer was often typed as tall shrub spp..

2.15.1.3.3 Canopy Closure

Total canopy closure was estimated to the nearest 10% for all polygons with tree species other than black spruce. If more than one canopy layer was present, separate closure values were estimated for the upper and lower layers. It should be noted that closure values for the lower canopy layer were biased since the lower canopy became increasingly obscured with increasing upper canopy closure.

2.15.1.3.4 Land Type and Ecosite Type

The ecosite classification used for ecosystem and habitat mapping was developed from soil sampling and photo-interpretation conducted in the Keeyask, LNR downstream and Wuskwatim areas. The ecosite classes reflect important ecological differences in soil properties, hydrology and permafrost. As described in Section 2.2.4.4, the peatland classes are somewhat adapted from the Canadian Wetland Classification System (National Wetlands Working Group 1997). The site and ecosite classifications used to classify soil profile samples and map polygons were developed to be compatible with each other to the extent this made ecological sense given the differences in spatial scale. Land type represented a more general grouping of different ecosite types, for example shallow and wet peatlands are grouped into "peatland". The photo-interpreted land type, broad, coarse and fine ecosite types and interpretation criteria are provided in Table 2B-3 and Table 2B-6. Ecosite types were based on dominant conditions throughout a polygon.

2.15.1.3.5 Topographic Form

Topographic form combined surface shape and topographic position. Topographic form plays an important role in ecosite development, particularly with respect to its influence on water drainage and substrate. The photo-interpreted topographic form types and interpretation criteria are provided in Table 2B-4. A total of 12 topographic forms were used. The topographic form of a particular polygon was based on dominant conditions throughout the polygon. Due to the relationship between ecosite and topography, boundaries between different topographic form types usually corresponded to boundaries between ecosite types.

2.15.1.3.6 Broad Vegetation Type

This derived variable identifies the leading vegetation species, and the degree of mixture with other types of species. For example, "black spruce mixedwood" refers to a treed stand with black spruce as the leading species, mixed with a broadleaf component greater than or equal to 30% of the canopy closure. Table 2B-5 describes the rules for assigning broad vegetation types to each polygon.

2.15.1.3.1 Vegetation Class

Vegetation class was derived by aggregating broad vegetation types into more general classes. For example, treed broad vegetation types with broadleaf species such as trembling aspen or white birch would be grouped into the vegetation class "Broadleaf Treed".

2.15.1.3.2 Broad Habitat Type

The broad habitat variable is derived by combining broad vegetation type and coarse ecosite type. The resulting value indicates the vegetation composition of a polygon, along with the type of ecosite it occurs on (e.g., black spruce on shallow peatland). This classification is more detailed than coarse habitat, and is the variable that priority habitat types are based on.

2.15.1.3.1 Coarse Habitat Type

This derived variable combines broad habitat types into more general classes. It includes the specific dominant conifer species and identifies mixedwoods, and provides a more detailed ecosite association, such as "black spruce mixedwood on shallow peatland".

2.15.1.3.2 Land Cover Type

This derived variable combines coarse habitat types into more general classes. It provides the general vegetation cover type (e.g. needleleaf treed or broadleaf treed) and the land type association, such as "peatland" or "mineral or thin peatlands". This represents the most general habitat class in the ecological land classification.

2.15.2 Habitat Relationships Studies – Data Collection

2.15.2.1 Inland Habitat

The sampling design was described in Section 2.2.4.5.1.

2.15.2.1.1 Plot Layout

Upland plots consisted of a 10 m x 20 m rectangular plot, cut into two 5 m by 20 m sections (Figure 2-39). The 20 m lines forming the long sides of the plot were marked at 5 m intervals, creating a 5 m by 5 m grid across the rectangular plot. In addition, a hexagon was formed by extending the plot 10 m out perpendicularly from the middle of each 20 m side. The hexagon was not sampled if it would extend the plot into a non-homogenous habitat, or if the number of large trees in the rectangular plot was sufficient. Each sampling component utilized different portions of the plot layout as described below.

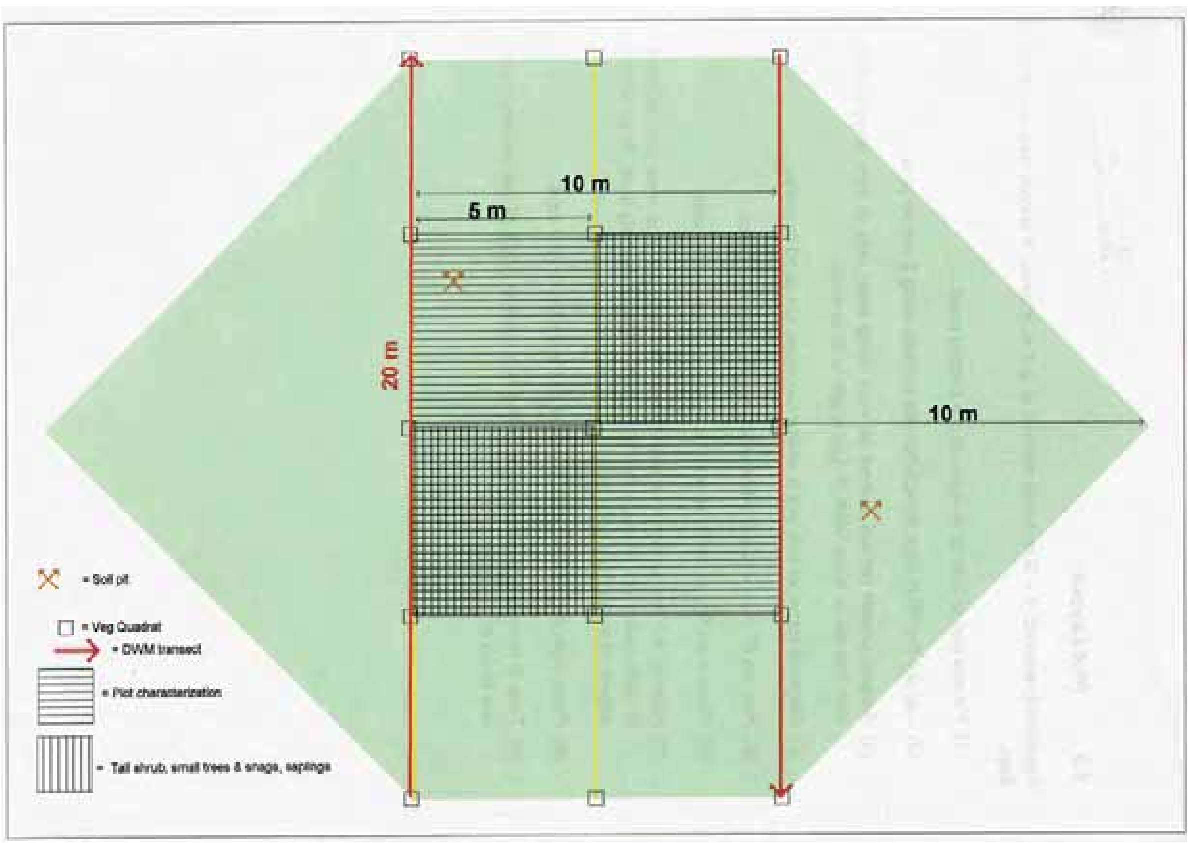

Figure 2B-1: Inland Habitat Plot Layout

2.15.2.1.2 Data Collection

Sampling components in each inland habitat plot are described below. The enumeration of trees and tall shrubs, as well as the collection of plant tissue, was done at the end of each plot, to avoid trampling understorey vegetation and small woody debris. In addition, soil sampling was done outside of the center 10 m by 10 m plot to avoid disturbing understorey vegetation and small woody debris.

Plot Characterization

Vegetation: Percent cover in the 10 m by 10 m plot was estimated for the following vegetation strata:

- Dominant and co-dominant canopy layers;
- Sub-dominant canopy layer;
- Tall shrub layer;
- Low shrub (includes low shrubs, herbs);
- Ground layer (mosses, lichens, hepatics).

Dominant/co-dominant and sub-dominant layer height was also recorded. The height of the tall shrub layer was recorded in 2003/2004 only.

Substrate: Percent cover was estimated for the 10 m by 10 m plot for each of the following ground cover classes: organic (including dead and living organic matter), buried wood, decaying wood, bedrock, rocks/cobbles/stones, mineral soil, and water. The percentages of all components added to a total of 100% substrate cover.

Preliminary Vegetation Type: Plots were classified as to their vegetation type in the field. From 2003 to 2005, preliminary vegetation type was classified according to the Forest Ecosystem Classification for Manitoba (Zoladeski *et al.* 1995), with modifications made to include vegetation classifications for the non-forest wetland plots that were sampled. For the 2010 sample year, the broad habitat type from habitat mapping was classified in the field for validation purposes.

Vegetation Plot: 7.5 m^2 sub-sample of 200 m^2

The vegetation sample unit was the entire 10 m by 20 m rectangular plot. It was sub-sampled with fifteen 0.5 m by 1.0 m quadrats. Quadrats were placed along a 5 m grid centered on the 10 m x 20 m vegetation plot, with 5 quadrats occurring along each of the three 20 m lines.

Species abundance was measured as quadrat frequency. All plants with leaf cover overhanging a quadrat were recorded. Tree species were recorded as pseudo-species, which was a combination of the species and its growth form (*i.e.* tree, sapling, seedling). If it was not possible to identify a plant due to their immaturity and/or lack of flowering parts, a voucher specimen was taken, for later identification. All spruce seedlings and saplings were recorded as *Picea mariana*, due to the difficulty in differentiating the spruce species without cones present. For bryophytes, red-stemmed feathermoss (*Pleurozium schreberi*), stair-step moss (*Hylocomium splendens*), and knight's plume moss (*Ptilium crista-castrensis*) were recorded, although all peat mosses (*Sphagnum* spp.) were grouped together. Other mosses were grouped together under a general moss taxon (moss spp.). The lichens recorded, if present, were green reindeer lichen (*Cladina mitis*), grey reindeer lichen (*Cladina rangiferina*), northern reindeer lichen (*Cladina stellaris*), club lichens (*Cladonia spp*.) and pelt lichens (*Peltigera* spp.). The presence of a tree trunk (all tree stems with a DBH) or tree snag (all standing snags with an angle to the ground >45°) was also recorded for each quadrat.

Inanimate ground cover presence in each quadrat was also recorded for rock, water, mineral soil, bare peat or woody debris. Fallen snags were counted as woody debris only where there was contact with the ground. Since litter was ubiquitous, it was only recorded as being present in the quadrat if its total cover was greater than 25%.

Downed Woody Material: 20 to 40 m transect

Downed woody material was sampled up one 20 m side of the vegetation plot and then down the far 20 m side, with the zero point for each line occurring at diagonal corners. Pieces of woody debris were tallied along each side of the plot: for 0 - 10 m, all pieces with a diameter above 1cm were counted; for 10 – 20 m, only pieces with a diameter > 7 cm were counted. Pieces < 7 cm in diameter were tallied according to their size class: 1.1 - 3.0 cm, 3.1 - 5.0 cm, and 5.1 - 7.0 cm and pieces ≥ 7 cm in diameter were tallied individually according to species, diameter, length and decay stage.

Small Snag, Small Tree, Sapling and Tall Shrubs: 50 m^2 Plot

Two diagonally positioned 5 m by 5 m squares in the center of the 10 m by 20 m tree plot (the corner of these squares met in the center of the 10 m x 20 m plot) were used to sample small trees, small snags and tall shrubs. All small snags (dead trees that were still standing, and were > 1.3 m in height but had a DBH ≤ 9 cm) were tallied, and recorded to species if possible. All trees with a DBH ≤ 9 cm were tallied by species. All saplings (tree species with no DBH, but taller than 0.5 m) and tall shrubs (stems taller than 0.5 m) were tallied by species. For tall shrubs, all individual stems were counted.

Large Tree & Large Snag Plot: 400 m^2

The 400 m^2 hexagon plot was used to sample large trees. All trees with a DBH > 9 cm were tallied according to species and size class (>9 – ≤15 cm DBH, >16 – ≤20 cm DBH, and >20 DBH). The hexagon plot was used for enumerating large trees unless there were more than stems in the 10 m by 20 m rectangular plot, in which case the large trees were only sampled in the rectangle plot.

Soils

One soil pit was sampled in a representative location outside of the center 10 m x 10 m. Several test holes were augered to select a representative location. Where possible, a soil pit depth was sampled to a depth of 100 cm. In the case of an organic soil, the soil pit was extended 20 cm into the first mineral layer, unless impenetrable frost was encountered. In these situations, as much data was recorded as possible, and the plot was revisited later in the season to determine if the frost was seasonal or permanent. If the plot was not frozen upon revisiting, the soil pit was sampled normally.

At each soil pit, pedon information was recorded for each soil pit, including thickness of LFH and organic matter, depth to permanent mottling, depth to gleying, depth to water table, depth to bedrock, depth to frost, deposit type, site type, drainage regime and moisture regime. Soil horizon data such as depth, texture and stoniness were also recorded. Soil samples were collected for all soil horizons during the initial years, and where possible, volumetric samples were collected of each mineral soil horizon. Fine ecosite type from habitat mapping was also recorded in the field during sample years 2008 to 2010.

Plant Tissue Samples

At the end of sampling in each plot, ground lichen and moss plant tissue samples were collected from within the 10 m by 20 m plot.

Tree cores were collected using an increment borer in plots with trees. Three dominant and two sub-dominant trees were cored, regardless of species. Dominant trees were defined as being the tallest trees within the 10 by 20 plot and sub-dominant trees were defined as being below the canopy of the dominant trees. In some cases, usually young stands, trees were cut using a hand saw and a cross section was collected. All samples were taken from the base of the stem, as close to the ground as possible, to ensure the oldest possible date for each tree.

In the lab, an AmScope binocular microscope with a minimum 5X magnification was used to determine the minimum age of the tree cores. A razor blade was used to prepare the cores and in cases where the pith was missing, an estimation of the number of rings to the pith was made.

2.15.2.2 Shoreline Wetland Habitat

2.15.2.3 Nelson River Shoreline Wetlands

2.15.2.3.1 Sampling Design

Shore zone wetland soils, surface water, ground water, permafrost, topography, surface materials, vegetation, vegetation age and disturbance regime were characterized for Nelson River shoreline wetlands using data collected at locations scattered throughout the Keeyask and Stephens Lake shoreline wetland study zones (Map 2.8-1).

Sample locations in the common shore material types were selected using a stratified, random sampling design. Stratification provided representation for the factors thought to influence wetland composition and dynamics at the site and waterbody levels. Shore segments within each stratum were randomly selected from the preliminary classified shoreline map. The sample location was centered in the selected shore segment. At each sampling location, data was collected along two parallel shore transects, in a willow zone plot and in an adjacent inland plot.

2.15.2.3.2 Shore Zone Transects

The two parallel shore zone transects were established 20 m apart and perpendicular to the shoreline. The origin of each transect was generally set 1 m inland from the tree line, if present, or at what appeared to be the elevation along the shore at which the surface was expected to be under water less than 5% of the open water days.

To lay out the transects, a string was attached to a survey pin placed firmly in the ground. The string was extended horizontally out over the water using a string level. The string was extended off-shore until a pre-established water depth was reached, as determined by the water regime for that shoreline wetland study zone. The water end of the horizontal string was tied to a soil auger screwed into the substrate. A measuring tape was placed on the substrate, running from the start to the end of the transect.

The height from the ground to the leveled string was measured at the origin, the end, at the waterline and at each substantial change in substrate slope. The distance along the transect was recorded wherever height was measured. These height and distance data were used to calculate water depth and substrate slope.

Plant species presence was recorded in contiguous 20 cm by 50 cm quadrats centered on the transect. The long side of the quadrat was perpendicular to the tape.

The surface substrate was classified into categories. Each substrate category was given an estimated percent cover value. Substrate at depth was classified by inserting a survey pin into the ground.

2.15.2.3.3 Willow Zone Plot

A willow zone plot was established if a band of willows (*Salix* spp.) was present on the inland side of the start of the shore transects. A 20 m tape was run between the origins of the two parallel transects to form the water side of the willow zone plot. Because the plot extended as far inland as needed to capture the entire willow band, the plot width differed within and between sample locations. A sketch was drawn of the willow zone to illustrate the overall shape and density of the tall shrub area. The percent cover of the tall shrub community and its species composition were estimated. Soil was sampled using a dutch auger in a representative location that was selected by testing multiple locations in the plot. Recorded pedon information included: thicknesses of the LFH layer, humus, and organic matter; depths to prominent mottling, gleying, water table and bedrock; and, soil texture for each mineral horizon as determined in the field by hand texturing. If ground ice that could not be hand-augered was encountered, depth to ice was noted.

2.15.2.3.4 Inland Habitat Plot

An inland habitat plot was established to provide the context for the shore zone and potential influences. Consequently, overview rather than detailed data was collected in this plot. A 10 m by 20 m plot was established inland from the shore transects and the willow zone (if present). One of the 20 m edges corresponded to the line between the starting points of the two shore zone transects. Tapes were laid out along each of the four sides.

Vegetation cover and stratum height was estimated for the dominant, sub-dominant, tall shrub, low shrub, and ground strata within the plot. Large diameter trees were tallied by DBH class (9-15 cm, 16-20 cm and >20 cm). The most frequent plant species were recorded. Frequency was estimated using an imaginary grid using the length marks on the side tapes.

Soils were sampled in a representative location using a dutch auger (hummocks and hollows were avoided). Recorded pedon information was the same as for the willow plot. In addition, moisture regime and drainage regime were determined based on the soil texture of the C horizon (for mineral soils), depth of organic horizons (for organic soils), depth to the water table and the presence of mottling/gleying in mineral horizons. Soil was also classified to Soil Order, with the exception that soils were classified as organic if the depth of the surface organic layer was greater or equal to 20 cm.

2.15.2.4 Off-System Shoreline Wetlands

For off-system shoreline wetlands, two main types of habitat relationships studies were undertaken. The primary shoreline wetlands study collected transect data using a slightly modified version of the Nelson River shoreline wetland sampling protocol. The muskrat habitat quality study focused primarily on collecting data to characterize muskrat habitat quality. The sampling protocol for this study was similar to that used for the off-system shoreline wetlands study.

2.15.2.4.1 Shoreline Wetlands

The two parallel shore zone transects were established in the same manner as for the Nelson River study with the exception that the transect extended into the water either to a depth of 1 metre, or to 5 metres past any emergent or floating-leaved vegetation with at least 5% cover, whichever was further.

Information was recorded along the transects as indicated in the Nelson River methodology. Start and stop locations of submerged vegetation were also recorded for species with a minimum of 25% cover. Any beaver, muskrat or otter sign was recorded.

A willow zone plot was established in the same manner as in the Nelson River. In place of the inland plot, general notes were made on the vegetation and soil characteristics.

2.15.2.4.2 Muskrat Ponds

The expected quality of ponds and lakes for muskrat habitat in the Regional Study Area was classified by the mammalogist. Four high quality and four low quality lakes were selected.

The shore zone of each of the selected ponds and lakes was sub-divided into segments of four classes. Major classes were optimal and unsuitable habitat for muskrats. The optimal quality segments were sub-divided into creeks and non-creek. The unsuitable quality segments were sub-divided into shallow and deep water.

For each pond or lake, two shore segments were selected from each of the above four classes, if present. A sample location was located in the center of each selected shore segment.

At each sample location, two replicate transects were established in a similar manner to that for the Nelson River shoreline wetland study with two exceptions. The transect origin was located 3 metres inland from the inland edge or tall shrub band, but not more than 50 metres from the water’s edge. The transects extended a distance of 25 metres into the water from the water’s edge.

Terrestrial vegetation and substrate type were recorded in the same manner as the Nelson River shore zone. Submergent vegetation was recorded according to the off-system shore zone methodology.

