Keeyask Generation Project

Environmental Impact Statement

Supporting Volume

Physical Environment

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KEEYASK
Hydropower Limited Partnership

June 2012

KEEYASK GENERATION PROJECT

PHYSICAL ENVIRONMENT

SUPPORTING VOLUME

DEBRIS

June 2012

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10.0 DEBRIS

10.1 INTRODUCTION

Debris referred to in this section of the Physical Environment Supporting Volume (PE SV) is woody vegetation and other **organic** material (*i.e.*, floating and suspended **peat**) that impedes the desired use or aesthetic appreciation of a waterway. Development of hydropower generation alters the natural **hydraulic** characteristics of a river and the water bodies located within the **generating station's hydraulic zone of influence**, which can affect **debris processes** in the waterway. The **Keeyask Generation Project** ("the **Project**") will result in the production of debris from the **open water** hydraulic zone of influence. This includes woody debris, as the soils supporting trees, shrubs, *etc.*, are eroded into the water, and peat material, as peatlands are eroded. Debris has the potential to increase operating costs, reduced safety during river navigation, a reduced ability to harvest resources, negatively **impact** the surrounding **environment**, and create unappealing **landscapes** within the **Project footprint**.

The purpose of this section is to characterize and quantify where practicable, the existing debris situation and predict how this might change with the proposed Project. This section also describes the **mitigation** measures incorporated into the Project to minimize debris and associated **environmental effects** due to debris. Assessment of the potential **effects** of the future debris environment on the **aquatic** and **terrestrial** environments is considered in the supporting volumes dedicated to those topics.

10.2 APPROACH AND METHODOLOGY

10.2.1 Overview to Approach

To understand the current debris environment and how it might change if the Project is constructed requires an understanding of the factors that shaped the present environment. To do this, information was collected from a variety of sources followed by a synthesis of this information.

A good source of data to assist in understanding debris is Manitoba Hydro's Waterways Management Program (**Joint Keeyask Development Agreement** (JKDA), Schedule 11-2). This program is comprised of several components including two-person boat patrols, debris clearing, and shoreline stabilization. Boat patrols travel the entire **reach** between Split Lake and Gull Rapids once per week. Using a GPS, the patrols map and record the routes travelled by boat, mark deadheads and reefs, identify debris work areas, place hazard markers identifying safe travel routes for resource users, gather floating debris, deadheads, old nets etc. and relocate them to safe areas. Debris that is collected is piled on the shore where it is burned after first snowfall. If a **camp** is situated near a debris pile, the debris will not be burned so that it can be used by campers for firewood. Since 2003 the program has recorded information including shoreline classification, locations of the floating debris, number of floating debris pieces removed and deadheads and reefs marked or removed, and locations are recorded using a GPS where appropriate. This information provides the basis for characterizing the amount and spatial distribution of floating debris that presents a navigation hazard.

To further characterize the type and density of existing debris in the Keeyask **study area**, representative areas of the shoreline were photographed and video taped. GPS referenced shoreline video was collected by Manitoba Hydro on August 19 and September 21 of 2003. The video coverage extended from the outlet of Clark Lake to the inlet of Stephens Lake. Video coverage included the shorelines on the north and south sides of the river, islands and larger tributaries. The video was collected from a helicopter at a height of approximately 30-60 m above the ground. GPS referenced photographs of the shoreline collected on June 25 to July 1, 2003, July 14 to 15, 2003, and September 1, 2008, were also reviewed to identify shoreline debris in these 2 years. At the time when shoreline video and photos were obtained in September 2003, Nelson River **flows** and water levels were at the lowest levels on record since 1977 and the inception of the **Churchill River Diversion** (CRD) and **Lake Winnipeg Regulation** (LWR). Water levels and flows at the beginning of September 2008 were in the top 5% of measured flow and water levels for that time of year since the CRD and LWR became operational. This information was therefore gathered during low-flow conditions in 2003 and high-flow conditions in 2008 to assess if the type, density and spatial distribution of debris changes during the intervening years as a result of variations in the factors that drive the debris process. Debris types and densities along the shorelines in both years were mapped using GIS and then compared to maps of **land cover type**, shoreline **erosion** due to ice processes, and forest fires to characterize the sources of debris.