Willow zone or inland habitat plots were not established for the muskrat ponds. Soil texture was sampled with a dutch auger at the start of the transects and at the water’s edge, as well as any location along where there was a change in vegetation. Beyond the water line, soils were sampled to a maximum depth of 50 cm, or 20 cm into the mineral layer. Soil samples were taken every five metres until 25 metres (transect end) was reached.

APPENDIX 2C
DETAILED RESULTS FOR OVERVIEW OF HABITAT AND ECOSYSTEMS

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2.16 APPENDIX 2C: DETAILED RESULTS FOR OVERVIEW OF HABITAT AND ECOSYSTEMS

2.16.1 Inland Habitat

Table 2C-1: Percentage Distribution of Vegetation Structure Types Across Coarse Ecosite Types in Study Zone 4

Vegetation Structure Type	Mineral	Thin peatland	Shallow peatland	Ground ice peatland	Permafrost peatland- other	Deep peatland	Wet deep peatland	Riparian Peatland	Ice Scoured Upland	Shoreline Wetland	Shoreline Wetland - regulated	Total area in type (ha)
Forest	35.2	31.2	21.5	9.1	0.2	2.1	0.0	0.7	-	-	-	*25,692*
Forest/ tall shrub	56.1	6.1	26.8	2.1	1.0	5.8	-	2.1	-	-	-	*89*
Woodland	10.4	49.3	22.1	15.3	0.2	2.1	-	0.6	-	-	-	*54,754*
Woodland/ tall shrub	52.0	35.3	10.7	0.6	-	0.7	-	0.7	-	-	-	*1,894*
Sparsely treed	4.2	35.8	28.6	18.4	0.2	10.7	0.1	2.1	-	-	-	*17,604*
Sparsely treed/ tall shrub	14.1	51.0	18.2	5.3	0.1	4.8	-	6.5	-	-	-	*964*
Woodland & sparsely treed mixture	2.1	38.5	36.7	18.0	0.4	3.7	-	0.5	-	-	-	*30,463*
Woodland & sparsely treed mixture/ tall shrub	-	10.8	45.2	4.9	-	36.7	-	2.3	-	-	-	*65*
Tall shrub	2.4	9.6	16.3	5.1	0.1	8.0	-	33.7	-	-	24.8	*2,625*
Tall shrub/ low vegetation mixture	-	-	-	-	-	-	-	15.5	21.2	-	63.4	*577*
Low vegetation	2.6	27.6	21.6	24.6	1.1	9.2	0.0	12.2	-	-	1.0	*24,687*
Emergent	-	-	-	-	-	-	-	-	-	92.6	7.4	*209*

Table 2C-2: Topographic Form Composition in the Project Study Zones as a Percentage of Land Area

Topography Type	Estimated Study Zone 5	Study Zone 4	Study Zone 2
Ridge/ Crest	11.0	11.1	18.8
Slope	41.8	42.1	45.8
Bank	0.1	0.1	
Beach	0.0	0.0	0.0
Horizontal	35.3	34.9	27.2
Horizontal- raised	1.0	1.0	2.1
Dissected	0.4	0.4	
Hummocky	0.1	0.1	
Ravine	0.2	0.2	
Runnel	3.8	3.8	2.5
Depression	6.3	6.2	3.6
Basin (pit/ hole)	0.0	0.0	0.0
Total land area (ha)	*1,239,328*	*167,255*	*13,043*

Table 2C-3: Broad Ecosite Composition in the Project Study Zones as a Percentage of Land Area

Broad Ecosite Type	Estimated Study Zone 5	Study Zone 4	Study Zone 2
Mineral	11.5	11.7	18.7
Thin peatland	39.1	38.8	39.7
Shallow peatland	25.0	24.7	20.0
Ground ice peatland	16.2	15.9	11.8
Wet peatland	4.9	4.8	2.6
Riparian Peatland	3.1	3.1	4.0
Ice Scoured Upland	0.0	0.1	1.0
Upper beach- regulated	0.1	0.6	1.4
Sunken peat- regulated	0.0	0.1	0.7
Lower beach- regulated	0.0	0.0	0.1
Upper beach	0.0	0.1	0.1
Lower beach	0.0	0.0	0.0
Littoral	0.0	0.0	0.0
Total land area (ha)	*1,239,328*	*167,255*	*13,043*

Table 2C-4: Percentage Distribution of Broad Ecosite Types Across Topography Types

Broad Ecosite Type	Topography Type*							Total area in type (ha)
	Ridge / Crest	Slope	Horizontal	Horizontal- raised	Dissected	Runnel	Depression	
Mineral	89.4	5.8	1.6	0.0		0.0	0.0	*19,517*
Thin peatland	1.7	98.3	0.0			0.0	0.0	*64,857*
Shallow peatland	0.2	9.8	78.1	1.9	1.8	6.5	1.7	*41,388*
Ground ice peatland		0.0	75.1	3.0		1.2	20.7	*26,650*
Wet peatland	0.0	0.0	38.6	0.6	0.0	15.8	44.9	*8,043*
Riparian Peatland	0.0	0.1	49.5	0.3		39.1	10.9	*5,173*
Ice Scoured Upland		100.0						*129*
Upper beach- regulated		100.0						*1,018*
Sunken peat- regulated		100.0						*247*
Lower beach- regulated		100.0						*11*
Upper beach		100.0						*94*
Lower beach		100.0						*18*
Littoral			100.0					*81*

* Not all types are shown. Cells in a row add to approximately 100% after rounding. Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 2C-5: Percentage Distribution of Coarse Ecosite Types Within Topography Types

Broad Ecosite Type	Topography Type*						
	Ridge/ Crest	Slope	Horizontal	Horizontal- raised	Dissected	Runnel	Depression
Mineral	93.6	1.6	0.5	0.4	-	0.1	0.0
Thin peatland	5.9	90.5	0.0		-	0.0	0.0
Shallow peatland	0.5	5.8	55.3	47.6	100.0	42.6	6.7
Ground ice peatland	-	0.0	34.3	48.2	-	5.0	53.1
Wet peatland	0.0	0.0	5.3	2.8	0.0	20.2	34.7
Riparian Peatland	0.0	0.0	4.4	1.0	-	32.1	5.4
Ice Scoured Upland	-	0.2	-	-	-	-	-
Upper beach- regulated	-	1.4	-	-	-	-	-
Sunken peat- regulated	-	0.4	-	-	-	-	-
Lower beach- regulated	-	0.0	-	-	-	-	-
Upper beach	-	0.1	-	-	-	-	-
Lower beach	-	0.0	-	-	-	-	-
Littoral	-	-	0.1	-	-	-	-
Total land area (ha)	*18,643*	*70,474*	*58,385*	*1,657*	*738*	*6,300*	*10,399*

* Not all types are shown, totals reflect only the types present. Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 2C-6: Broad Vegetation Type Composition in the Project Study Zones as a Percentage of Vegetated Area

Broad Vegetation Type	Estimated Study Zone 5	Study Zone 4	Study Zone 2
BA Mixedwood	0.0	0.0	-
BA Mixture	0.0	0.0	0.0
BA Pure	0.0	0.0	0.0
TA Mixedwood	0.2	0.2	0.8
TA Mixedwood/ Tall Shrub	0.2	0.2	0.1
TA Mixture	0.2	0.2	0.4
TA Mixture/ Tall Shrub	0.0	0.0	0.0
TA Pure	0.0	0.0	0.1
TA Pure/ Tall Shrub	0.3	0.3	0.7
WB Mixedwood	0.0	0.0	0.3
WB Mixedwood/ Tall Shrub	0.0	0.0	0.0
WB Mixture	0.0	0.0	0.2
WB Pure	0.0	0.0	-
WB Pure/ Tall Shrub	0.0	0.0	0.0
JP Mixedwood	0.2	0.2	0.3
JP Mixedwood/ Tall Shrub	0.1	0.1	0.3
JP Mixture	0.9	0.9	1.8
JP Mixture/ Tall Shrub	0.6	0.6	0.9
JP Pure	0.2	0.2	0.1
JP Pure/ Tall Shrub	0.1	0.1	0.2
BS Mixedwood	0.3	0.3	0.3
BS Mixedwood/ Tall Shrub	0.1	0.1	-
BS Mixture	2.1	2.0	6.3
BS Mixture/ Tall Shrub	0.1	0.1	0.1
BS Pure	74.7	73.2	60.8
BS Pure/ Tall Shrub	0.3	0.3	0.4
TL Mixedwood	0.0	0.0	-
TL Mixture	1.5	1.5	1.9
TL Mixture/ Tall Shrub	0.0	0.0	0.0
TL Pure	0.3	0.2	0.1
TL Pure/ Tall Shrub	0.0	0.0	0.0
Tall Shrub	1.3	1.6	3.3
Shrub/Low Veg Mixture	0.1	0.3	1.9
Low Vegetation	14.9	14.8	12.5
Emergent	0.0	0.1	0.2
Emergent Island	0.0	0.0	0.0
Young Regeneration	0.5	0.5	0.0
Human	0.9	2.0	6.1
Total land area (ha)	*1,239,328*	*167,255*	*13,043*

Table 2C-6: Broad Vegetation Type Composition in the Project Study Zones as a Percentage of Vegetated Area

Broad Vegetation Type	Estimated Study Zone 5	Study Zone 4	Study Zone 2

* Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.
** BA= balsam poplar; TA=trembling aspen; WB=white birch; JP=jack pine; BS=black spruce; TL=tamarack.

Table 2C-7: Percentage Distribution of Broad Vegetation Types Across Coarse Ecosite Types

Broad Vegetation Type	Mineral	Thin peatland	Shallow peatland	Ground ice peatland	Permafrost peatland-other	Deep peatland	Wet deep peatland	Riparian Peatland	Ice Scoured Upland	Shoreline Wetland	Shoreline Wetland - regulated	Total area in type (ha)
BA Mixedwood	-	41.2	58.8	-	-	-	-	-	-	-	-	*1*
BA Mixture	56.8	2.4	40.8	-	-	-	-	-	-	-	-	*1*
BA Pure	100.0	-	-	-	-	-	-	-	-	-	-	*1*
TA Mixedwood	78.1	11.9	7.2	2.8	-	-	-	-	-	-	-	*404*
TA Mixedwood/ Tall Shrub	16.9	73.6	9.5	-	-	-	-	-	-	-	-	*347*
TA Mixture	74.7	14.1	8.8	2.3	-	-	-	-	-	-	-	*275*
TA Mixture/ Tall Shrub	60.8	16.0	23.2	-	-	-	-	-	-	-	-	*16*
TA Pure	62.9	24.6	12.5	-	-	-	-	-	-	-	-	*70*
TA Pure/ Tall Shrub	37.1	50.4	12.5	-	-	-	-	-	-	-	-	*544*
WB Mixedwood	66.2	10.6	15.3	7.9	-	-	-	-	-	-	-	*52*
WB Mixedwood/ Tall Shrub	-	1.7	98.3	-	-	-	-	-	-	-	-	*5*
WB Mixture	72.4	12.5	-	11.0	-	-	-	4.0	-	-	-	*36*
WB Pure	-	-	-	93.2	-	-	-	6.8	-	-	-	*13*
WB Pure/ Tall Shrub	-	-	-	92.0	-	8.0	-	-	-	-	-	*21*
JP Mixedwood	71.6	23.1	5.2	-	-	-	-	-	-	-	-	*253*
JP Mixedwood/ Tall Shrub	43.9	36.9	19.2	-	-	-	-	-	-	-	-	*219*
JP Mixture	70.9	27.4	1.7	0.0	-	-	-	-	-	-	-	*1,481*
JP Mixture/ Tall Shrub	68.8	26.9	4.3	-	-	-	-	-	-	-	-	*992*
JP Pure	72.2	24.7	3.1	-	-	-	-	-	-	-	-	*336*
JP Pure/ Tall Shrub	17.1	76.6	6.3	-	-	-	-	-	-	-	-	*113*

Table 2C-7: Percentage Distribution of Broad Vegetation Types Across Coarse Ecosite Types

Broad Vegetation Type	Mineral	Thin peatland	Shallow peatland	Ground ice peatland	Permafrost peatland-other	Deep peatland	Wet deep peatland	Riparian Peatland	Ice Scoured Upland	Shoreline Wetland	Shoreline Wetland - regulated	Total area in type (ha)
BS Mixedwood	85.0	10.9	4.1	-	-	-	-	-	-	-	-	*445*
BS Mixedwood/ Tall Shrub	17.8	63.7	18.5	-	-	-	-	-	-	-	-	*102*
BS Mixture	35.2	29.3	21.4	7.0	0.2	6.5	-	0.5	-	-	-	*3,377*
BS Mixture/ Tall Shrub	47.1	38.7	11.6	-	-	0.1	-	2.5	-	-	-	*136*
BS Pure	10.2	43.2	27.1	15.9	0.2	2.5	0.0	0.8	-	-	-	*122,399*
BS Pure/ Tall Shrub	4.2	17.6	37.1	9.4	0.4	16.2	-	15.1	-	-	-	*507*
TL Mixedwood	-	98.8	1.2	-	-	-	-	-	-	-	-	*7*
TL Mixture	5.6	15.9	18.3	8.1	0.5	50.1	-	1.5	-	-	-	*2,436*
TL Mixture/ Tall Shrub	-	16.8	43.0	-	-	33.5	-	6.7	-	-	-	*4*
TL Pure	9.4	5.7	12.1	8.5	0.3	61.5	-	2.5	-	-	-	*417*
TL Pure/ Tall Shrub	-	2.8	53.0	-	-	43.1	-	1.1	-	-	-	*11*
Tall Shrub	2.4	9.6	16.3	5.1	0.1	8.0	-	33.7	-	-	24.8	*2,625*
Shrub/Low Veg Mixture	-	-	-	-	-	-	-	15.5	21.2	-	63.4	*577*
Low Vegetation	2.6	27.6	21.6	24.6	1.1	9.2	0.0	12.2	-	-	1.0	*24,687*
Emergent	-	-	-	-	-	-	-	-	-	87.9	12.1	*127*
Emergent Island	-	-	-	-	-	-	-	-	-	100.0	-	*81*

* Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.
** BA= balsam poplar; TA=trembling aspen; WB=white birch; JP=jack pine; BS=black spruce; TL=tamarack.

Table 2C-8: Broad Vegetation Type as a Percentage of Forest Area in the Study Zones

Forest Broad Vegetation Type	Estimated Study Zone 5	Study Zone 4	Study Zone 2
BA Mixedwood	0.0	0.0	-
BA Mixture	0.0	0.0	0.0
BA Pure	0.0	0.0	-
TA Mixedwood	0.7	0.7	2.5
TA Mixedwood/ Tall Shrub	0.1	0.1	-
TA Mixture	0.5	0.5	1.9
TA Mixture/ Tall Shrub	0.0	0.0	0.1
TA Pure	0.1	0.1	0.1
WB Mixedwood	0.2	0.2	1.3
WB Mixture	0.0	0.0	0.3
WB Pure	0.0	0.0	-
JP Mixedwood	0.3	0.3	0.2
JP Mixture	1.6	1.6	2.0
JP Mixture/ Tall Shrub	0.1	0.1	0.0
JP Pure	0.2	0.2	0.1
BS Mixedwood	0.8	0.8	0.7
BS Mixture	5.6	5.6	16.9
BS Mixture/ Tall Shrub	0.0	0.0	-
BS Pure	87.9	87.9	70.3
BS Pure/ Tall Shrub	0.1	0.1	0.0
TL Mixture	1.6	1.6	3.6
TL Mixture/ Tall Shrub	0.0	0.0	-
TL Pure	0.1	0.1	0.0
TL Pure/ Tall Shrub	0.0	0.0	-
Total forested area (ha)	*194,869*	*25,781*	*2,576*

* Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.
** BA= balsam poplar; TA=trembling aspen; WB=white birch; JP=jack pine; BS=black spruce; TL=tamarack.

Table 2C-9: Percentage Distribution of Forest Broad Vegetation Types Across Coarse Ecosite Types

Forest Broad Vegetation Type	Coarse Ecosite Type								Total area in type (ha)
	Mineral	Thin peatland	Shallow peatland	Ground ice peatland	Permafrost peatland-other	Deep peatland	Wet deep peatland	Riparian Peatland	
BA Mixedwood	-	23.9	76.1	-	-	-	-	-	*1*
BA Mixture	95.9	4.1	-	-	-	-	-	-	*1*
BA Pure	100.0	-	-	-	-	-	-	-	*1*
TA Mixedwood	80.3	9.3	4.8	5.6	-	-	-	-	*173*
TA Mixedwood/ Tall Shrub	97.8	2.2	-	-	-	-	-	-	*22*
TA Mixture	83.4	12.1	3.5	1.0	-	-	-	-	*122*
TA Mixture/ Tall Shrub	100.0	-	-	-	-	-	-	-	*3*
TA Pure	73.0	15.6	11.4	-	-	-	-	-	*34*
WB Mixedwood	75.4	10.0	6.5	8.1	-	-	-	-	*46*
WB Mixture	87.2	12.8	-	-	-	-	-	-	*10*
WB Pure	-	-	-	95.2	-	-	-	4.8	*3*
JP Mixedwood	80.5	11.9	7.6	-	-	-	-	-	*75*
JP Mixture	85.3	12.7	2.0	-	-	-	-	-	*419*
JP Mixture/ Tall Shrub	99.5	0.5	-	-	-	-	-	-	*23*
JP Pure	82.9	13.3	3.8	-	-	-	-	-	*58*
BS Mixedwood	90.8	6.2	3.0	-	-	-	-	-	*206*
BS Mixture	38.2	26.8	23.8	8.2	0.1	2.3	-	0.5	*1,450*
BS Mixture/ Tall Shrub	-	50.6	20.3	-	-	-	-	29.1	*3*
BS Pure	33.0	32.5	22.0	9.5	0.2	2.1	0.0	0.8	*22,667*
BS Pure/ Tall Shrub	7.5	9.3	57.1	5.9	3.0	14.0	-	3.1	*31*
TL Mixture	10.7	30.2	37.6	8.3	0.0	11.0	-	2.2	*410*
TL Mixture/ Tall Shrub	-	9.4	53.1	-	-	37.6	-	-	*2*
TL Pure	32.1	6.0	20.0	28.8	-	9.6	-	3.5	*16*
TL Pure/ Tall Shrub	-	3.3	95.3	-	-	0.7	-	0.6	*5*

* Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.
** BA= balsam poplar; TA=trembling aspen; WB=white birch; JP=jack pine; BS=black spruce; TL=tamarack.

Table 2C-10: Predicted composition of habitat lost in Study Zone 4 to ongoing shoreline erosion without project between 2006 and 2047

Coarse Habitat Type	Broad Habitat Type	Erosion in Zone 4 to Year 30 Without Project
Broadleaf treed on all ecosites	Trembling aspen dominant on all ecosites	0.7
	White birch dominant on all ecosites	0.1
Broadleaf mixedwood on all ecosites	Trembling aspen mixedwood on all ecosites	1.3
Black spruce mixedwood on mineral or thin peatland	Black spruce mixedwood on mineral	0.2
	Black spruce mixedwood on thin peatland	0.0
Black spruce treed on mineral soil	Black spruce dominant on mineral	19.4
	Black spruce mixture on mineral	5.9
Black spruce treed on thin peatland	Black spruce dominant on thin peatland	9.4
Black spruce treed thin peatland	Black spruce mixture on thin peatland	0.1
Jack pine mixedwood on mineral or thin peatland	Jack pine mixedwood on mineral	0.3
Jack pine treed on mineral or thin peatland	Jack pine dominant on mineral	0.0
	Jack pine mixture on thin peatland	0.1
Tall shrub on mineral or thin peatland	Tall shrub on mineral	0.3
	Tall shrub on thin peatland	0.1
Low vegetation on mineral or thin peatland	Low vegetation on mineral	0.2
	Low Vegetation on thin peatland	2.7
Black spruce treed on riparian peatland	Black spruce dominant on riparian peatland	0.1
Black spruce treed on shallow peatland	Black spruce dominant on ground ice peatland	0.3
	Black spruce dominant on shallow peatland	8.5
Black spruce treed on wet peatland	Black spruce dominant on wet peatland	0.0
Tamarack treed on shallow peatland	Tamarack mixture on ground ice peatland	0.0
Low vegetation on shallow peatland	Low vegetation on ground ice peatland	1.0
	Low vegetation on shallow peatland	0.2
Low vegetation on wet peatland	Low vegetation on wet peatland	0.0
Tall shrub on riparian peatland	Tall shrub on riparian peatland	13.8
Low vegetation on riparian peatland	Low vegetation on riparian peatland	2.8
Nelson River shrub and/or low vegetation on ice scoured upla	Shrub/Low veg mixture on ice scoured upland	25.4
Nelson River shrub and/or low vegetation on upper beach	Shrub/Low Veg Mixture on Upper beach-regulated	0.0
Nelson River shrub and/or low vegetation on sunken peat	Low vegetation on upper beach- regulated	0.8
	Tall Shrub on upper beach- regulated	3.9
Nelson River marsh	Emergent on lower beach- regulated	0.0
Human Infrastructure		2.3
Total land area (ha)		*91*

Table 2C-11: Percentage Distribution of Coarse Habitat Types Across the Project Footprints and Their Habitat Zone of Influence During Construction*

Land Cover Type	Coarse Habitat Type	Infra-structure	Road & Road Corridor	Camp & Work Area	Borrow Areas	Reservoir	EMPA	River Management	Flooding	PDA	Mitigation Area	Altered Water Levels	Project Footprint Total	ZOI Construction	All
Broadleaf treed on all ecosites	Broadleaf treed on all ecosites	9.8	5.7	0.0	28.8	12.6	10.4	-	0.3	10.3	1.3	-	79.2	20.8	154
	Broadleaf mixedwood on all ecosites	-	0.3	-	40.5	20.4	0.1	-	0.5	3.1	2.0	-	66.8	33.2	100
Needleleaf treed on mineral or thin peatland	Black spruce mixedwood on mineral or thin peatland	1.4	13.0	-	6.7	17.9	1.1	-	0.6	7.7	4.8	-	53.2	46.8	24
	Jack pine mixedwood on mineral or thin peatland	6.9	0.0	4.2	38.1	0.1	-	-	-	9.8	-	-	59.2	40.8	44
	Jack pine treed on mineral or thin peatland	4.4	3.5	0.2	42.3	2.1	4.5			5.3	2.3		64.6	35.4	262
	Black spruce treed on mineral soil	3.5	3.2		27.4	21.3	1.8	0.2	0.7	6.8	3.8	0.2	68.9	31.1	1,100
	Black spruce treed on thin peatland	2.7	7.2	0.0	20.2	34.5	2.0	0.2	0.4	5.5	1.8	0.0	74.4	25.6	2,845
Tall shrub on mineral or thin peatland	Tall shrub on mineral or thin peatland	1.3	10.0	-	12.3	18.1	21.8	-	4.6	9.8	0.1	-	77.9	22.1	63
Low vegetation on mineral or thin peatland	Low vegetation on mineral or thin peatland	8.8	8.6	0.0	22.7	12.0	9.9	0.1	1.1	12.1	0.2	0.0	75.7	24.3	326
Needleleaf treed on other peatlands	Jack pine treed on shallow peatland	-	1.1	-	0.4	-	-	-	-	-	-	-	1.4	98.6	6
	Black spruce mixedwood on shallow peatland	-	1.1	-	-	33.5	6.9	-	-	21.9	-	-	63.4	36.6	3
	Black spruce treed on shallow peatland	1.4	2.7	0.1	9.0	56.8	2.3	0.1	1.1	6.3	1.1	-	80.8	19.2	2,328
	Black spruce treed on wet peatland	0.5	10.3		7.3	61.3	0.0	-	1.3	2.7	0.0	-	83.5	16.5	90
	Tamarack- black spruce mixture on wet peatland	0.3	5.4	-	-	73.2	-	-	-	5.8	-	-	84.7	15.3	26
	Tamarack treed on shallow peatland	0.9	13.1	-	4.8	55.8	0.0	-	0.5	1.8	0.2	-	77.2	22.8	67
	Tamarack treed on wet peatland	-	-	-	-	80.1	-	-	-	3.4	-	-	83.6	16.4	2
	Black spruce treed on riparian peatland	0.0	3.1	-	0.0	65.5	0.6	-	4.3	8.5	-	-	82.0	18.0	33
	Tamarack- black spruce mixture on riparian peatland	-	0.0	-	-	83.1	-	-	-	2.8	-	-	85.9	14.1	1
Tall shrub on other peatlands	Tall shrub on shallow peatland	2.9	2.6	-	-	38.0	0.1	-	9.4	10.6	0.3	-	63.7	36.3	23
	Tall shrub on wet peatland	-	-	-	-	81.2	-	-	4.0	3.3	-	-	88.5	11.5	29
Low vegetation on other peatlands	Low vegetation on shallow peatland	4.3	2.5	0.3	10.3	47.0	7.5	0.0	1.9	7.0	0.2	-	81.1	18.9	524
	Low vegetation on wet peatland	0.6	4.6	-		75.6	0.0	0.1	1.5	2.3	2.5	-	87.1	12.9	112
Shrub/ low vegetation on riparian peatland	Tall shrub on riparian peatland	0.1	0.5	-	0.0	42.2	0.3	0.0	37.2	14.6	0.6	1.4	96.8	3.2	221
	Low vegetation on riparian peatland	0.1	2.1	-	0.1	67.0	0.4	-	15.9	4.8	0.3	0.0	90.6	9.4	190
Nelson River shore zone	Nelson River shrub and/or low vegetation on ice scoured upland	11.6	1.1	-	7.1	30.7	7.6	1.1	8.9	17.6	-	3.9	89.6	10.4	121
	Nelson River shrub and/or low vegetation on upper beach	-	0.0	-	2.8	7.5	0.2	0.1	46.9	29.2	0.5	1.6	88.7	11.3	165
	Nelson River shrub and/or low vegetation on sunken peat	-	7.0	-	16.0	-	15.7	0.0	-	0.8	-	0.0	39.4	60.6	45
	Nelson River marsh	-	-	-	-	0.0	-	-	46.8	53.2	-	-	100.0	0.0	11
Off-system shore zone	Off-system marsh	0.3	-	-	-	73.7	0.2	-	11.5	3.7	0.0	-	89.4	10.6	9

Note: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 2C-12: Percentage Distribution of Coarse Habitat Types Within Features of the Infrastructure Footprint Type During Construction

Land Cover Type	Coarse Habitat Type	Dam	Dyke	Powerhouse	Parking Lot and Ramp	Ditch	Ramp	Rock Groin	Transmission Tower Spur	Intake Channel	Tailrace Channel	Disturbed Area	Total
Broadleaf treed on all ecosites	Broadleaf treed on all ecosites	-	6.7	-	-	6.5	-	-	-	-	-	7.4	6.1
	Broadleaf mixedwood on all ecosites	-	-	-	-	-	-	-	-	-	-	-	-
Needleleaf treed on mineral or thin peatland	Black spruce mixedwood on mineral or thin peatland	-	0.1	-	-	-	-	-	-	-	-	0.2	0.1
	Jack pine mixedwood on mineral or thin peatland	-	0.9	-	-	2.2	-	-	-	-	-	1.7	1.3
	Jack pine treed on mineral or thin peatland	-	4.6	-	-	4.5	-	-	-	-	-	6.1	4.7
	Black spruce treed on mineral soil	6.6	17.7	3.8	84.8	13.0	2.8	-	-	-	14.3	16.9	15.6
	Black spruce treed on thin peatland	16.8	31.3	-	0.6	23.5	96.4	-	-	69.1	-	30.4	30.8
Tall shrub on mineral or thin peatland	Tall shrub on mineral or thin peatland	-	-	-	-	1.0	-	-	-	-	-	0.5	0.3
Low vegetation on mineral or thin peatland	Low vegetation on mineral or thin peatland	6.9	13.1	-	7.8	10.1	0.8	-	-	1.3	1.4	13.0	11.7
Needleleaf treed on other peatlands	Jack pine treed on shallow peatland	-	-	-	-	-	-	-	-	-	-	-	-
	Black spruce mixedwood on shallow peatland	-	-	-	-	-	-	-	-	-	-	-	-
	Black spruce treed on shallow peatland	10.0	13.9	-	-	24.1	-	-	-	6.4	-	12.5	13.4
	Black spruce treed on wet peatland	-	0.3	-	-	0.2	-	-	-	-	-	0.2	0.2
	Tamarack- black spruce mixture on wet peatland	-	-	-	-	0.3	-	-	-	-	-	-	0.0
	Tamarack treed on shallow peatland	-	0.4	-	-	0.3	-	-	-	-	-	0.2	0.2
	Tamarack treed on wet peatland	-	-	-	-	-	-	-	-	-	-	-	-
	Black spruce treed on riparian peatland	-	-	-	-	0.1	-	-	-	-	-	-	0.0
	Tamarack- black spruce mixture on riparian peatland	-	-	-	-	-	-	-	-	-	-	-	-
Tall shrub on other peatlands	Tall shrub on shallow peatland	-	0.4	-	-	0.1	-	-	-	-	-	0.3	0.3
	Tall shrub on wet peatland	-	-	-	-	-	-	-	-	-	-	-	-
Low vegetation on other peatlands	Low vegetation on shallow peatland	0.3	10.5	-	-	11.7	-	-	-	0.1	-	10.4	9.2
	Low vegetation on wet peatland	-	0.1	-	-	1.9	-	-	-	-	-	0.1	0.3
Shrub/ low vegetation on riparian peatland	Tall shrub on riparian peatland	0.8	-	-	-	-	-	-	-	-	-	-	0.0
	Low vegetation on riparian peatland	-	-	-	-	0.4	-	-	-	-	-	0.1	0.1
Nelson River shore zone	Nelson River shrub and/or low vegetation on ice scoured upland	58.6	0.0	96.2	6.8	-	-	100.0	100.0	23.1	84.3	0.1	5.7
	Nelson River shrub and/or low vegetation on upper beach	-	-	-	-	-	-	-	-	-	-	-	-
	Nelson River shrub and/or low vegetation on sunken peat	-	-	-	-	-	-	-	-	-	-	-	-
	Nelson River marsh	-	-	-	-	-	-	-	-	-	-	-	-
Off-system shore zone	Off-system marsh	-	-	-	-	0.1	-	-	-	-	-	-	0.0
Total habitat area (ha)		*15*	*83*	*1*	*1*	*23*	*1*	*0*	*0*	*11*	*2*	*109*	*246*

Note: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 2C-13: Percentage Distribution of Coarse Habitat Types Within Features of the Road and Road Corridor Footprint Types During Construction

Land Cover Type	Coarse Habitat Type	Road Footprint										Road Corridor Footprint			
		Haul Road	Haul Road ROW	Haul Roads - Causeway	North Access Road	Potential Boat Launch Infrastructure	Potential Portage Routes	Road - South Access Road	Road - Perm	Road-Temp	Total Road	Road Corridor	Haul Road Corridor	Road - Ice Boom Preferred Route Corridor	Total Road Corridor
Broadleaf treed on all ecosites	Broadleaf treed on all ecosites	1.0	8.1	-	-	-	-	0.2	3.3	-	0.8	7.8	1.3	19.8	9.1
	Broadleaf mixedwood on all ecosites	1.1	-	-	-	-	-	-	-	-	0.1	-	-	-	-
Needleleaf treed on mineral or thin peatland	Black spruce mixedwood on mineral or thin peatland	2.5	-	-	-	-	-	0.6	-	-	0.7	-	2.8	-	1.1
	Jack pine mixedwood on mineral or thin peatland	-	-	-	0.4	-	-	-	-	-	0.0	-	-	-	-
	Jack pine treed on mineral or thin peatland	5.8	-	-	30.9	-	83.2	0.5	2.7	-	1.0	-	5.5	20.9	8.6
	Black spruce treed on mineral soil	10.9	0.4	14.3	3.7	-	-	8.8	2.8	32.5	8.5	1.1	13.4	10.6	9.0
	Black spruce treed on thin peatland	36.7	28.8	14.6	24.8	-	-	60.0	20.4	-	54.3	28.6	39.9	19.5	29.8
Tall shrub on mineral or thin peatland	Tall shrub on mineral or thin peatland	3.9	11.5	-	-	-	-	0.2	-	-	1.2	4.3	5.0	-	3.2
Low vegetation on mineral or thin peatland	Low vegetation on mineral or thin peatland	10.5	22.4	-	8.4	1.2	16.8	2.5	13.6	1.8	4.5	25.5	8.3	25.1	18.9
Needleleaf treed on other peatlands	Jack pine treed on shallow peatland	-	-	-	0.8	-	-	-	-	-	0.0	-	0.2	-	0.1
	Black spruce mixedwood on shallow peatland	0.0	-	-	-	-	-	-	-	-	0.0	-	0.1	-	0.0
	Black spruce treed on shallow peatland	15.7	21.7	29.9	16.3	-	-	14.7	16.4	-	15.7	24.7	14.8	1.3	13.5
	Black spruce treed on wet peatland	-	-	-	-	-	-	3.4	-	-	2.7	-	-	-	-
	Tamarack- black spruce mixture on wet peatland	-	-	-	-	-	-	0.5	-	-	0.4	-	-	-	-
	Tamarack treed on shallow peatland	3.1	1.1	-	-	-	-	2.4	-	-	2.2	1.8	3.3	-	1.8
	Tamarack treed on wet peatland	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Black spruce treed on riparian peatland	-	0.0	-	-	-	-	0.4	-	-	0.3	0.3	-	-	0.1
	Tamarack- black spruce mixture on riparian peatland	-	-	-	0.0	-	-	-	-	-	0.0	-	-	-	-
Tall shrub on other peatlands	Tall shrub on shallow peatland	-	-	-	0.9	-	-	-	-	-	0.0	-	-	2.7	0.9
	Tall shrub on wet peatland	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Low vegetation on other peatlands	Low vegetation on shallow peatland	7.4	5.9	5.9	13.2	-	-	2.5	3.1	-	3.3	5.8	4.0	0.0	3.4
	Low vegetation on wet peatland	-	-	-	-	-	-	1.9	0.6	-	1.5	-	-	-	-
Shrub/ low vegetation on riparian peatland	Tall shrub on riparian peatland	-	-	-	0.6	98.8	-	0.3	0.0	31.4	0.3	-	-	-	-
	Low vegetation on riparian peatland	1.3	-	-	-	-	-	1.2	-	-	1.1	-	1.3	-	0.5
Nelson River shore zone	Nelson River shrub and/or low vegetation on ice scoured upland	0.0	-	-	-	-	-	-	34.9	34.3	0.4	-	0.1	-	0.1
	Nelson River shrub and/or low vegetation on upper beach	-	-	-	-	-	-	-	2.1	-	0.0	-	-	-	-
	Nelson River shrub and/or low vegetation on sunken peat	-	-	35.3	-	-	-	-	-	-	0.9	-	-	-	-
	Nelson River marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Off-system shore zone	Off-system marsh	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total habitat area (ha)	*27*	*23*	*9*	*1*	*0*	*0*	*275*	*3*	*0*	*338*	*21*	*25*	*21*	*67*

Note: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 2C-14: Percentage Distribution of Coarse Habitat Types Within Features of the Borrow Area Footprint Type During Construction

Land Cover Type	Coarse Habitat Type	Borrow - Rock	Borrow - Granular	Borrow - Impervious	Borrow - Impervious Area to Avoid	Total
Broadleaf treed on all ecosites	Broadleaf treed on all ecosites	-	0.0	2.2	39.7	3.0
	Broadleaf mixedwood on all ecosites	6.4	0.0	1.0	46.1	2.8
Needleleaf treed on mineral or thin peatland	Black spruce mixedwood on mineral or thin peatland	-	-	0.2	-	0.1
	Jack pine mixedwood on mineral or thin peatland	-	4.6	-	-	1.2
	Jack pine treed on mineral or thin peatland	12.5	22.3	2.2	-	7.6
	Black spruce treed on mineral soil	11.2	38.7	14.8	14.2	20.6
	Black spruce treed on thin peatland	38.7	27.9	45.7	-	39.2
Tall shrub on mineral or thin peatland	Tall shrub on mineral or thin peatland	-	0.2	0.7	0.0	0.5
Low vegetation on mineral or thin peatland	Low vegetation on mineral or thin peatland	0.1	0.9	7.2	0.0	5.1
Needleleaf treed on other peatlands	Jack pine treed on shallow peatland	0.0	-	-	-	0.0
	Black spruce mixedwood on shallow peatland	-	-	-	-	-
	Black spruce treed on shallow peatland	13.3	4.0	18.9	-	14.2
	Black spruce treed on wet peatland	-	-	0.7	-	0.4
	Tamarack- black spruce mixture on wet peatland	-	-	-	-	-
	Tamarack treed on shallow peatland	1.7	-	0.2	-	0.2
	Tamarack treed on wet peatland	-	-	-	-	-
	Black spruce treed on riparian peatland	-	-	0.0	-	0.0
	Tamarack- black spruce mixture on riparian peatland	-	-	-	-	-
Tall shrub on other peatlands	Tall shrub on shallow peatland	-	-	-	-	-
	Tall shrub on wet peatland	-	-	-	-	-
Low vegetation on other peatlands	Low vegetation on shallow peatland	2.1	0.3	5.3	-	3.7
	Low vegetation on wet peatland	-	-	-	-	-
Shrub/ low vegetation on riparian peatland	Tall shrub on riparian peatland	0.0	0.0	-	-	0.0
	Low vegetation on riparian peatland	0.1	-	0.0	-	0.0
Nelson River shore zone	Nelson River shrub and/or low vegetation on ice scoured upland	13.8	-	-	-	0.6
	Nelson River shrub and/or low vegetation on upper beach	-	0.2	0.4	-	0.3
	Nelson River shrub and/or low vegetation on sunken peat	-	0.9	0.4	-	0.5
	Nelson River marsh	-	-	-	-	-
Off-system shore zone	Off-system marsh	-	-	-	-	-
	Total habitat area (ha)	*62*	*364*	*982*	*57*	*1,466*

Note: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 2C-15: Percentage Distribution of Coarse Habitat Types Within Features of the Altered Water Levels, River Management and Fish Mitigation Area Footprint Types During Construction