The amount of peat debris that may result without mitigation is quantified in the shoreline erosion processes study (Section 6, Shoreline Erosion Processes) and the **sedimentation** study (Section 7, Sedimentation). The amount of woody debris that may result without mitigation is not quantified because plans to manage and minimize the **adverse** effects of woody debris were developed early in the Keeyask planning process. Plans to manage and minimize woody debris are fundamental components of the JKDA between Manitoba Hydro and KCNs and are fundamental components of the Project design.

10.2.2 Woody Debris Classification

Woody debris on waterbodies exists in several different forms. Through debris management programs along other waterways (*e.g.*, Burntwood River) Manitoba Hydro has developed seven broad categories in which debris may be classified:

1. Beached Woody Debris: debris that is found at or above the average water level along the shore (Photo 10.2-1 and Photo 10.2-2).
2. Standing Dead Trees: flooded trees that are still standing but no longer alive (Photo 10.2-5).
3. Rafted Woody Debris: floating debris that is interlocked and “rafted” together. This debris can either be rafted adjacent to, but not on the shoreline due to the existing quantity of beached woody debris or lack of a shoreline beach, or it can be a mat of debris that becomes entangled amongst the leading edge of standing dead trees. For the most part, this rafted woody debris is relatively stationary and tends not to move about on the **reservoir** due to wind or wave action.
4. Floating Woody Debris: there are two forms: the first type is the occasional floating log that is being moved by wind and wave action in a lake or by currents in a river. The other type of floating woody

debris floats loosely near the shore (Photo 10.2-3), but is not entangled amongst other debris, as with rafted debris.

5. Leaning Trees: trees along the shoreline that are tipping towards the water due to shoreline erosion of their root structure. In most cases, leaning trees will eventually enter the water after the shoreline upon which they are rooted has eroded (Photo 10.2-4).
6. Submerged Debris: trees or brush that are in the water but are not mobile (Photo 10.2-3). Typically, submerged logs are those below the surface and can occasionally be seen in areas of clear shallow water or when there is a high water level condition.
7. Deadheads: trees which are in the waterway but not mobile. Deadheads have one end floating just at the surface while the other end is either on the bottom **substrate** or embedded into it.

In addition to categorizing debris types, the study area shorelines were visually assessed and the density of debris along the shorelines was subjectively classified into one of three density classes:

- Density = 1: low density and sparsely distributed (Photo 10.2-2).
- Density = 2: medium density distribution (Photo 10.2-3).
- Density = 3: densely distributed debris (Photo 10.2-1).

Photo 10.2-1: Example of Densely Distributed Beached Woody Debris Found on the South Shore of Gull Lake

Photo 10.2-2: Beached Debris that is of Light Density and Sparsely Distributed

Photo 10.2-3: Medium Density Floating as well as Light Submerged Debris can be seen here on the North Shore of Gull Lake

Photo 10.2-4: Leaning Trees of Medium Density on the North Shore of Gull Lake

Photo 10.2-5: Medium Density Standing Dead Trees in an Inlet on the North Side of the Nelson River

10.2.3 Study Area

The study area identified for the debris study is identical to the Keeyask GS open-water hydraulic zone of influence, which extends from approximately 3 **km** downstream of Clark Lake to a to approximately 3 km downstream of Gull Rapids (Map 10.2-1).