Land Cover Type	Coarse Habitat Type	Altered Water Levels Footprint			Total Altered Water Levels	River Management Footprint			Total River Management	Fish Mitigation Area Footprint		Total Fish Mitigation Area
		Dewatered Area	Dewatered Islands	Downstream Coffer Dam Diversion		Channel Improvement Area	Central Dam Excavation	Stage 2 Cofferdam		Borrow - Deposit TYPE - Granular	Fish Mitigation Area	
Broadleaf treed on all ecosites	Broadleaf treed on all ecosites	-	-	-	-	-	-	-	-	3.3	0.2	1.4
	Broadleaf mixedwood on all ecosites	-	-	-	-	-	-	-	-	-	2.4	1.5
Needleleaf treed on mineral or thin peatland	Black spruce mixedwood on mineral or thin peatland	-	-	-	-	-	-	-	-	-	1.4	0.8
	Jack pine mixedwood on mineral or thin peatland	-	-	-	-	-	-	-	-	-	-	-
	Jack pine treed on mineral or thin peatland	-	-	-	-	-	-	-	-	11.3	-	4.4
	Black spruce treed on mineral soil	1.0	28.9	97.0	16.7	21.3	-	-	18.2	46.4	20.1	30.3
	Black spruce treed on thin peatland	9.5	-	-	5.6	48.3	-	3.2	42.2	26.8	45.1	38.0
Tall shrub on mineral or thin peatland	Tall shrub on mineral or thin peatland	-	-	-	-	-	-	-	-	-	0.0	0.0
Low vegetation on mineral or thin peatland	Low vegetation on mineral or thin peatland	0.0	-	-	0.0	2.0	5.2	17.5	3.5	0.3	0.8	0.6
Needleleaf treed on other peatlands	Jack pine treed on shallow peatland	-	-	-	-	-	-	-	-	-	-	-
	Black spruce mixedwood on shallow peatland	-	-	-	-	-	-	-	-	-	-	-
	Black spruce treed on shallow peatland	-	-	-	-	26.7	-	20.2	24.1	11.4	22.2	18.1
	Black spruce treed on wet peatland	-	-	-	-	-	-	-	-	-	0.0	0.0
	Tamarack- black spruce mixture on wet peatland	-	-	-	-	-	-	-	-	-	-	-
	Tamarack treed on shallow peatland	-	-	-	-	-	-	-	-	-	0.1	0.1
	Tamarack treed on wet peatland	-	-	-	-	-	-	-	-	-	-	-
	Black spruce treed on riparian peatland	-	-	-	-	-	-	-	-	-	-	-
	Tamarack- black spruce mixture on riparian peatland	-	-	-	-	-	-	-	-	-	-	-
Tall shrub on other peatlands	Tall shrub on shallow peatland	-	-	-	-	-	-	-	-	0.1	-	0.0
	Tall shrub on wet peatland	-	-	-	-	-	-	-	-	-	-	-
Low vegetation on other peatlands	Low vegetation on shallow peatland	-	-	-	-	0.7	-	-	0.6	0.4	1.0	0.8
	Low vegetation on wet peatland	-	-	-	-	0.7	-	-	0.6	0.0	3.4	2.1
Shrub/ low vegetation on riparian peatland	Tall shrub on riparian peatland	35.5	5.9	-	23.1	-	-	-	0.0	-	1.5	0.9
	Low vegetation on riparian peatland	0.2	-	-	0.1	-	-	-	-	0.1	0.6	0.4
Nelson River shore zone	Nelson River shrub and/or low vegetation on ice scoured upland	20.5	65.2	3.0	34.8	0.2	94.8	59.2	9.4	-	-	-
	Nelson River shrub and/or low vegetation on upper beach	33.3	-	-	19.7	0.0	-	-	1.5	-	1.0	0.6
	Nelson River shrub and/or low vegetation on sunken peat	-	-	0.0	0.0	-	-	-	0.0	-	-	-
	Nelson River marsh	-	-	-	-	-	-	-	-	-	-	-
Off-system shore zone	Off-system marsh	-	-	-	-	-	-	-	-	-	0.0	0.0

Total habitat area (ha)	*8*	*5*	*1*	*14*	*12*	*1*	*1*	*14*	*53*	*84*	*138*

Note: Most river management footprint components are almost entirely within the existing Nelson River extents. Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 2C-16: Percentage Distribution of Coarse Habitat Types Within Features of the Potential Disturbance Area Footprint Type During Construction

Land Cover Type	Coarse Habitat Type	Dyke Buffer	Dyke Ditch Turnout Buffer	Reservoir Clearing 10m Buffer	Reservoir Clearing	KIP Work Area 100m Buffer	Spillway Fill-in	Dam Buffer	Fill-in Between Dyke and EMPA	In Water Disturbed Areas	Potential Area for Boat Launch	Quarry 50m Buffer	Water Treament Cooridor	Central Dam Fill-in	Small Gaps	Powerhouse Fill-in	Total
Broadleaf treed on all ecosites	Broadleaf treed on all ecosites	4.5	-	1.1	0.0	2.1	-	-	-	-	-	-	33.0	-	13.3	-	2.5
	Broadleaf mixedwood on all ecosites	0.4	-	0.9	0.0	-	-	-	-	-	-	-	-	-	-	-	0.5
Needleleaf treed on mineral or thin peatland	Black spruce mixedwood on mineral or thin peatland	0.3	-	0.4	0.0	-	-	-	-	-	-	-	-	-	8.8	-	0.3
	Jack pine mixedwood on mineral or thin peatland	1.4	2.2	0.0	-	-	-	-	-	-	-	-	-	-	-	-	0.7
	Jack pine treed on mineral or thin peatland	4.7	-	0.4	-	-	-	13.5	-	-	-	-	-	-	-	-	2.2
	Black spruce treed on mineral soil	13.6	2.2	15.4	0.0	3.2	5.1	1.6	-	0.0	-	-	-	-	28.6	-	11.8
	Black spruce treed on thin peatland	25.8	5.9	32.5	0.0	25.7	-	5.6	-	-	-	85.7	34.3	-	-	-	24.7
Tall shrub on mineral or thin peatland	Tall shrub on mineral or thin peatland	1.4	0.1	0.1	-	8.9	-	-	-	-	-	-	-	-	-	-	1.0
Low vegetation on mineral or thin peatland	Low vegetation on mineral or thin peatland	7.3	1.9	0.8	0.4	56.3	64.6	0.7	24.9	-	-	2.0	9.9	0.5	-	-	6.3
Needleleaf treed on other peatlands	Jack pine treed on shallow peatland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Black spruce mixedwood on shallow peatland	-	-	0.0	-	-	-	-	-	-	-	-	-	-	29.2	-	0.1
	Black spruce treed on shallow peatland	27.9	55.5	26.6	0.0	-	-	2.8	4.7	-	-	12.4	12.0	-	16.3	-	23.3
	Black spruce treed on wet peatland	0.1	0.6	0.9	0.0	-	-	-	-	-	-	-	-	-	-	-	0.4
	Tamarack- black spruce mixture on wet peatland	0.2	1.0	0.4	-	-	-	-	-	-	-	-	-	-	-	-	0.2
	Tamarack treed on shallow peatland	0.0	0.1	0.5	-	-	-	-	-	-	-	-	-	-	-	-	0.2
	Tamarack treed on wet peatland	-	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	0.0
	Black spruce treed on riparian peatland	0.4	-	0.6	0.2	1.6	-	-	-	-	-	-	-	-	-	-	0.5
	Tamarack- black spruce mixture on riparian peatland	-	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	0.0
Tall shrub on other peatlands	Tall shrub on shallow peatland	0.6	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	0.4
	Tall shrub on wet peatland	-	-	0.4	0.1	-	-	-	-	-	-	-	-	-	-	-	0.2
Low vegetation on other peatlands	Low vegetation on shallow peatland	10.0	23.0	2.0	-	0.7	-	0.5	70.5	0.4	-	-	10.8	-	-	-	5.8
	Low vegetation on wet peatland	0.0	6.9	0.6	-	-	-	-	-	-	-	-	-	-	-	-	0.4
Shrub/ low vegetation on riparian peatland	Tall shrub on riparian peatland	-	-	5.2	27.8	-	-	-	-	4.3	-	-	-	-	-	-	5.1
	Low vegetation on riparian peatland	1.2	0.8	1.6	2.7	0.2	-	-	-	-	-	-	-	-	-	-	1.4
Nelson River shore zone	Nelson River shrub and/or low vegetation on ice scoured upland	-	-	4.1	11.2	-	30.3	66.8	-	42.3	-	-	-	99.5	3.7	100.0	3.4
	Nelson River shrub and/or low vegetation on upper beach	-	-	4.8	50.3	-	-	8.5	-	52.9	-	-	-	-	-	-	7.6
	Nelson River shrub and/or low vegetation on sunken peat	-	-	-	-	1.4	-	-	-	-	100.0	-	-	-	-	-	0.1
	Nelson River marsh	-	-	0.2	7.2	-	-	-	-	-	-	-	-	-	-	-	0.9

Off-system shore zone	Off-system marsh	0.1	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-	0.1
	Total habitat area (ha)	*275*	*15*	*229*	*73*	*23*	*6*	*2*	*1*	*1*	*0*	*4*	*1*	*0*	*2*	*0*	*631*

Note: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 2C-17: Percentage Distribution of Coarse Habitat Types Among Features of the Potential but Unlikely Borrow Area and Borrow Access Footprints During Construction

Land Cover Type	Coarse Habitat Type	Footprint	Habitat Zone of Influence	All
Needleleaf treed on mineral or thin peatland	Black spruce treed on mineral soil	88.0	12.0	*35*
	Black spruce treed on thin peatland	50.6	49.4	*27*
	Black spruce treed thin peatland	51.4	48.6	*1*
	Jack pine treed on mineral or thin peatland	43.0	57.0	*2*
Low vegetation on mineral or thin peatland	Low vegetation on mineral or thin peatland	43.9	56.1	*16*
Needleleaf treed on other peatlands	Black spruce treed on riparian peatland	45.2	54.8	*1*
	Black spruce treed on shallow peatland	49.7	50.3	*33*
	Black spruce treed on wet peatland	50.7	49.3	*2*
	Tamarack treed on shallow peatland	39.3	60.7	*0*
Low vegetation on other peatlands	Low vegetation on shallow peatland	35.2	64.8	*20*
	Low vegetation on wet peatland	44.4	55.6	*5*
Shrub/ low vegetation on riparian peatland	Low vegetation on riparian peatland	53.5	46.5	*1*

Table 2C-18: Broad Habitat Composition Percentage of the Project Footprint By Component and Their Habitat Zone of Influence During Construction

Coarse Habitat Type	Broad Habitat Type	Infrastructure	Road & Road Corridor	Camp & Work Area	Borrow Areas	Reservoir	EMPA	River Management	Flooding	PDA	Mitigation Area	Altered Water Levels	Project Footprint Total	ZOI Construction	All
Broadleaf treed on all ecosites	Balsam poplar dominant on all ecosites	-	-	-	-	0.0	-	-	-	0.0	-	-	0.0	0.0	0.0
	Trembling aspen dominant on all ecosites	6.1	2.1	1.0	2.1	0.5	5.9	-	0.1	2.5	1.4	-	1.5	1.5	1.5
	White birch dominant on all ecosites	-	0.1	-	0.9	0.1	0.2	-	0.1	0.0	-	-	0.3	0.0	0.2
Broadleaf mixedwood on all ecosites	Balsam poplar mixedwood on all ecosites	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trembling aspen mixedwood on all ecosites	-	0.1	-	1.0	0.5	0.0	-	0.1	0.4	1.5	-	0.5	1.4	0.7
	White birch mixedwood on all ecosites	-	-	-	1.8	0.1	-	-	0.0	0.0	-	-	0.4	0.2	0.4
Black spruce mixedwood on mineral or thin peatland	Black spruce mixedwood on mineral	0.1	0.6	-	0.1	0.1	0.1	-	0.1	0.3	-	-	0.1	0.5	0.2
	Black spruce mixedwood on thin peatland	-	0.2	-	-	0.0	-	-	-	0.0	0.8	-	0.0	0.1	0.0
Jack pine mixedwood on mineral or thin peatland	Jack pine mixedwood on mineral	1.3	-	-	0.5	0.0	-	-	-	0.7	-	-	0.2	0.3	0.2
	Jack pine mixedwood on thin peatland	-	0.0	35.7	0.6	-	-	-	-	-	-	-	0.2	0.6	0.3
Jack pine treed on mineral or thin peatland	Jack pine dominant on mineral	2.2	0.6	-	3.3	0.0	1.3	-	-	1.4	3.8	-	1.1	1.6	1.2
	Jack pine dominant on thin peatland	-	-	-	0.1	-	2.3	-	-	0.0	-	-	0.1	0.4	0.2
	Jack pine mixture on thin peatland	1.8	1.3	9.3	2.7	0.0	0.8	-	-	0.5	0.6	-	0.8	2.4	1.2
	Tamarack dominant on mineral	-	0.2	-	0.2	-	-	-	-	-	-	-	0.1	0.0	0.0
	Tamarack mixture on mineral	0.7	0.1	-	1.3	0.1	0.1	-	-	0.2	-	-	0.4	0.1	0.3
Black spruce treed on mineral soil	Black spruce dominant on mineral	9.7	5.4	-	6.8	5.2	4.5	18.2	2.6	9.7	29.1	16.7	6.5	13.4	8.1
	Black spruce mixture on mineral	5.9	3.2	-	13.8	1.7	3.1	-	0.3	2.1	1.2	-	4.5	3.2	4.2
Black spruce treed on thin peatland	Black spruce dominant on thin peatland	29.2	46.0	1.1	36.2	25.7	20.9	42.2	3.9	23.3	38.0	5.6	28.2	32.5	29.2
	Black spruce mixture on thin peatland	1.4	3.2	-	2.3	2.1	0.9	-	0.0	0.8	-	-	1.9	1.9	1.9
	Tamarack dominant on thin peatland	-	-	-	0.0	0.0	-	-	-	0.0	-	-	0.0	0.0	0.0
	Tamarack mixture on thin peatland	0.2	1.0	-	0.7	0.9	0.0	-	0.0	0.6	-	-	0.7	1.0	0.8
Tall shrub on mineral or thin peatland	Tall shrub on mineral	0.3	0.6	-	0.1	0.0	0.9	-	0.4	0.5	-	-	0.2	0.2	0.2
	Tall shrub on thin peatland	-	1.0	-	0.5	0.3	4.4	-	0.7	0.5	0.0	-	0.6	0.4	0.5
Low vegetation on mineral or thin peatland	Low vegetation on mineral	3.9	0.6	-	0.4	0.1	2.8	1.9	0.3	1.5	0.4	-	0.6	0.4	0.5
	Low Vegetation on thin peatland	7.7	6.3	0.1	4.7	1.1	9.5	1.6	1.0	4.7	0.2	0.0	3.0	3.4	3.1
Jack pine treed on shallow peatland	Jack pine dominant on shallow peatland	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0
	Jack pine mixture on ground ice peatland	-	-	-	0.0	-	-	-	-	-	-	-	0.0	-	0.0
	Jack pine mixture on shallow peatland	-	0.0	-	-	-	-	-	-	-	-	-	0.0	0.3	0.1
Black spruce mixedwood on shallow peatland	Black spruce mixedwood on shallow peatland	-	0.0	-	-	0.0	0.1	-	-	0.1	-	-	0.0	0.0	0.0
	Jack pine mixedwood on shallow peatland	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0
Black spruce treed on shallow peatland	Black spruce dominant on ground ice peatland	5.2	2.7	-	2.6	13.4	7.3	6.6	2.9	7.7	2.9	-	8.7	6.5	8.2
	Black spruce dominant on shallow peatland	8.1	12.6	27.1	11.2	24.0	12.1	17.5	6.2	15.0	15.0	-	17.8	14.2	16.9
	Black spruce mixture on ground ice peatland	0.1	-	-	-	0.2	0.6	-	-	0.2	0.1	-	0.1	0.1	0.1
	Black spruce mixture on shallow peatland	0.0	0.1	-	0.4	1.2	0.2	-	0.1	0.4	-	-	0.7	0.9	0.8

Table 2C-18: Broad Habitat Composition Percentage of the Project Footprint By Component and Their Habitat Zone of Influence During Construction

Coarse Habitat Type	Broad Habitat Type	Infrastructure	Road & Road Corridor	Camp & Work Area	Borrow Areas	Reservoir	EMPA	River Management	Flooding	PDA	Mitigation Area	Altered Water Levels	Project Footprint Total	ZOI Construction	All
Black spruce treed on wet peatland	Black spruce dominant on wet peatland	0.2	2.3	-	0.4	1.6	0.0	-	0.4	0.4	0.0	-	1.1	0.7	1.0
Tamarack- black spruce mixture on wet peatland	Black spruce mixture on wet peatland	-	0.1	-	-	0.1	-	-	-	0.1	-	-	0.0	0.1	0.1
	Tamarack mixture on wet peatland	0.0	0.3	-	-	0.5	-	-	-	0.1	-	-	0.3	0.1	0.2
Tamarack treed on shallow peatland	Tamarack dominant on ground ice peatland	-	-	-	-	0.0	-	-	-	-	-	-	0.0	-	0.0
	Tamarack dominant on shallow peatland	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tamarack mixture on ground ice peatland	0.2	-	-	0.1	0.3	-	-	0.0	0.1	0.1	-	0.2	0.1	0.2
	Tamarack mixture on shallow peatland	-	2.2	-	0.1	0.7	0.0	-	0.1	0.1	-	-	0.5	0.7	0.6
Tamarack treed on wet peatland	Tamarack dominant on wet peatland	-	-	-	-	0.0	-	-	-	0.0	-	-	0.0	0.0	0.0
Black spruce treed on riparian peatland	Black spruce dominant on riparian peatland	0.0	0.3	-	0.0	0.6	0.1	-	0.5	0.5	-	-	0.4	0.3	0.4
Tamarack- black spruce mixture on riparian peatland	Tamarack- black spruce mixture on riparian peatland	-	0.0	-	-	0.0	-	-	-	0.0	-	-	0.0	0.0	0.0
Tamarack treed on riparian peatland	Tamarack dominant on riparian peatland	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tall shrub on shallow peatland	Tall shrub on ground ice peatland	-	0.0	-	-	0.1	-	-	0.5	0.0	-	-	0.0	0.0	0.0
	Tall shrub on shallow peatland	0.3	0.1	-	-	0.2	0.0	-	0.3	0.4	0.0	-	0.2	0.4	0.2
Tall shrub on wet peatland	Tall shrub on wet peatland	-	-	-	-	0.7	-	-	0.4	0.2	-	-	0.4	0.2	0.3
Low vegetation on shallow peatland	Low vegetation on ground ice peatland	7.3	1.8	-	1.1	4.7	13.5	0.1	2.8	3.7	0.4	-	3.9	2.6	3.6
	Low vegetation on shallow peatland	1.9	1.4	25.8	2.6	2.5	1.5	0.5	0.9	2.1	0.3	-	2.3	2.2	2.3
Low vegetation on wet peatland	Low vegetation on wet peatland	0.3	1.3	-	-	2.5	0.0	0.6	0.6	0.4	2.1	-	1.4	0.7	1.3
Tall shrub on riparian peatland	Tall shrub on riparian peatland	0.0	0.3	-	0.0	2.7	0.3	0.0	29.7	5.1	0.9	23.1	3.1	0.3	2.5
Low vegetation on riparian peatland	Low vegetation on riparian peatland	0.1	1.0	-	0.0	3.7	0.3	-	10.9	1.4	0.4	0.1	2.5	0.9	2.1
Nelson River shrub and/or low vegetation on ice scoured upland	Shrub/Low veg mixture on ice scoured upland	5.7	0.3	-	0.6	1.1	3.5	9.4	3.9	3.4	-	34.8	1.6	0.6	1.4
Nelson River shrub and/or low vegetation on upper beach	Tall Shrub on upper beach- regulated	-	0.0	-	0.0	0.3	-	1.5	7.3	2.1	0.6	14.8	0.7	0.4	0.6
	Low vegetation on upper beach- regulated	-	-	-	0.1	0.1	-	-	17.1	4.4	-	4.9	1.2	0.2	0.9
	Shrub/Low Veg Mixture on Upper beach- regulated	-	-	-	0.2	0.0	0.1	-	3.5	1.1	-	-	0.3	0.3	0.3
Nelson River shrub and/or low vegetation on sunken peat	Shrub/Low Veg Mixture on Sunken Peat- regulated	-	0.8	-	0.5	-	2.7	0.0	-	0.1	-	0.0	0.3	1.3	0.5
	Low vegetation on sunken peat- regulated	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nelson River marsh	Emergent on lower beach- regulated	-	-	-	-	0.0	-	-	1.8	0.9	-	-	0.2	0.0	0.1
	Emergent on sunken peat- regulated	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Off-system marsh	Emergent on upper beach	0.0	-	-	-	0.2	0.0	-	0.2	0.0	0.0	-	0.1	0.0	0.1
	Emergent on lower beach	0.0	-	-	-	0.0	-	-	-	0.0	-	-	0.0	0.0	0.0
	Emergent island in littoral	-	-	-	-	0.0	-	-	0.2	-	-	-	0.0	-	0.0
Total Land Area (ha)		*246*	*405*	*5*	*1,466*	*3,414*	*263*	*14*	*277*	*631*	*138*	*14*	*6,872*	*2,055*	*8,927*

Note: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 2C-19: Distribution of Broad Habitat Types Across the Project Footprints and Habitat Zone of Influence (%) During Construction*

Coarse Habitat Type	Broad Habitat Type	Infrastructure	Road & Road Corridor	Camp & Work Area	Borrow Areas	Reservoir	EMPA	River Management	Flooding	PDA	Mitigation Area	Altered Water Levels	Project Footprint Total	ZOI Construction	*Area (ha)*
Broadleaf treed on all ecosites	Balsam poplar dominant on all ecosites	-	-	-	-	15.3	-	-	-	8.4	-	-	23.7	76.3	*0*
	Trembling aspen dominant on all ecosites	11.1	6.3	0.0	22.8	12.2	11.4	-	0.1	11.6	1.4	-	77.0	23.0	*136*
	White birch dominant on all ecosites	-	1.7	-	73.8	15.9	3.0	-	1.2	1.2	-	-	96.7	3.3	*18*
Broadleaf mixedwood on all ecosites	Balsam poplar mixedwood on all ecosites	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trembling aspen mixedwood on all ecosites	-	0.4	-	21.2	25.1	0.1	-	0.6	4.3	3.1	-	54.8	45.2	*66*
	White birch mixedwood on all ecosites	-	-	-	77.3	11.4	-	-	0.1	0.9	-	-	89.8	10.2	*34*
Black spruce mixedwood on mineral or thin peatland	Black spruce mixedwood on mineral	1.7	12.2	-	8.1	15.7	1.4	-	0.7	9.1	-	-	48.8	51.2	*20*
	Black spruce mixedwood on thin peatland	-	16.7	-	-	28.3	-	-	-	1.0	28.4	-	74.3	25.7	*4*
Jack pine mixedwood on mineral or thin peatland	Jack pine mixedwood on mineral	14.7	-	-	36.2	0.1	-	-	-	20.7	-	-	71.7	28.3	*21*
	Jack pine mixedwood on thin peatland	-	0.0	8.0	39.9	-	-	-	-	-	-	-	47.9	52.1	*23*
Jack pine treed on mineral or thin peatland	Jack pine dominant on mineral	5.0	2.3	-	45.3	1.0	3.2	-	-	8.3	4.8	-	70.0	30.0	*108*
	Jack pine dominant on thin peatland	-	-	-	5.5	-	41.7	-	-	0.6	-	-	47.8	52.2	*15*
	Jack pine mixture on thin peatland	4.0	4.9	0.5	37.1	1.4	1.9	-	-	3.1	0.7	-	53.7	46.3	*108*
	Tamarack dominant on mineral	-	23.1	-	70.0	-	-	-	-	-	-	-	93.0	7.0	*4*
	Tamarack mixture on mineral	6.1	1.6	-	66.3	10.3	0.6	-	-	5.7	-	-	90.5	9.5	*28*
Black spruce treed on mineral soil	Black spruce dominant on mineral	3.3	3.0	-	13.8	24.5	1.6	0.3	1.0	8.5	5.5	0.3	61.9	38.1	*724*
	Black spruce mixture on mineral	3.9	3.4	-	53.6	15.1	2.2	-	0.2	3.5	0.4	-	82.4	17.6	*377*
Black spruce treed on thin peatland	Black spruce dominant on thin peatland	2.8	7.2	0.0	20.4	33.7	2.1	0.2	0.4	5.6	2.0	0.0	74.4	25.6	*2606*
	Black spruce mixture on thin peatland	2.0	7.8	-	19.9	42.4	1.4	-	0.0	2.9	-	-	76.4	23.6	*167*
	Tamarack dominant on thin peatland	-	-	-	17.0	41.0	-	-	-	5.0	-	-	63.0	37.0	*1*
	Tamarack mixture on thin peatland	0.7	5.8	-	14.8	44.3	0.0	-	0.0	5.7	-	-	71.4	28.6	*71*
Tall shrub on mineral or thin peatland	Tall shrub on mineral	5.1	14.3	-	4.7	5.9	14.5	-	6.1	19.6	-	-	70.1	29.9	*16*
	Tall shrub on thin peatland	-	8.5	-	14.8	22.2	24.2	-	4.1	6.5	0.1	-	80.5	19.5	*47*
Low vegetation on mineral or thin peatland	Low vegetation on mineral	20.5	4.9	-	11.0	5.6	15.6	0.5	1.6	20.5	1.2	-	81.4	18.6	*47*
	Low Vegetation on thin peatland	6.8	9.2	0.0	24.7	13.1	9.0	0.1	1.0	10.7	0.1	0.0	74.7	25.3	*279*
Jack pine treed on shallow peatland	Jack pine dominant on shallow peatland	-	-	-	-	-	-	-	-	-	-	-	-	100.0	*0*
	Jack pine mixture on ground ice peatland	-	-	-	100.0	-	-	-	-	-	-	-	100.0	-	*0*
	Jack pine mixture on shallow peatland	-	1.1	-	-	-	-	-	-	-	-	-	1.1	98.9	*6*
Black spruce mixedwood on shallow peatland	Black spruce mixedwood on shallow peatland	-	1.6	-	-	49.2	10.2	-	-	32.1	-	-	93.1	6.9	*2*
	Jack pine mixedwood on shallow peatland	-	-	-	-	-	-	-	-	-	-	-	-	100.0	*1*
Black spruce treed on shallow peatland	Black spruce dominant on ground ice peatland	1.7	1.5	-	5.2	62.3	2.6	0.1	1.1	6.6	0.6	-	81.8	18.2	*734*
	Black spruce dominant on shallow peatland	1.3	3.4	0.1	10.8	54.1	2.1	0.2	1.1	6.3	1.4	-	80.7	19.3	*1513*
	Black spruce mixture on ground ice peatland	1.9	-	-	-	53.5	14.0	-	-	9.7	1.4	-	80.6	19.4	*12*
	Black spruce mixture on shallow peatland	0.1	0.3	-	9.0	57.6	0.6	-	0.5	4.0	-	-	72.3	27.7	*70*
Black spruce treed on wet peatland	Black spruce dominant on wet peatland	0.5	10.3	-	7.3	61.3	0.0	-	1.3	2.7	0.0	-	83.5	16.5	*90*
Tamarack- black spruce mixture on wet peatland	Black spruce mixture on wet peatland	-	6.6	-	-	48.5	-	-	-	16.4	-	-	71.4	28.6	*5*
	Tamarack mixture on wet peatland	0.3	5.2	-	-	78.6	-	-	-	3.5	-	-	87.6	12.4	*21*
Tamarack treed on shallow peatland	Tamarack dominant on ground ice peatland	-	-	-	-	100.0	-	-	-	-	-	-	100.0	-	*1*
	Tamarack dominant on shallow peatland	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tamarack mixture on ground ice peatland	3.7	-	-	6.9	76.6	-	-	0.3	2.6	0.7	-	90.8	9.2	*15*

Table 2C-19: Distribution of Broad Habitat Types Across the Project Footprints and Habitat Zone of Influence (%) During Construction*

Coarse Habitat Type	Broad Habitat Type	Infrastructure	Road & Road Corridor	Camp & Work Area	Borrow Areas	Reservoir	EMPA	River Management	Flooding	PDA	Mitigation Area	Altered Water Levels	Project Footprint Total	ZOI Construction	*Area (ha)*
	Tamarack mixture on shallow peatland	-	17.4	-	4.3	48.7	0.0	-	0.6	1.6	-	-	72.6	27.4	*51*
Tamarack treed on wet peatland	Tamarack dominant on wet peatland	-	-	-	-	80.1	-	-	-	3.4	-	-	83.6	16.4	*2*
Black spruce treed on riparian peatland	Black spruce dominant on riparian peatland	0.0	3.1	-	0.0	65.5	0.6	-	4.3	8.5	-	-	82.0	18.0	*33*
Tamarack- black spruce mixture on riparian peatland	Tamarack- black spruce mixture on riparian peatland	-	0.0	-	-	83.1	-	-	-	2.8	-	-	85.9	14.1	*1*
Tamarack treed on riparian peatland	Tamarack dominant on riparian peatland	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tall shrub on shallow peatland	Tall shrub on ground ice peatland	-	0.1	-	-	48.4	-	-	37.9	2.2	-	-	88.6	11.4	*4*
	Tall shrub on shallow peatland	3.4	3.0	-	-	35.9	0.1	-	3.8	12.2	0.3	-	58.9	41.1	*19*
Tall shrub on wet peatland	Tall shrub on wet peatland	-	-	-	-	81.2	-	-	4.0	3.3	-	-	88.5	11.5	*29*
Low vegetation on shallow peatland	Low vegetation on ground ice peatland	5.6	2.3	-	4.8	49.9	11.0	0.0	2.4	7.3	0.2	-	83.4	16.6	*322*
	Low vegetation on shallow peatland	2.4	2.9	0.7	19.1	42.4	1.9	0.0	1.2	6.5	0.2	-	77.4	22.6	*202*
Low vegetation on wet peatland	Low vegetation on wet peatland	0.6	4.6	-	-	75.6	0.0	0.1	1.5	2.3	2.5	-	87.1	12.9	*112*
Tall shrub on riparian peatland	Tall shrub on riparian peatland	0.1	0.5	-	0.0	42.2	0.3	0.0	37.2	14.6	0.6	1.4	96.8	3.2	*221*
Low vegetation on riparian peatland	Low vegetation on riparian peatland	0.1	2.1	-	0.1	67.0	0.4	-	15.9	4.8	0.3	0.0	90.6	9.4	*190*
Nelson River shrub and/or low vegetation on ice scoured upland	Shrub/Low veg mixture on ice scoured upland	11.6	1.1	-	7.1	30.7	7.6	1.1	8.9	17.6	-	3.9	89.6	10.4	*121*
Nelson River shrub and/or low vegetation on upper beach	Tall Shrub on upper beach- regulated	-	0.1	-	0.7	17.9	-	0.4	36.7	23.6	1.5	3.7	84.6	15.4	*55*
	Low vegetation on upper beach- regulated	-	-	-	1.0	2.6	-	-	56.7	33.5	-	0.8	94.6	5.4	*84*
	Shrub/Low Veg Mixture on Upper beach- regulated	-	-	-	13.0	1.4	1.4	-	37.0	27.1	-	-	78.5	21.5	*26*
Nelson River shrub and/or low vegetation on sunken peat	Shrub/Low Veg Mixture on Sunken Peat- regulated	-	7.0	-	16.0	-	15.7	0.0	-	0.8	-	0.0	39.4	60.6	*45*
	Low vegetation on sunken peat- regulated	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nelson River marsh	Emergent on lower beach- regulated	-	-	-	-	0.0	-	-	46.8	53.2	-	-	100.0	0.0	*11*
	Emergent on sunken peat- regulated	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Off-system marsh	Emergent on upper beach	0.1	-	-	-	75.2	0.3	-	8.8	3.7	0.0	-	88.1	11.9	*7*
	Emergent on lower beach	1.8	-	-	-	77.5	-	-	-	7.0	-	-	86.3	13.7	*1*
	Emergent island in littoral	-	-	-	-	60.9	-	-	39.1	-	-	-	100.0	-	*1*

Note: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 2C-20: Percentage Composition of Broad Habitat Lost During Initial Flooding, and the Predicted Expansion Area for Time Periods up to the First 30 Years of Project Operation

Coarse Habitat Type	Broad Habitat Type	Initial Flooding	Year 1	Years 2 to 5	Years 6 to 15	Years 16 to 30	Total
Broadleaf treed on all ecosites	Balsam poplar dominant on all ecosites	0.0	0.0	0.0	-	-	0.0
	Trembling aspen dominant on all ecosites	0.5	1.0	0.8	0.6	0.3	0.5
	White birch dominant on all ecosites	0.1	0.2	0.1	0.1	-	0.1
Broadleaf mixedwood on all ecosites	Trembling aspen mixedwood on all ecosites	0.7	2.3	1.3	0.5	0.3	0.8
	White birch mixedwood on all ecosites	0.2	1.0	0.4	0.2	0.0	0.2
Black spruce mixedwood on mineral or thin peatland	Black spruce mixedwood on mineral	0.1	0.2	0.1	0.1	0.0	0.1
	Black spruce mixedwood on thin peatland	0.1	0.0	0.0	0.0	0.0	0.0
Black spruce mixedwood on shallow peatland	Black spruce mixedwood on shallow peatland	0.0	0.0	0.0	0.0	0.3	0.0
Black spruce treed on mineral soil	Black spruce dominant on mineral	5.2	24.6	9.3	5.3	1.6	5.4
	Black spruce mixture on mineral	1.5	11.5	4.5	2.3	1.3	1.8
Black spruce treed on thin peatland	Black spruce dominant on thin peatland	24.9	4.5	31.3	32.5	22.8	25.3
	Black spruce mixture on thin peatland	1.7	0.4	1.8	2.4	1.5	1.8
	Tamarack dominant on thin peatland	0.0	0.0	0.0	0.1	0.0	0.0
	Tamarack mixture on thin peatland	0.8	0.0	1.1	1.1	0.7	0.8
Jack pine treed on mineral or thin peatland	Jack pine dominant on mineral	0.0	0.4	0.1	0.0	0.0	0.0
	Jack pine mixture on thin peatland	0.0	0.0	0.0	0.1	0.1	0.0
	Tamarack mixture on mineral	0.1	0.1	0.0	0.1	0.1	0.1
Jack pine mixedwood on mineral or thin peatland	Jack pine mixedwood on mineral	0.0	0.1	0.0	0.0	0.0	0.0
Tall shrub on mineral or thin peatland	Tall shrub on mineral	0.1	0.0	0.0	0.0	0.0	0.1
	Tall shrub on thin peatland	0.5	0.0	0.3	0.5	0.4	0.5
Low vegetation on mineral or thin peatland	Low vegetation on mineral	0.2	0.1	0.0	0.0	0.0	0.2
	Low Vegetation on thin peatland	1.8	0.0	1.5	1.3	2.2	1.8
Black spruce treed on riparian peatland	Black spruce dominant on riparian peatland	0.6	0.0	1.7	0.1	0.0	0.6
Black spruce treed on wet peatland	Black spruce dominant on wet peatland	1.3	1.6	1.0	1.0	1.9	1.3

Table 2C-20: Percentage Composition of Broad Habitat Lost During Initial Flooding, and the Predicted Expansion Area for Time Periods up to the First 30 Years of Project Operation

Coarse Habitat Type	Broad Habitat Type	Initial Flooding	Year 1	Years 2 to 5	Years 6 to 15	Years 16 to 30	Total
Black spruce treed on shallow peatland	Black spruce dominant on ground ice peatland	11.5	3.1	12.6	18.0	24.7	12.3
	Black spruce dominant on shallow peatland	21.6	1.9	15.3	23.0	25.4	21.3
	Black spruce mixture on ground ice peatland	0.2	0.0	0.2	0.1	0.6	0.2
	Black spruce mixture on shallow peatland	1.0	0.3	0.7	1.3	1.3	1.0
Tamarack treed on shallow peatland	Tamarack dominant on ground ice peatland	0.0	-	-	-	-	0.0
	Tamarack mixture on ground ice peatland	0.3	0.0	0.2	0.2	0.3	0.3
	Tamarack mixture on shallow peatland	0.6	0.0	0.4	0.7	0.7	0.6
Tamarack- black spruce mixture on riparian peatland	Tamarack- black spruce mixture on riparian peatland	0.0	0.0	1.0	0.0	0.0	0.1
Tamarack- black spruce mixture on wet peatland	Black spruce mixture on wet peatland	0.1	0.0	0.1	0.1	0.4	0.1
	Tamarack mixture on wet peatland	0.4	0.8	0.4	0.2	0.3	0.4
Tamarack treed on wet peatland	Tamarack dominant on wet peatland	0.0	0.1	0.1	0.1	0.2	0.0
Tall shrub on shallow peatland	Tall shrub on ground ice peatland	0.1	0.0	0.0	0.0	0.0	0.1
	Tall shrub on shallow peatland	0.2	0.0	0.7	0.2	0.9	0.2
Tall shrub on wet peatland	Tall shrub on wet peatland	0.6	0.6	0.5	0.7	1.2	0.6
Low vegetation on shallow peatland	Low vegetation on ground ice peatland	4.5	0.2	1.6	2.2	3.5	4.2
	Low vegetation on shallow peatland	2.3	1.3	1.0	1.7	2.0	2.2
Low vegetation on wet peatland	Low vegetation on wet peatland	2.1	2.4	0.6	0.8	2.1	2.0
Tall shrub on riparian peatland	Tall shrub on riparian peatland	4.8	11.3	3.7	0.6	0.4	4.5
Low vegetation on riparian peatland	Low vegetation on riparian peatland	3.8	3.6	3.6	0.4	1.2	3.5
Nelson River shrub and/or low vegetation on ice scoured upla	Shrub/Low veg mixture on ice scoured upland	2.0	10.7	1.4	0.8	0.6	1.9
Nelson River shrub and/or low vegetation on sunken peat	Low vegetation on upper beach- regulated	1.7	10.4	0.0	0.0	0.0	1.6
	Tall Shrub on upper beach- regulated	0.9	0.7	0.3	0.4	0.9	0.9

Table 2C-20: Percentage Composition of Broad Habitat Lost During Initial Flooding, and the Predicted Expansion Area for Time Periods up to the First 30 Years of Project Operation

Coarse Habitat Type	Broad Habitat Type	Initial Flooding	Year 1	Years 2 to 5	Years 6 to 15	Years 16 to 30	Total
Nelson River marsh	Emergent on lower beach- regulated	0.2	4.4	0.0	-	-	0.2
Nelson River shrub and/or low vegetation on upper beach	Shrub/Low Veg Mixture on Upper beach-regulated	0.4	0.0	0.0	-	-	0.4
Off-system marsh	Emergent island in littoral	0.0	-	-	-	-	0.0
	Emergent on lower beach	0.0	0.0	0.0	-	-	0.0
	Emergent on upper beach	0.1	0.0	0.0	-	-	0.1
	Total habitat area (ha)	*4,173*	*48*	*182*	*266*	*176*	*4,845*

Note: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

Table 2C-21: Net Hectares of Broad Habitat Affected After 30 Years of Project Operation