10.2.4 Assumptions

The following assumptions were made in carrying out this debris assessment:

- In the absence of previous historical debris data, it is assumed that the data collected since 2003 by Manitoba Hydro's Waterways Management Program, and the video and photos used for this study represents typical debris conditions in the Project area.
- Based on debris removal statistics and field observations by the boat patrol workers from Manitoba Hydro's Waterways Management Program (for Split Lake and the Nelson River to Gull Rapids) it is assumed that 20% of the debris removed from this area is debris removed from the Keeyask study area, from Split Lake outlet to Gull Rapids.
- Global and regional climate changes and effects are not considered in this section. Effects of climate change are discussed in Section 11.
- No catastrophic natural events (*e.g.,* earthquake, flood, landslides) will occur in the future.
- Ice processes that exist in the current environment will not change if Keeyask is not constructed.
- Forest fires likely generate shoreline debris that may eventually become floating debris. This study does not attempt to predict future fires and assumes that current conditions will persist into the future.
- This assessment represents debris conditions for the range of river flows and water levels experienced since LWR and CRD.

10.3 ENVIRONMENTAL SETTING

Assessment of the existing debris environment reflects the current situation and, based on this assessment, considers debris conditions in the future without the Project. The debris conditions in the future without the Project are also used to assess changes to debris conditions resulting from the Project. The current environmental setting has been influenced by past **hydroelectric** development in northern Manitoba.

In 1970, Manitoba Hydro was granted a license to regulate Lake Winnipeg, which, subject to license constraints, allows Manitoba Hydro to store water in Lake Winnipeg during periods of high water supply and release this water during periods of higher power demand. LWR has resulted in a shift in seasonal patterns of flow on the Nelson River (Section 4). In 1977, the CRD was constructed, diverting water from the Churchill River into the Rat River and Burntwood River and eventually into Split Lake. The amount of water diverted into Split Lake fluctuates monthly and annually between 400 m^3/s and 1,000 m^3/s (Section 4). While CRD increased annual average flows at Gull Rapids, the change in seasonal flow patterns results in existing flow conditions that are typically within the range of flows experienced prior to LWR and CRD; the difference between annual peak and minimum flows is smaller in the current environment.

It is expected that prior to LWR/CRD most of the shorelines in the study area would have had no woody debris or locally light amounts of debris. Dense debris, if present, was likely confined to very localized areas. Some debris would have been generated from these shorelines prior to LWR/CRD as a result of natural processes.

10.3.1 Current Conditions

10.3.1.1 Factors Contributing to Debris Generation

Major factors that contribute to debris processes in the Keeyask study area are shoreline erosion, **peatland disintegration**, ice, river flow and water level, and forest fires. Shoreline erosion and peatland disintegration are the primary factors because the resulting shoreline recession allows new debris to become available to the waterbody. Ice, river flow and water level, and forest fires are important factors in the debris process because they may affect both shoreline recession and the mobilization and transport of debris. Additional sources of debris may be present such as **timber** harvesting (*e.g.,* for firewood) and beaver activity on the water body or **tributary** streams. These additional factors are deemed to be minor based on boat patrol surveys and are not considered further because they likely contribute little to the overall debris mass.

10.3.1.1.1 Shoreline Recession

Shoreline recession may occur due to breakdown of peat shorelines and erosion of mineral shorelines (Section 6). Peat shorelines may break down due to high erosive **energy** (wave action), as well as the disintegration of the peat layer, thereby causing the peat shoreline to recede. As peat shorelines disintegrate, the peat material may move into the water body, thus becoming debris. Mobilized peat may be present in the waterbody as large mats (*e.g.,* floating islands), smaller chunks, and individual fibers or particles that are either floating or suspended.

As peatlands disintegrate, underlying **mineral soils** become exposed. This increases the length of mineral shoreline exposed to wave action and erosion. Where shores comprised of mineral material are exposed to sufficient energy the shoreline material may be gradually eroded, resulting in shoreline recession. **Mineral erosion** creates eroded beach slopes and adjacent, steeply sloping banks in **shore zone** areas. Vegetation growing on **upland** areas adjacent to eroding banks may fall onto the shoreline resulting in debris that may mobilize and move into the waterbody (Photo 10.3-1 and Photo 10.3-2). Localized slope failures also generate debris that enters the river (Photo 10.3-3).