Coarse Habitat Type	Broad Habitat Type	Permanent habitat loss			Permanent habitat alteration		Temporary habitat Alteration	Total Area
		Infra-structure/ Dewatered area	Initial Flooding	Reservoir Expansion	Indirect reservoir effects	Other long term indirect effects	Undisturbed potential construction areas and regenerating construction areas	
Broadleaf treed on all ecosites	Balsam poplar dominant on all ecosites	-	0.0	0.0	0.1	-	-	0.0
	Trembling aspen dominant on all ecosites	3.1	0.5	0.6	1.1	2.6	2.5	1.3
	White birch dominant on all ecosites	0.1	0.1	0.1	0.2	0.2	0.1	0.1
Broadleaf mixedwood on all ecosites	Balsam poplar mixedwood on all ecosites	-	-	-	-	-	-	-
	Trembling aspen mixedwood on all ecosites	-	0.7	0.8	2.2	0.2	0.1	0.7
	White birch mixedwood on all ecosites	-	0.2	0.3	0.5	0.2	0.0	0.2
Black spruce mixedwood on mineral or thin peatland	Black spruce mixedwood on mineral	0.3	0.1	0.1	0.8	0.1	0.2	0.2
	Black spruce mixedwood on thin peatland	0.1	0.1	0.0	0.0	0.0	-	0.0
Jack pine mixedwood on mineral or thin peatland	Jack pine mixedwood on mineral	0.6	0.0	0.0	0.0	0.7	0.5	0.2
	Jack pine mixedwood on thin peatland	0.0	-	-	-	0.9	0.7	0.2
Jack pine treed on mineral or thin peatland	Jack pine dominant on mineral	1.1	0.0	0.0	0.1	3.1	3.9	1.1
	Jack pine dominant on thin peatland	-	-	-	-	0.4	0.5	0.1
	Jack pine mixture on thin peatland	0.9	0.0	0.1	0.2	4.2	3.0	1.2
	Tamarack dominant on mineral	0.2	-	-	-	0.0	0.2	0.0
	Tamarack mixture on mineral	0.4	0.1	0.1	0.2	0.1	1.2	0.3
Black spruce treed on mineral soil	Black spruce dominant on mineral	7.9	5.2	6.8	18.4	4.6	8.3	7.7
	Black spruce mixture on mineral	4.3	1.5	3.3	3.6	2.0	13.6	4.1
Black spruce treed on thin peatland	Black spruce dominant on thin peatland	40.8	24.9	27.7	33.0	30.6	34.6	29.4
	Black spruce mixture on thin peatland	3.0	1.7	1.8	2.6	1.3	2.3	2.0
	Tamarack dominant on thin peatland	-	0.0	0.0	0.1	0.0	0.0	0.0
	Tamarack mixture on thin peatland	0.8	0.8	0.9	1.1	0.9	0.7	0.8
Tall shrub on mineral or thin peatland	Tall shrub on mineral	0.2	0.1	0.0	0.1	0.5	0.2	0.2
	Tall shrub on thin peatland	0.1	0.5	0.4	0.0	0.8	0.8	0.5
Low vegetation on mineral or thin peatland	Low vegetation on mineral	2.1	0.2	0.0	0.1	1.3	0.6	0.5
	Low Vegetation on thin peatland	4.8	1.8	1.5	1.0	6.2	4.0	2.8
Jack pine treed on shallow peatland	Jack pine dominant on shallow peatland	-	-	-	-	0.0	-	0.0
	Jack pine mixture on ground ice peatland	-	-	-	-	-	0.0	0.0
	Jack pine mixture on shallow peatland	0.0	-	-	-	0.5	-	0.1
Black spruce mixedwood on shallow peatland	Black spruce mixedwood on shallow peatland	-	0.0	0.1	0.0	0.0	0.0	0.0
	Jack pine mixedwood on shallow peatland	-	-	-	-	0.1	-	0.0
Black spruce treed on shallow peatland	Black spruce dominant on ground ice peatland	3.9	11.5	17.2	10.5	5.8	3.4	9.3
	Black spruce dominant on shallow peatland	10.0	21.6	20.0	14.2	14.9	11.2	17.3
	Black spruce mixture on ground ice peatland	0.0	0.2	0.3	0.3	0.1	0.1	0.2
	Black spruce mixture on shallow peatland	0.0	1.0	1.1	0.7	0.8	0.4	0.8
Black spruce treed on wet peatland	Black spruce dominant on wet peatland	2.0	1.3	1.3	0.9	0.7	0.4	1.1
Tamarack- black spruce mixture on wet peatland	Black spruce mixture on wet peatland	0.1	0.1	0.2	0.0	0.1	-	0.0
	Tamarack mixture on wet peatland	0.2	0.4	0.4	0.4	0.1	-	0.3
Tamarack treed on shallow peatland	Tamarack dominant on ground ice peatland	-	0.0	-	-	-	-	0.0
	Tamarack dominant on shallow peatland	-	-	-	-	-	-	-

Table 2C-21: Net Hectares of Broad Habitat Affected After 30 Years of Project Operation

Coarse Habitat Type	Broad Habitat Type	Permanent habitat loss			Permanent habitat alteration		Temporary habitat Alteration	Total Area
		Infra-structure/ Dewatered area	Initial Flooding	Reservoir Expansion	Indirect reservoir effects	Other long term indirect effects	Undisturbed potential construction areas and regenerating construction areas	
	Tamarack mixture on ground ice peatland	0.1	0.3	0.2	0.2	0.1	0.1	0.2
	Tamarack mixture on shallow peatland	1.3	0.6	0.6	0.2	0.9	0.2	0.6
Tamarack treed on wet peatland	Tamarack dominant on wet peatland	-	0.0	0.1	0.0	-	-	0.0
Black spruce treed on riparian peatland	Black spruce dominant on riparian peatland	0.2	0.6	0.5	0.2	0.4	0.0	0.4
Tamarack- black spruce mixture on riparian peatland	Tamarack- black spruce mixture on riparian peatland	0.0	0.0	0.3	0.3	0.0	-	0.1
Tamarack treed on riparian peatland	Tamarack dominant on riparian peatland	-	-	-	-	-	-	-
Tall shrub on shallow peatland	Tall shrub on ground ice peatland	0.0	0.1	0.0	0.0	0.0	-	0.0
	Tall shrub on shallow peatland	0.1	0.2	0.5	0.2	0.5	0.0	0.2
Tall shrub on wet peatland	Tall shrub on wet peatland	-	0.6	0.8	0.1	0.1	-	0.3
Low vegetation on shallow peatland	Low vegetation on ground ice peatland	3.4	4.5	2.2	2.4	4.3	2.5	3.6
	Low vegetation on shallow peatland	2.0	2.3	1.6	0.7	3.4	2.0	2.1
Low vegetation on wet peatland	Low vegetation on wet peatland	1.2	2.1	1.2	0.4	0.9	0.0	1.3
Tall shrub on riparian peatland	Tall shrub on riparian peatland	0.8	4.8	2.2	0.6	0.3	0.0	2.5
Low vegetation on riparian peatland	Low vegetation on riparian peatland	0.7	3.8	1.7	1.0	1.3	0.1	2.2
Nelson River shrub and/or low vegetation on ice scoured upland	Shrub/Low veg mixture on ice scoured upland	2.6	2.0	1.6	0.3	0.7	0.0	1.3
Nelson River shrub and/or low vegetation on upper beach	Tall Shrub on upper beach- regulated	0.4	0.9	0.5	0.8	0.2	0.0	0.6
	Low vegetation on upper beach- regulated	0.1	1.7	0.7	0.2	0.3	0.1	0.9
	Shrub/Low Veg Mixture on Upper beach- regulated	-	0.4	0.0	-	0.4	0.2	0.3
Nelson River shrub and/or low vegetation on sunken peat	Shrub/Low Veg Mixture on Sunken Peat- regulated	0.0	-	-	-	2.0	1.1	0.5
	Low vegetation on sunken peat- regulated	-	-	-	-	-	-	-
Nelson River marsh	Emergent on lower beach- regulated	-	0.2	0.3	-	-	-	0.1
	Emergent on sunken peat- regulated	-	-	-	-	-	-	-
Off-system marsh	Emergent on upper beach	0.0	0.1	0.0	0.0	0.1	0.0	0.1
	Emergent on lower beach	0.0	0.0	0.0	-	0.0	-	0.0
	Emergent island in littoral	-	0.0	-	-	-	-	0.0
	Total Land Area (ha)	*494*	*4,173*	*671*	*1,266*	*1,314*	*1,496*	*9,416*

Note: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

APPENDIX 2D
FIRE REGIME

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2.17APPENDIX 2D: FIRE REGIME

Table 2D-1: Number of human caused forest fires in Manitoba from 1985 to 2004

Year	Human		Lightning		Total
	Number	Percent of Total	Number	Percent of Total	Number
1985	211	61%	135	39%	346
1986	144	66%	73	34%	217
1987	314	61%	205	39%	519
1988	382	39%	600	61%	982
1989	513	42%	713	58%	1,226
1990	282	49%	288	51%	570
1991	388	57%	288	43%	676
1992	193	65%	105	35%	298
1993	171	72%	68	28%	239
1994	239	43%	316	57%	555
1995	264	40%	396	60%	660
1996	203	48%	221	52%	424
1997	188	51%	183	49%	371
1998	296	57%	220	43%	516
1999	330	54%	283	46%	613
2000	214	60%	140	40%	354
2001	234	43%	304	57%	538
2002	502	67%	252	33%	754
2003	685	56%	529	44%	1214
2004	110	47%	123	53%	233
Total	5,683	52%	5,442	48%	11,305

Table 2D-2: Total area burned in human caused forest fires in Manitoba from 1985 to 2004

Year	Human		Lightning		Total
	Number	Percent of Total	Number	Percent of Total	Number
1985	1,967	17%	9,856	83%	11,823
1986	6,512	63%	3,830	37%	10,342
1987	15,224	9%	154,296	91%	169,520
1988	34,214	7%	451,439	93%	485,653
1989	634,763	18%	2,933,184	82%	3,567,947
1990	5,938	36%	10,427	64%	16,365
1991	23,835	18%	109,856	82%	133,691
1992	103,658	23%	353,796	77%	457,454
1993	3,117	5%	64,158	95%	67,275
1994	8,482	1%	1,420,272	99%	1,428,754
1995	10,532	1%	878,717	99%	889,249
1996	5,718	5%	111,006	95%	116,724
1997	3,656	9%	38,140	91%	41,795
1998	7,392	2%	401,525	98%	408,917
1999	59,442	51%	56,101	49%	115,543
2000	21,012	19%	89,912	81%	110,924
2001	4,972	6%	73,942	94%	78,914
2002	16,599	18%	77,964	82%	94,563
2003	89,859	10%	828,986	90%	918,845
2004	937	4%	25,066	96%	26,003
Total	1,057,829	12%	8,092,473	88%	9,150,301

Table 2D-3: Annual Percentage of Total Area Burned Between 1979 and 2008 by Most Recent Fire in the Study Areas

Burn Year	Burn Age (years old)	Regional Study Area (%)	Study Zone 5 (%)	Study Zone 4 (%)	*Area Burned (ha) in Regional Study Area*
2008	1	0	0	0	*0*
2007	2	0.1	0.0		*626*
2006	3	0.9	0.0	0.0	*9,415*
2005	4	7.7	9.2	32.2	*80,348*
2004	5	0.0	0.0		*80*
2003	6	8.0	8.8	1.6	*83,889*
2002	7	1.0	2.2	0.0	*10,452*
2001	8	1.0	0.4	1.7	*10,396*
2000	9	0.9	0.0	0.0	*9,286*
1999	10	3.0	2.0	20.2	*30,886*
1998	11	10.4	5.2	0.2	*108,637*
1997	12	0.0	0.0	0.0	*282*
1996	13	4.0	1.9	0.2	*42,121*
1995	14	8.7	16.4	13.2	*91,341*
1994	15	9.0	5.7	0.3	*93,824*
1993	16	0.0	0.0	0.1	*64*
1992	17	13.8	12.8	2.5	*143,779*
1991	18	0.4	0.0		*4,050*
1990	19	0.8	2.0		*8,444*
1989	20	17.3	19.8	8.1	*180,755*
1988	21	0.3	0.4		*3,187*
1987	22	0.1	0.1	0.0	*532*
1986	23	0.1	0.0		*757*
1985	24	0.2	0.3	0.0	*2,093*
1984	25	1.8	4.5	3.5	*19,125*
1983	26	0.0	0.0	0.0	*5*
1982	27	0.2	0.6		*2,510*
1981	28	8.7	3.8	16.0	*91,440*
1980	29	1.6	3.9	0.3	*16,727*
1979	30	0.0	0.0	0.0	*8*
All	All	100.0	100.0	100.0	*1,045,059*
Total Area (ha)		*1,045,059*	*425,879*	*42,088*	

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APPENDIX 2E
ECOSYSTEM DIVERSITY

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2.18 APPENDIX 2E: ECOSYSTEM DIVERSITY

2.18.1 Existing Environment

Twenty-six broad habitat types in the Study Zone 4 were considered diverse. Eighteen broad habitat types have high plant species richness (Table 2E-1) and 16 have relatively high structural complexity (Table 2E-1). Among the rare broad habitat types, tall shrub habitat on shallow peatlands and uplands, upland broadleaf habitat types, upland jack pine and black spruce mixtures, and upland tamarack mixtures had the highest species diversity. All of these broad habitat types were estimated to have at least 19 species per sampled location on average. Young regeneration and low vegetation on all site types generally had the lowest mean number of species.

Generally, the ecosite types associated with the highest plant species richness included slope fens, veneer bogs, and veneer bog on slope had the highest species richness on average. Feathermoss bogs are primarily associated with the veneer bog on slope fine ecosite type, while slope fen fine ecosites were primarily associated with the fen site type.

Treed forest or tall shrub types are generally the most structurally complex habitat types. Broad habitat types with high structural diversity include trembling aspen and balsam poplar dominant and mixedwoods on uplands, white birch dominant and mixedwoods on uplands, jack pine dominant and mixedwoods on mineral soils, and tamarack habitat on mineral soils.

Table 2E-1: Mean Number of Plant Species and Rare Plant Species in each of the Priority Habitat Types

Broad Habitat Type	Mean Number of Species*	Mean Number of Rare Plant Species*	Number of Sample Plots
Balsam poplar dominant on all ecosites			
Trembling aspen dominant on all ecosites	16	2.2	10
White birch dominant on all ecosites	15	1.7	7
Balsam poplar mixedwood on all ecosites			
Trembling aspen mixedwood on all ecosites	19	3.4	5
White birch mixedwood on all ecosites	14	1.8	5
Black spruce mixedwood on mineral	15	1.5	2
Black spruce mixedwood on thin peatland	24	4.7	3
Jack pine mixedwood on mineral	17	3.3	8
Jack pine mixedwood on thin peatland	21	3	1
Jack pine dominant on mineral	18	3.3	12
Jack pine dominant on thin peatland	20	4	4
Jack pine mixture on thin peatland	15	3.3	8
Tamarack dominant on mineral	23	3	1
Tamarack mixture on mineral			
Black spruce dominant on mineral	11	1.1	22
Black spruce mixture on mineral	15	2.2	45
Black spruce mixture on thin peatland	16	2.4	13
Tamarack dominant on thin peatland	26	4.7	3
Tamarack mixture on thin peatland	27	3.5	2
Tall shrub on mineral	27	3	3
Tall shrub on thin peatland	27	5.7	3
Low Vegetation on thin peatland	14	0.5	2
Jack pine dominant on shallow peatland			
Jack pine mixture on shallow peatland	19	3.5	2
Black spruce mixedwood on shallow peatland	24	0.5	1
Jack pine mixedwood on shallow peatland			
Black spruce mixture on shallow peatland	19	1.8	5
Black spruce dominant on wet peatland	22	1.5	2
Black spruce mixture on wet peatland	18	2	2
Tamarack mixture on wet peatland	20	1.3	3

Table 2E-1: Mean Number of Plant Species and Rare Plant Species in each of the Priority Habitat Types

Broad Habitat Type	Mean Number of Species*	Mean Number of Rare Plant Species*	Number of Sample Plots
Tamarack dominant on shallow peatland			
Tamarack mixture on shallow peatland	17	1.3	3
Tamarack dominant on wet peatland	17	1	5
Black spruce dominant on riparian peatland	28	6	2
Tamarack- black spruce mixture on riparian peatland	22	2	1
Tamarack dominant on riparian peatland	10		1
Tall shrub on shallow peatland	23	3.8	4
Tall shrub on wet peatland	12	0.7	3
Low vegetation on shallow peatland	10	0.5	2
Low vegetation on wet peatland	12	1.5	31
Tall shrub on riparian peatland	13	0.6	11
Low vegetation on riparian peatland	13	0.7	7
75th percentile cutoff	18.9	2.4	

* For broad habitat types where N < 3, mean number of species or rare species were estimated from the most similar habitat types that had sufficient replication. Rare species were those identified in Section 3 as being nationally, provincially or regionally rare.

Table 2E-2: Mean Number of Species for Fine Ecosite Types with More Than Three Plots Sampled in the Type in the Study Zone 4

Fine Ecosite Type	Mean Number of Species	Number of Plots
Deep dry mineral	14.9	124
Veneer bog on slope	17.4	106
Veneer bog	19.0	5
Blanket bog	15.9	21
Slope fen	21.4	5
Peat plateau bog	8.5	29
Peat plateau bog transitional stage	11.9	22
Blanket bog/ collapse scar peatland mosaic	8.3	4
Collapse scar bog	9.9	7
Collapse scar fen	10.8	4
Horizontal fen	15.5	22
Riparian fen	14.4	22

Table 2E-3: Mean Number of Species for Structural Types With More Than Five Plots Sampled in the Type in the Study Zone 4

Structure Type	Mean Number of Species	Number of Plots
Forest	17.1	18
Woodland	15.8	100
Sparsely Treed	14.2	137
Tall Shrub	18.4	25
Low Shrub	14.1	30
Bryoid	14.2	58
Sparsely Vegetated	14.2	9

Table 2E-4: Mean Percent Cover of the Three Uppermost Vegetation Strata for Treed Broad Habitat Types With at Least Three Plots Sampled in the Type in the Study Zone 4

Broad Habitat Type	N	Dominant	Sub-dominant	0.5-1.3 m
Black spruce dominant on ground ice peatland	35	9.03	8	9.66
Black spruce dominant on mineral soil	22	21.95	4.45	13.86
Black spruce dominant on shallow peatland	14	11.79	1.07	15
Black spruce dominant on thin peatland	61	12.31	5.05	10.67
Black spruce mixedwood on thin peatland	3	50	1.67	16.67
Black spruce mixture on mineral soil	45	23.71	8.78	20.64
Black spruce mixture on shallow peatland	5	19	-	21
Black spruce mixture on thin peatland	13	17.23	10.23	18.15
Jack pine dominant on mineral soil	12	40.42	0.83	24.75
Jack pine dominant on thin peatland	4	18.5	-	6.5
Jack pine mixedwood on mineral soil	8	38.75	0.63	27.13
Jack pine mixture on thin peatland	8	25.25	-	14.5
Tamarack dominant on thin peatland	3	46.67	-	36.67
Tamarack dominant on wet peatland	5	13	-	20
Tamarack mixture on shallow peatland	3	36.67	-	40
Tamarack mixture on wet peatland	3	17.33	-	20
Trembling aspen dominant on all ecosites	10	50	2.5	28
Trembling aspen mixedwood on all ecosites	5	20	2	34
White birch dominant on all ecosites	7	47.14	5.71	39.29
White birch mixedwood on all ecosites	5	46	11	16

Note: Dominant= Uppermost vegetation layer; Sub-dominant= Distinct continous vegetation layer below the dominant layer, but taller than 1.3 m. Types that have ≥20% cover in the dominant and 0.5-1.3 m strata are considered structurally complex. Some types with less than 3 plots were estimated to be structurally complex based on vegetation cover and ecosite type.

Table 2E-5: Potential Percentage of Priority Habitat Types Altered or Lost Within the Regional Study Area Due to the Project Footprints and Habitat Zone of Influence During Construction

Broad Habitat Type	Priority Criteria Met	Infra-structure	Road & Road Corridor	Camp & Work Area	Borrow Areas	Reservoir	EMPA	River Management	Flooding	PDA	Mitigation Area	Altered Water Levels	Project Footprint Total	Habitat Zone of Influence	All
Balsam poplar dominant on all ecosites	RD	-	-	-	-	0.3	-	-	-	0.2	-	-	0.4	1.4	1.9
Trembling aspen dominant on all ecosites	RD	0.2	0.1	0.0	0.4	0.2	0.2	-	0.0	0.2	0.0	-	1.5	0.4	1.9
White birch dominant on all ecosites	RD	-	0.1	-	2.4	0.5	0.1	-	0.0	0.0	-	-	3.2	0.1	3.3
Balsam poplar mixedwood on all ecosites	RDS	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trembling aspen mixedwood on all ecosites	RDS	-	0.0	-	0.2	0.3	0.0	-	0.0	0.0	0.0	-	0.6	0.5	1.1
White birch mixedwood on all ecosites	R	-	-	-	6.0	0.9	-	-	0.0	0.1	-	-	6.9	0.8	7.7
Black spruce mixedwood on mineral	R	0.0	0.1	-	0.1	0.1	0.0	-	0.0	0.1	-	-	0.3	0.3	0.6
Black spruce mixedwood on thin peatland	RDS	-	0.1	-	-	0.1	-	-	-	0.0	0.1	-	0.3	0.1	0.5
Jack pine mixedwood on mineral	RD	0.1	-	-	0.4	0.0	-	-	-	0.2	-	-	0.7	0.3	1.0
Jack pine mixedwood on thin peatland	RDS	-	0.0	0.1	0.7	-	-	-	-	-	-	-	0.8	0.9	1.6
Jack pine dominant on mineral	UDS	0.0	0.0	-	0.3	0.0	0.0	-	-	0.1	0.0	-	0.5	0.2	0.7
Jack pine dominant on thin peatland	RDS	-	-	-	0.1	-	0.5	-	-	0.0	-	-	0.5	0.6	1.1
Jack pine mixture on thin peatland	R	0.1	0.1	0.0	0.8	0.0	0.0	-	-	0.1	0.0	-	1.1	1.0	2.1
Tamarack dominant on mineral	RDS	-	0.3	-	0.9	-	-	-	-	-	-	-	1.2	0.1	1.3
Tamarack mixture on mineral	RDS	0.2	0.0	-	1.7	0.3	0.0	-	-	0.1	-	-	2.4	0.2	2.6
Black spruce dominant on mineral	U	0.0	0.0	-	0.1	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.5	0.3	0.7
Black spruce mixture on mineral	RD	0.1	0.1	-	2.1	0.6	0.1	-	0.0	0.1	0.0	-	3.2	0.7	3.8
Black spruce mixture on thin peatland	R	0.0	0.2	-	0.4	0.9	0.0	-	0.0	0.1	-	-	1.6	0.5	2.1
Tamarack dominant on thin peatland	RDS	-	-	-	0.1	0.2	-	-	-	0.0	-	-	0.4	0.2	0.6
Tamarack mixture on thin peatland	RDS	0.0	0.1	-	0.3	1.0	0.0	-	0.0	0.1	-	-	1.7	0.7	2.3
Tall shrub on mineral	RD	0.2	0.5	-	0.2	0.2	0.5	-	0.2	0.6	-	-	2.3	1.0	3.3
Tall shrub on thin peatland	RDS	-	0.3	-	0.4	0.4	0.6	-	0.1	0.2	0.0	-	1.9	0.5	2.4

Table 2E-5: Potential Percentage of Priority Habitat Types Altered or Lost Within the Regional Study Area Due to the Project Footprints and Habitat Zone of Influence During Construction

Low Vegetation on thin peatland	U	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.4	0.1	0.5
Jack pine dominant on shallow peatland	RS	-	-	-	-	-	-	-	-	-	-	-	-	0.1	0.1
Jack pine mixture on shallow peatland	RDS	-	0.0	-	-	-	-	-	-	-	-	-	0.0	1.1	1.1
Black spruce mixedwood on shallow peatland	RD	-	0.0	-	-	0.4	0.1	-	-	0.2	-	-	0.7	0.0	0.7
Jack pine mixedwood on shallow peatland	RS	-	-	-	-	-	-	-	-	-	-	-	-	0.9	0.9
Black spruce mixture on shallow peatland	RD	0.0	0.0	-	0.1	0.7	0.0	-	0.0	0.0	-	-	0.9	0.3	1.2
Black spruce dominant on wet peatland	UD	0.0	0.0	-	0.0	0.2	0.0	-	0.0	0.0	0.0	-	0.3	0.1	0.3
Black spruce mixture on wet peatland	R	-	0.0	-	-	0.1	-	-	-	0.0	-	-	0.2	0.1	0.3
Tamarack mixture on wet peatland	RD	0.0	0.0	-	-	0.2	-	-	-	0.0	-	-	0.2	0.0	0.2
Tamarack dominant on shallow peatland	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tamarack mixture on shallow peatland	RD	-	0.3	-	0.1	0.7	0.0	-	0.0	0.0	-	-	1.1	0.4	1.4
Tamarack dominant on wet peatland	R	-	-	-	-	0.1	-	-	-	0.0	-	-	0.1	0.0	0.1
Black spruce dominant on riparian peatland	RDS	0.0	0.0	-	0.0	0.3	0.0	-	0.0	0.0	-	-	0.3	0.1	0.4
Tamarack- black spruce mixture on riparian peatland	RD	-	0.0	-	-	0.3	-	-	-	0.0	-	-	0.3	0.0	0.3
Tamarack dominant on riparian peatland	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tall shrub on shallow peatland	RDS	0.0	0.0	-	-	0.2	0.0	-	0.0	0.1	0.0	-	0.3	0.2	0.6
Tall shrub on wet peatland	R	-	-	-	-	1.4	-	-	0.1	0.1	-	-	1.6	0.2	1.8
Low vegetation on shallow peatland	U	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	-	0.4	0.1	0.5
Low vegetation on wet peatland	U	0.0	0.0	-	-	0.4	0.0	0.0	0.0	0.0	0.0	-	0.5	0.1	0.6
Tall shrub on riparian peatland	R	0.0	0.0	-	0.0	1.2	0.0	0.0	1.1	0.4	0.0	0.0	2.8	0.1	2.9
Low vegetation on riparian peatland	U	0.0	0.0	-	0.0	0.5	0.0	-	0.1	0.0	0.0	0.0	0.7	0.1	0.8

Table 2E-6: Potential Percentage of Priority Habitat Types Altered or Lost Within The Regional Study Area During Construction Including Cumulative Areas For Unlikely Footprints and Their Habitat Zones of Influence

Priority Habitat Type*	Priority (R, U, D, S)	Footprints	Unlikely Ellis Esker Footprint	Unlikely ZOI (Zone 2)
Balsam poplar dominant on all ecosites	RD	6.8	6.8	10.0
Balsam poplar mixedwood on all ecosites	RDS	-	-	-
Black spruce dominant on mineral	U	5.7	5.7	6.1
Black spruce dominant on riparian peatland	RDS	5.3	5.4	5.5
Black spruce dominant on wet peatland	UD	5.3	5.3	5.4
Black spruce mixedwood on mineral	R	5.6	5.6	5.9
Black spruce mixedwood on shallow peatland	RD	5.7	5.7	5.8
Black spruce mixedwood on thin peatland	RDS	5.4	5.4	5.6
Black spruce mixture on mineral	RD	8.8	8.8	9.7
Black spruce mixture on shallow peatland	RD	6.2	6.2	6.6
Black spruce mixture on thin peatland	R	7.0	7.0	8.0
Black spruce mixture on wet peatland	R	5.2	5.2	5.3
Jack pine dominant on mineral	UDS	5.6	5.6	6.0
Jack pine dominant on shallow peatland	RS	5.0	5.0	6.8
Jack pine dominant on thin peatland	RDS	6.1	6.1	7.6
Jack pine mixedwood on mineral	RD	5.9	5.9	6.5
Jack pine mixedwood on shallow peatland	RS	5.9	5.9	7.8
Jack pine mixedwood on thin peatland	RDS	6.6	6.6	7.4
Jack pine mixture on shallow peatland	RDS	6.1	6.1	8.8
Jack pine mixture on thin peatland	R	7.0	7.0	8.2
Low vegetation on riparian peatland	U	5.8	5.8	5.9
Low vegetation on shallow peatland	U	5.4	5.4	5.6
Low vegetation on thin peatland	U	5.5	5.5	5.7
Low vegetation on wet peatland	U	5.5	5.5	5.7
Tall shrub on mineral	RD	8.2	8.2	8.8
Tall shrub on riparian peatland	R	7.9	7.9	8.0
Tall shrub on shallow peatland	RDS	5.5	5.5	5.8
Tall shrub on thin peatland	RDS	7.3	7.3	7.9
Tall shrub on wet peatland	R	6.7	6.7	7.0
Tamarack- black spruce mixture on riparian peatland	RD	5.3	5.3	5.4
Tamarack dominant on mineral	RDS	6.3	6.3	6.7
Tamarack dominant on riparian peatland	R	-	-	-
Tamarack dominant on shallow peatland	R	-	-	-
Tamarack dominant on thin peatland	RDS	5.5	5.5	5.8
Tamarack dominant on wet peatland	R	5.0	5.0	5.1
Tamarack mixture on mineral	RDS	7.6	7.7	8.3
Tamarack mixture on shallow peatland	RD	6.4	6.4	7.0
Tamarack mixture on thin peatland	RDS	7.3	7.4	8.1
Tamarack mixture on wet peatland	RD	5.2	5.2	5.2
Trembling aspen dominant on all ecosites	RD	6.9	6.9	7.2
Trembling aspen mixedwood on all ecosites	RDS	6.1	6.1	7.0
White birch dominant on all ecosites	RD	8.3	8.3	8.6
White birch mixedwood on all ecosites	R	12.7	12.7	13.2
Number of priority habitat types with >1% of Historical RSA area impacted		40	40	36
Number of priority habitat types with >10% of Historical RSA area impacted		1	1	2

Note: Cells with 0 values are values that round to 0 while "-" cells indicate a value of 0.

APPENDIX 2F
WETLAND FUNCTION

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2.19 APPENDIX 2F: WETLAND FUNCTION

Table 2F-1: Functions Performed by Wetland Classes, Forms and Subforms from Hanson *et al.* (2006)

Wetland Class	Function	Value	Function Level	Attributes	Wetland Sub-Forms Applicable To If Not All	Probable Performance of Service
BOG	Hydrological	Water Flow Moderation (flood protection)	Low	Capacity is related to volume difference between the maximum high-water and normal water level in wetland and size of the wetland compared to size of watershed. Value of function increases with increasing downstream at-risk infrastructure.		Generally low performance. Bogs are typically isolated from surface water inputs. Studies find that headwater wetlands increase the immediate response of rivers to rainfall because saturated soils convey rainfall rapidly.
BOG	Hydrological	Groundwater Recharge	Low	Variable and difficult to quantify. Depends on basin shape, location within the watershed, substrate, local groundwater gradients, etc.	Bogs in permafrost regions, riparian, floating, shore, and slope.	Performance is low. Bogs in permafrost regions provide little opportunity for groundwater recharge. Riparian, shore and slope bogs may be located in areas of groundwater discharge. Floating bogs have no potential to directly recharge groundwater.
BOG	Hydrological	Groundwater Recharge	Variable	Variable and difficult to quantify. Depends on basin shape, location within the watershed, substrate, local groundwater gradients, etc.	Mound, dome, plateau, collapse, or scar.	Variable performance expected. Areas of groundwater recharge and discharge may be located in a single bog. Recharge may occur at the bog perimeter, or within the bog where underlying soils are permeable and the flow gradient is towards groundwater. Bogs located in topographic highs with thin peat deposits may have a higher probability of performance compared to bogs in low-lying areas.
BOG	Hydrological	Shoreline and Erosion Protection	Low	Presence/absence of wetland in shoreline area. Erodibility of terrestrial region inland of wetland is related to composition of substrate and energy of adjacent water body. Value related to adjacent terrestrial land use.		Generally low performance, unless in coastal areas. Bogs are typically present in low energy environments where erosion is not expected to be significant.
BOG	Hydrological	Climate Regulation	Low	May be related to evapo-transpiration rates and the size of the wetland.		Generally low performance. Bog communities have adapted to retain surface water, are perched above local water tables and may be associated with low evapotranspiration rates.
BOG	Biogeochemical	Water Quality Treatment	Low	Physical, chemical and biological water quality treatment is a function of the constituents of concern, the loading rates, water balance and hydroperiod, the substrate and vegetation assemblages. The performance can be estimated through chemistry monitoring and water budget estimates. The value is related to the sensitivity or use of receiving waters.		Generally low performance. Bogs are typically isolated from surface water inputs.
BOG	Biogeochemical	Nutrient and Organic Export	High	Export of nutrients and organic carbon to streams can increase primary productivity and subsequently the aquatic food chain. Peat lands and swamps are known to contribute to metabolism in stream ecosystems in this way; however, the internal dynamics are complex and not well understood.		Potentially high performance. Soluble, partially decomposed organic matter and associated nutrients produced in pore waters are flushed to down gradient water bodies during precipitation and high water events. May be a sink for nutrients (low export).
BOG	Biogeochemical	Carbon Sequestration and Storage	High	The key attributes are the volume and degree of decomposition (humification) of peat, and volume of woody and ericaceous biomass. Carbon balance studies of wetland types in various climates may provide estimates of uptake; carbon uptake rates are highly variable within and between wetlands.		Potentially high performance. Atmospheric carbon is stored in peat and woody biomass on the order of decades to millennia. Moderately decomposed sphagnum peat with buried woody remains offers high potential for release of carbon if the wetland is disturbed or altered.
BOG	Habitat	Biological Productivity and Support for Biodiversity	High	Presence or absence of significant species, and abundance of significant species. Significant species include species at risk, species related to recreation or subsistence, and commercially valued species.		Potentially high performance. Assessment requires site specific evaluation of the presence and abundance of locally valued species. Sources may include local museums, interviews with relevant stakeholders, site visits, local and provincial / territorial rare species databases, research documents, etc.
FEN	Hydrological	Water Flow Moderation Services (flood and storm protection)	Moderate	Capacity is related to volume difference between the maximum high-water and normal water level in wetland and size of the wetland compared to size of watershed. Value of function increases with increasing downstream at risk infrastructure.		Moderate performance. Small water table fluctuation provides some opportunity for additional storm flow storage; however, performance is seasonal and variable depending on morphology and placement within the watershed.

Table 2F-1: Functions Performed by Wetland Classes, Forms and Subforms from Hanson *et al.* (2006)

Wetland Class	Function	Value	Function Level	Attributes	Wetland Sub-Forms Applicable To If Not All	Probable Performance of Service
FEN	Hydrological	Groundwater Recharge	Variable	Variable and difficult to quantify, and depends on basin shape, location within the watershed, substrate, local groundwater gradients, etc.		Variable to low performance expected. Highly decomposed gramminoid peat provides an impermeable layer to vertical flow. Recharge may occur at the margins of the peat.
FEN	Hydrological	Shoreline and Erosion Protection	Variable	Presence/absence of wetland in shoreline area. Erodability of terrestrial region inland of wetland is related to composition of substrate and energy of adjacent water body. Value related to the use of terrestrial land adjacent to wetland.		Variable performance. Fens are typically present in low energy environments where erosion is not expected to be significant. Assessment requires site specific evaluation.
FEN	Hydrological	Climate Regulation	Moderate	Will be related to evapotranspiration rates and the size of the wetland.		Potentially moderate performance. A mix of emergent herbaceous plants and shrubs may be associated with moderate rates of evapotranspiration.
FEN	Biogeochemical	Water Quality Treatment	High	Physical, chemical and biological water quality treatment is a function of the constituents of concern, the loading rates, water balance and hydroperiod, the substrate and vegetation assemblages. The performance can be estimated through chemistry monitoring and water budget estimates. The value is related to the sensitivity or use of receiving waters.		Potentially high performance due to a combination of physical processes, high interaction between water and root-bacteria assemblages, flow through substrate, and heterogeneity in oxidation. Performance is largely dependent on loading rates and the particular constituents of concern. Generalizations are not possible.
FEN	Biogeochemical	Nutrient and Organic Export	High	Export of nutrients and organic carbon to streams can fuel bacteria and subsequently the aquatic food chain. Peat lands and swamps are known to contribute to metabolism in stream ecosystems in this way; however, the internal dynamics are complex and not well understood.		Potentially high performance. Soluble, partially decomposed organic matter and associated nutrients produced in pore waters are flushed to down gradient water bodies during precipitation and high water events. May be a sink for nutrients (low export).
FEN	Biogeochemical	Carbon Sequestration and Storage	High	The key attributes are the volume and degree of decomposition (humification) of peat, and volume of woody and ericaceous biomass. Carbon balance studies of wetland types in various climates may provide estimates of uptake; carbon uptake rates are highly variable within and between wetlands.		Potentially high performance. Atmospheric carbon is stored in peat and woody biomass on the order of decades to millennia. Highly decomposed peat and the general lack of trees suggest lower carbon storage than the bog form.
FEN	Habitat	Biological Productivity and Support for Biodiversity	High	Presence or absence of significant species, and abundance of significant species. Significant species include species at risk, species related to recreation or subsistence, and commercially valued species.		Potentially high performance. Assessment requires site specific evaluation of the presence and abundance of locally valued species. Sources may include local museums, interviews with relevant stakeholders, site visits, local and provincial / territorial rare species databases, research documents, etc.
MARSH	Hydrological	Water Flow Moderation Services (flood and storm protection)	Low	Capacity is related to volume difference between the maximum high-water and normal water level in wetland and size of the wetland compared to size of watershed. Value of function increases with increasing downstream at-risk infrastructure.	Tidal, estuarine, riparian, lacustrine, slope	Low to high performance. Marshes adjacent to watercourses, lakes and the ocean generally derive water from flood events in that body of water rather than from landscape runoff inputs. Riparian and floodplain marshes may provide significant storm water retention if there is a significant area of marsh present on the watercourse.
MARSH	Hydrological	Water Flow Moderation Services (flood and storm protection)	High	Capacity is related to volume difference between the maximum high-water and normal water level in wetland and size of the wetland compared to size of watershed. Value of function increases with increasing downstream at-risk infrastructure.	Basin, hummock, spring.	Potentially high performance. Fluctuations in water level and the size of the wetland provide an indication of the capacity for the wetland to store storm flow. Marshes located high in the watershed, up-gradient of developed areas can be expected to provide significant storm flow moderation services.
MARSH	Hydrological	Groundwater Recharge	Low	Variable and difficult to quantify, and depends on basin shape, location within the watershed, substrate, local groundwater gradients, etc.	Tidal, estuarine, riparian, spring, lacustrine, slope, some basin marshes.	Low performance expected. Fringe marshes located adjacent to water bodies are likely to have upward gradients in subsurface water. Wetlands located in topographic lows are typically sites of groundwater discharge. Recharge may occur in seasonal dry periods.
MARSH	Hydrological	Groundwater Recharge	Moderate	Variable and difficult to quantify, and depends on basin shape, location within the watershed, substrate, local groundwater gradients, etc.	Basin, hummock marshes.	Moderate to variable performance expected. Basins are typically areas of groundwater discharge; however, marshes located in prairie potholes, craters, cirques and vernal pools have demonstrated groundwater recharge potential. Marshes located in topographic highs may raise local water tables through recharge.

Table 2F-1: Functions Performed by Wetland Classes, Forms and Subforms from Hanson *et al.* (2006)

Wetland Class	Function	Value	Function Level	Attributes	Wetland Sub-Forms Applicable To If Not All	Probable Performance of Service
MARSH	Hydrological	Shoreline and Erosion Protection	High	Presence/absence of wetland in shoreline area. Erodability of terrestrial region inland of wetland is related to composition of substrate and energy of adjacent water body. Value related to the use of terrestrial land adjacent to wetland.	Tidal, riparian, lacustrine, estuarine.	Potentially high performance. Tidal marshes and riparian marshes adjacent to channels, floodplains, lakes and rivers are particularly important for capturing and depositing sediment (land creation), dissipating high- energy flows and waves, and maintaining cohesion of shoreline materials. Other marsh sub-forms have variable roles in shoreline and erosion protection.
MARSH	Hydrological	Climate Regulation	High	May be related to evapotranspiration rates and the size of the wetland.		Potentially high performance. Dense communities of herbaceous plant species adapted to fluctuating water tables may be associated with high rates of evapotranspiration.
MARSH	Hydrological	Water Quality Treatment	High	Physical, chemical and biological water quality treatment is a function of the constituents of concern, the loading rates, water balance and hydroperiod, the substrate and vegetation assemblages. The performance can be estimated through chemistry monitoring and water budget estimates. The value is related to the sensitivity or use of receiving waters.		Potentially high performance due to a combination of physical processes, high interaction between water and root-bacteria assemblages, flow through substrate, and heterogeneity in oxidation. Performance may be estimated through inflow and outflow constituent monitoring, taking into account dilution, storm events discharges, and seasonal vegetation die off. Performance is largely dependent on loading rates and the particular constituents of concern. Generalizations are not possible.
MARSH	Biogeochemical	Nutrient and Organic Export	Variable	Export of nutrients and organic carbon to streams can fuel bacteria and subsequently the aquatic food chain. Marshes are known to contribute to metabolism in stream ecosystems in this way; however, the internal dynamics are complex and not well understood.		Variable performance. Actual performance due to a combination of both physical processes, high interaction between water and root-bacteria assemblages, flow through substrate, and heterogeneity in oxidation. These wetlands may mitigate upstream nutrient inputs, resulting in a net sink. Performance may be estimated through inflow and outflow constituent monitoring, taking into account dilution, storm events discharges, and seasonal vegetation die off.
MARSH	Biogeochemical	Carbon Sequestration and Storage	Moderate	The key attributes are the volume and degree of decomposition (humification) of peat, and volume of woody and ericaceous biomass. Carbon balance studies of wetland types in various climates may provide estimates of uptake; carbon uptake rates are highly variable within and between wetlands.	Tidal, lacustrine, and riparian marshes.	Moderate performance. Fluctuating water levels allow soil oxidation and release of stored carbon. High productivity of biomass provides significant sequestration of atmospheric carbon; however, rates of decomposition and metabolism are high and, thus, on an annual basis sequestration can be variable.
MARSH	Biogeochemical	Carbon Sequestration and Storage	Moderate	The key attributes are the volume and degree of decomposition (humification) of peat, and volume of woody and ericaceous biomass. Carbon balance studies of wetland types in various climates may provide estimates of uptake; carbon uptake rates are highly variable within and between wetlands.	Riparian, basin, hummock, lacustrine, spring, and slope marshes.	Moderate to high performance. Under persistent inundation organic soils may accumulate. Vegetation productivity in rich conditions may be greater than decomposition in persistent anaerobic conditions.
MARSH	Habitat	Biological Productivity and Support for Biodiversity	Variable	Presence or absence of significant species, and abundance of significant species. Significant species include species at risk, species related to recreation or subsistence, and commercially valued species.		Performance is highly variable, but can be very high. Does not fit into a categorical framework of function. Assessment requires site specific evaluation of the presence and abundance of locally valued species. Sources may include local museums, interviews with relevant stakeholders, site visits, local and provincial / territorial rare species databases, research documents, etc.
SWAMP	Hydrological	Water Flow Moderation Services (flood and storm protection)	Low	Capacity is related to volume difference between the maximum high-water and normal water level in wetland and size of the wetland compared to size of watershed. Value of function increases with increasing downstream at risk infrastructure.	Discharge swamp, mineral rise swamp, raised peatland, slope swamp, tidal swamp.	Generally low performance. The typical topography and watershed position of these wetlands suggest that they have little capacity to capture and store storm water.

Table 2F-1: Functions Performed by Wetland Classes, Forms and Subforms from Hanson *et al.* (2006)

Wetland Class	Function	Value	Function Level	Attributes	Wetland Sub-Forms Applicable To If Not All	Probable Performance of Service
SWAMP	Hydrological	Water Flow Moderation Services (flood and storm protection)	High	Capacity is related to volume difference between the maximum high-water and normal water level in wetland and size of the wetland compared to size of watershed. Value of function increases with increasing downstream at risk infrastructure.	Riparian flat swamp, inland swamp.	Potentially high performance. Treed riparian areas with a full understory act to capture flood waters, slow velocities and store flood water on the order of days to weeks, depending on the size, morphology and location within the watershed. The location of the swamp at the bottom of a watershed or on the shore of a large water body suggests that any storm flow moderation services would be insignificant in the context of the watershed size of the receiving body. Flat swamps are generally fed by surface runoff and experience water level fluctuations, indicating a capacity during low water periods to accommodate additional storm water inputs.
SWAMP	Hydrological	Groundwater Recharge	Low	Variable and difficult to quantify, and depends on basin shape, location within the watershed, substrate, local groundwater gradients, etc.	Discharge, riparian, tidal, inland salt swamp or slope swamp.	Generally low performance. The typical hydrology giving rise to these systems suggests that groundwater recharge potential is low.
SWAMP	Hydrological	Groundwater Recharge	Variable	Variable and difficult to quantify, and depends on basin shape, location within the watershed, substrate, local groundwater gradients, etc.	Raised peatland, flat or mineral-rise swamp.	Unknown potential for performance. Depends on site specific morphology, substrate, and location within the watershed flow system.
SWAMP	Hydrological	Shoreline and Erosion Protection	High	Presence/absence of wetland in shoreline area. Erodability of terrestrial region inland of wetland is related to composition of substrate and energy of adjacent water body. Value related to the use of terrestrial land adjacent to wetland.	Riparian and tidal swamps.	Potentially high performance. Tidal swamps and those riparian swamps adjacent to channels, floodplains, lakes and rivers are particularly important for capturing and depositing sediment (land creation), dissipating high-energy flows and waves, and maintaining cohesion of shoreline materials. Other swamp sub- forms have variable roles in shoreline and erosion protection in comparison to terrestrial and engineered systems, depending on site specific conditions.
SWAMP	Hydrological	Climate Regulation	Moderate	May be related to evapotranspiration rates and the size of the wetland.		Potentially moderate performance. A mix of emergent herbaceous plants and shrubs may be associated with moderate rates of evapotranspiration.
SWAMP	Biogeochemical	Water Quality Treatment	High	Physical, chemical and biological water quality treatment is a function of the constituents of concern, the loading rates, water balance and hydroperiod, the substrate and vegetation assemblages. The performance can be estimated through chemistry monitoring and water budget estimates. The value is related to the sensitivity or use of receiving waters.		Potentially high performance due to a combination of physical processes, high interaction between water and root-bacteria assemblages, flow through substrate, and heterogeneity in oxidation. Performance may be estimated through inflow and outflow constituent monitoring, taking into account dilution, storm events discharges, and seasonal vegetation die off. Performance is largely dependent on loading rates and the particular constituents of concern. Generalizations are not possible.
SWAMP	Biogeochemical	Nutrient and Organic Export	Variable	Export of nutrients and organic carbon to streams can fuel bacteria and subsequently the aquatic food chain. Peat lands and swamps are known to contribute to metabolism in stream ecosystems in this way; however, the internal dynamics are complex and not well understood.		Variable performance. Actual performance due to a combination of physical processes, high interaction between water and root-bacteria assemblages, flow through substrate, and heterogeneity in oxidation. These wetlands may mitigate upstream nutrient inputs, resulting in a net sink. Performance may be estimated through inflow and outflow constituent monitoring, taking into account dilution, storm events discharges, and seasonal vegetation die off.
SHALLOW WATER	Hydrological	Water Flow Moderation Services (flood and storm protection)	High	Capacity is related to volume difference between the maximum high-water and normal water level in wetland and size of the wetland compared to size of watershed. Value of function increases with increasing downstream at risk infrastructure.	Basin.	Potentially high performance. Fluctuations in water level and the size of the wetland provide an indication of the capacity for the wetland to store storm flow. The location of the shallow water wetland at the bottom of a watershed suggests that any storm flow moderation services would be insignificant in the context of the watershed size of the receiving body.
SHALLOW WATER	Hydrological	Water Flow Moderation Services (flood and storm protection)	Low	Capacity is related to volume difference between the maximum high-water and normal water level in wetland and size of the wetland compared to size of watershed. Value of function increases with increasing downstream at risk infrastructure.	Tidal, estuarine, lacustrine, riparian.	Generally low performance. Shallow water wetlands without basin morphology have a low probability of collecting and retaining significant amounts of storm flow from the adjacent landscape. The location of the wetland at the bottom of a watershed or on the shore of a large water body suggests that any storm flow moderation services would be insignificant in the context of the watershed size of the receiving body.

Table 2F-1: Functions Performed by Wetland Classes, Forms and Subforms from Hanson *et al.* (2006)

Wetland Class	Function	Value	Function Level	Attributes	Wetland Sub-Forms Applicable To If Not All	Probable Performance of Service
SHALLOW WATER	Hydrological	Groundwater Recharge	Variable	Variable and difficult to quantify, and depends on basin shape, location within the watershed, substrate, local groundwater gradients, etc.		Unknown potential for performance. Depends on site specific conditions.
SHALLOW WATER	Hydrological	Shoreline and Erosion Protection	Moderate	Presence/absence of wetland in shoreline area. Erodability of terrestrial region inland of wetland is related to composition of substrate and energy of adjacent water body. Value related to the use of terrestrial land adjacent to wetland.	Estuarine, lacustrine and riparian.	Potentially moderate performance. Submerged vegetation may contribute to dissipating and buffering high energy flows and wave activity prior to entering adjacent emergent wetland system.
SHALLOW WATER	Hydrological	Shoreline and Erosion Protection	Low	Presence/absence of wetland in shoreline area. Erodability of terrestrial region inland of wetland is related to composition of substrate and energy of adjacent water body. Value related to the use of terrestrial land adjacent to wetland.	Basin.	Generally low performance. Basin form shallow water wetlands are not typically in a position in the landscape to provide shoreline and erosion protection.
SHALLOW WATER	Hydrological	Climate Regulation	Moderate	May be related to evapotranspiration rates and the size of the wetland.		Potentially moderate performance. Standing open water and a mix of emergent and submergent plant species may be associated with moderate rates of evapotranspiration.
SHALLOW WATER	Biogeochemical	Water Quality Treatment	High	Physical, chemical and biological water quality treatment is a function of the constituents of concern, the loading rates, water balance and hydroperiod, the substrate and vegetation assemblages. The performance can be estimated through chemistry monitoring and water budget estimates. The value is related to the sensitivity or use of receiving waters.		Potentially high performance due to settling, photo- degradation and aeration. Performance is largely dependent on loading rates and constituents of concern. May be estimated through inflow and outflow constituent monitoring, taking into account dilution and seasonal events such as water column turnover and vegetation die off.
SHALLOW WATER	Biogeochemical	Nutrient and Organic Export	Low	Export of nutrients and organic carbon to streams can fuel bacteria and subsequently the aquatic food chain. Peat lands and swamps are known to contribute to metabolism in stream ecosystems in this way; however, the internal dynamics are complex and not well understood.		Generally low performance. Labile organic matter and nutrients released from root exudates and the decomposition of biomass are circulated and used within the water column.
SHALLOW WATER	Biogeochemical	Carbon Sequestration and Storage	Variable	The key attributes are the volume and degree of decomposition (humification) of peat, and volume of woody and ericaceous biomass. Carbon balance studies of wetland types in various climates may provide estimates of uptake; carbon uptake rates are highly variable within and between wetlands.		Variable performance. Significant seasonal productivity of biomass results in seasonal uptake. Rates of decomposition and metabolism are high and, thus, on an annual basis sequestration is typically low.
SHALLOW WATER	Habitat	Biological Productivity and Support for Biodiversity	Variable	Presence or absence of significant species, and abundance of significant species. Significant species include species at risk, species related to recreation or subsistence, and commercially valued species.		Performance is highly variable, and does not fit into a categorical framework of function. Assessment requires site specific evaluation of the presence and abundance of locally valued species. Sources may include local museums, interviews with relevant stakeholders, site visits, local and provincial / territorial rare species databases, etc.

APPENDIX 2G
SOIL QUANTITY AND QUALITY

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2.20 APPENDIX 2G: SOIL QUANTITY AND QUALITY

Table 2G-1: Inland Fine Ecosite Composition in the Project Footprints During Construction

Fine Ecosite Type	Infra-structure	Road & Road Corridor	Camp & Work Area	Borrow Areas	Reservoir	EMPA	River Management	Flooding	PDA	Mitigation Area	Altered Water Levels	Total Footprints	Zone of Influence	All
Outcrop	-	-	-	-	0.0	-	-	-	0.0	-	-	0.0	-	0.0
Shallow/ thin mineral	0.7	0.0	-	0.8	0.3	1.9	0.5	1.9	1.1	12.7	23.0	0.8	2.1	1.1
Deep dry mineral	32.2	15.3	17.7	34.7	7.8	18.3	18.9	3.8	19.8	24.2	13.7	17.0	21.4	18.0
Deep wet mineral	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Veneer bog on slope	44.5	55.9	56.8	46.7	31.2	42.2	56.1	8.6	34.7	40.6	12.4	38.3	44.3	39.6
Veneer bog	2.5	0.4	0.1	1.1	1.6	0.4	0.8	0.0	2.4	7.2	-	1.5	0.9	1.4
Blanket bog	7.3	17.7	12.0	12.2	26.7	13.4	16.6	11.0	15.9	8.2	-	19.5	17.7	19.1
Slope bog	-	0.6	0.2	0.3	0.5	0.5	-	0.1	0.4	0.0	-	0.4	0.4	0.4
Slope fen	-	0.1	-	-	0.3	0.2	-	0.5	0.1	-	-	0.2	0.1	0.2
Peat plateau bog	0.5	0.1	0.1	0.1	1.6	0.4	-	0.6	0.8	0.0	-	0.9	0.7	0.8
Peat plateau bog transitional stage	4.5	0.9	0.4	0.8	6.2	7.2	0.1	2.0	4.8	1.6	-	4.0	2.0	3.6
Peat plateau bog/ collapse scar peatland mosaic	7.3	5.8	12.6	3.2	11.9	14.9	7.0	7.1	10.3	2.2	-	8.9	7.1	8.5
Blanket bog/ collapse scar peatland mosaic	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 2G-1: Inland Fine Ecosite Composition in the Project Footprints During Construction

Horizontal fen/ blanket bog mosaic	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Basin fen	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flat bog	0.1	0.1	-	-	1.3	-	-	0.0	0.3	-	-	0.6	0.2	0.5
Horizontal fen	0.2	2.1	-	-	3.5	0.0	-	2.1	1.2	1.9	-	2.0	1.5	1.9
String fen	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Riparian bog	-	-	-	-	0.3	-	-	0.2	0.0	-	-	0.2	0.0	0.1
Riparian fen	0.1	0.9	0.1	0.2	6.9	0.6	0.0	62.1	8.2	1.3	50.9	5.7	1.5	4.8
Total land area (ha)	*260*	*709*	*152*	*1,575*	*3,374*	*251*	*14*	*183*	*628*	*137*	*6*	*7,287*	*2,034*	*9,321*

Table 2G-2: Summary of Inland Fine Ecosite Composition in the Overall Project Footprints and Habitat Zone of Influence During Construction and the 30-Year Operation Periods

Fine Ecosite Type	Construction	% Land Area	Operation	% Land Area
Outcrop	0	0.0	0	0.0
Shallow/ thin mineral	100	1.1	100	1.0
Deep dry mineral	1,677	18.0	1,644	16.8
Deep wet mineral	-	-	-	-
Veneer bog on slope	3,690	39.6	3,859	39.3
Veneer bog	127	1.4	128	1.3
Blanket bog	1,783	19.1	1,897	19.3
Slope bog	37	0.4	41	0.4
Slope fen	14	0.2	17	0.2
Peat plateau bog	77	0.8	85	0.9
Peat plateau bog transitional stage	334	3.6	384	3.9
Peat plateau bog/ collapse scar peatland mosaic	794	8.5	909	9.3
Blanket bog/ collapse scar peatland mosaic	-	-	-	-
Horizontal fen/ blanket bog mosaic	-	-	-	-
Basin fen	-	-	-	-
Flat bog	50	0.5	50	0.5
Horizontal fen	179	1.9	202	2.1
String fen	-	-	-	-
Riparian bog	11	0.1	11	0.1
Riparian fen	447	4.8	479	4.9
Total land area (ha)	*9,321*		*9,807*	

Note:

Table 2G-3: Inland Fine Ecosite Composition (%) of the Potential but Unlikely Ellis Esker Borrow Area (E-1) Footprint During Construction

Fine Ecosite Type	Unlikely Footprints			Habitat Zone of Influence	Total
	Borrow Area E-1	Access Road	Both		
Deep dry mineral	82.8	3.3	42.7	9.2	28.0
Veneer bog on slope	11.3	34.0	22.8	35.5	28.3
Blanket bog	-	34.3	17.3	21.5	19.1
Slope bog	-	1.0	0.5	0.6	0.6
Peat plateau bog	-	2.0	1.0	1.3	1.1
Peat plateau bog transitional stage	-	1.5	0.8	1.3	1.0
Peat plateau bog/ collapse scar peatland mosaic	5.9	15.1	10.5	23.8	16.4
Flat bog	-	2.8	1.4	2.6	1.9
Horizontal fen	-	3.6	1.8	2.6	2.2
Riparian fen	-	2.4	1.2	1.5	1.4
Total land area (ha)	*40*	*41*	*80*	*63*	*143*

Table 2G-4: Composition (%) of Inland Fine Ecosites Lost During Initial Flooding, and the Predicted Expansion Area for Time Periods up to the First 30 Years of Project Operation

Fine Ecosite Type	Initial Flooding	Year 1	Years 2 to 5	Years 6 to 15	Years 16 to 30	Total
Outcrop	-	-	-	0.0	-	0.0
Shallow/ thin mineral	0.5	1.9	0.7	0.5	0.0	0.5
Deep dry mineral	8.3	54.7	16.0	8.7	3.5	8.8
Veneer bog on slope	32.2	6.7	37.1	38.6	28.2	32.4
Veneer bog	1.9	0.0	1.4	0.8	0.9	1.8
Blanket bog	24.4	4.6	16.4	25.4	28.7	24.1
Slope bog	0.5	0.1	0.4	0.5	1.1	0.5
Slope fen	0.3	0.1	0.2	0.6	0.3	0.3
Peat plateau bog	1.4	0.0	1.7	2.1	2.5	1.5
Peat plateau bog transitional stage	5.6	0.4	2.4	3.2	6.7	5.3
Peat plateau bog/ collapse scar peatland mosaic	11.0	5.2	10.9	15.8	21.3	11.6
Flat bog	1.1	0.3	0.6	0.7	0.7	1.0
Horizontal fen	3.1	5.8	1.9	2.0	4.3	3.1
Riparian bog	0.3	0.0	0.0	-	-	0.2
Riparian fen	9.4	20.1	10.1	1.1	1.7	8.8
Total land area (ha)	*3,976*	*36*	*179*	*263*	*173*	*4,627*

Table 2G-5: Net Area (ha) of Inland Fine Ecosite Types Affected at Year 30 of Project Operation

Fine Ecosite Type	Permanent habitat loss			Permanent habitat alteration		Temporary habitat Alteration	Total Area
	Infra-structure/ Dewatered areas	Initial Flooding	Reservoir Expansion	Indirect reservoir effects	Other long term indirect effects	Undisturbed potential construction areas and regenerating construction areas	
Outcrop	-	-	0.0	-	-	-	0.0
Shallow/ thin mineral	0.4	0.5	0.5	2.7	0.8	1.7	1.0
Deep dry mineral	19.3	8.3	11.8	24.8	15.6	31.7	16.8
Deep wet mineral	-	-	-	-	-	-	-
Veneer bog on slope	51.9	32.2	33.7	38.7	46.7	46.6	39.3
Veneer bog	0.7	1.9	1.0	1.2	1.0	0.5	1.3
Blanket bog	15.7	24.4	22.7	14.3	18.9	12.3	19.3
Slope bog	0.4	0.5	0.6	0.5	0.5	0.2	0.4
Slope fen	0.0	0.3	0.4	0.2	0.1	-	0.2
Peat plateau bog	0.1	1.4	2.0	0.6	0.4	0.1	0.9
Peat plateau bog transitional stage	2.0	5.6	3.8	4.1	3.3	1.4	3.9
Peat plateau bog/ collapse scar peatland mosaic	6.2	11.0	15.3	9.2	8.3	5.4	9.3
Blanket bog/ collapse scar peatland mosaic	-	-	-	-	-	-	-
Horizontal fen/ blanket bog mosaic	-	-	-	-	-	-	-
Basin fen	-	-	-	-	-	-	-
Flat bog	0.1	1.1	0.7	0.0	0.1	-	0.5
Horizontal fen	2.0	3.1	2.8	1.5	1.8	0.0	2.1
String fen	-	-	-	-	-	-	-
Riparian bog	-	0.3	0.0	0.0	-	-	0.1
Riparian fen	1.2	9.4	4.8	2.1	2.4	0.2	4.9
Total land area (ha)	*781*	*3,976*	*651*	*1,250*	*1,394*	*1,755*	*9,807*