10.3.1.1.2 Ice Processes

The Surface Water and Ice Regimes section (Section 4) provides details on ice process with and without the Project while the Shoreline Erosion Processes section (Section 6) provides a thorough summary of the ice processes in the study area that contribute to shoreline erosion that can result in debris generation.

In addition to current flow, ice scour along shorelines during the spring break-up period is one of the dominant processes that removes vegetation from the ice-scoured area creating a potential source of debris. Many of the banks along the Nelson River are ice scoured for a short distance above the normal

Photo 10.3-1 Eroding Mineral Soil Bank Between Clark Lake and Birthday Rapids. Photo Taken 19 September 2007

Photo 10.3-2: High Banks, South Side of Caribou Island, in Gull Lake Upstream from Gull Rapids

Photo 10.3-3: Localized Slope Failure in Mineral Soil Bank Between Clark Lake and Birthday Rapids. Photo Taken 19 September 2007

open water elevation. In some locations, ice has shoved coarse **gravel**, **cobbles** and **boulders** onto the shore, effectively protecting these shorelines from erosion. In other places, the ice shoving pushes over trees and other vegetation (Photo 10.3-4 and Photo 10.3-5). There are certain areas of Gull Lake where the shores may be protected by **border ice** that remains attached to the shore, thereby acting as a **buffer** to ice shoving. Border ice, however, may create new debris if it causes woody or peat material to be pulled away from the shore when the ice recedes in spring (Photo 10.3-6).

The formation of **hanging ice dams** downstream of **rapids** such as Birthday Rapids and Gull Rapids may cause some abrasion by ice along the shoreline and could also lead to some channelization of flow along the shoreline. Typically, the majority of the flow would be contained within the center of the channel. However, with the build-up of a large hanging dam downstream of the rapids, and the collapse and shoving action expected within the rapids if the ice-cover advances through them, it is possible that the flow may be temporarily redirected under the ice cover. This could lead to high flow velocities over erosion-susceptible shore zone areas. At Gull Rapids, if the accumulation of ice in the hanging dam is large enough, it can also result in a redistribution of flows within the rapids. This can result in a redirection of flow along the riverbanks as the main channel conveyance capacity drops. If local velocities increase substantially, any material susceptible to erosion may begin to move. Heavy pack ice in this area, for example, led to the formation of a new cross-over channel through the central island during the 2000/2001 winter.

Photo 10.3-4: Example of Low Eroding Mineral Soil Bank and Ice-Scour Zone Below Trees in River Reach Between Birthday Rapids and Gull Lake

Photo 10.3-5: Example of River Ice Bull Dozing Trees Along Shoreline

Photo 10.3-6: Example of Border Ice Collapsing Onto Shore Zone Where Woody Debris is Pulled into the River by the Ice

Typically, the ice cover at Gull Rapids will not progress upstream through the rapids even under the conditions of an extremely cold winter. This results in the formation of a hanging ice-dam just downstream of the rapids at the inlet to Stephens Lake. This congestion restricts the conveyance capacity of the channel below the rapids, and can lead to **significant** local **staging** (*i.e.,* water level increase). In this environment, the riverbanks become susceptible to erosion in areas of localized high velocities and because staging can allow ice to move directly along the shoreline, abrading the riverbank. This can lead to the mobilization of woody debris into the waterway both during spring when the shore is being abraded and during the later months if ice abrasion makes a shoreline more susceptible to erosion (*e.g.,* if abrasion reduces bank stability leading to later collapse).

10.3.1.1.3 River Flows and Water Levels

In lakes and reservoirs, shoreline erosion typically results from the combined effect of water level variation, both within and between years, and wave action. Wave action is generally not a significant factor along **riverine** sections; rather water level variation and flow current over erosion-susceptible material are driving factors in debris creation through shoreline erosion. The rate at which banks recede tends to be cyclic over time, reflecting the effect of changing water levels, variable wave energy conditions including periodic storm events and local obstructions to wave attack, and varying current conditions affecting erodible shorelines.

When water levels are high enough to reach the **toe of the bank**, erosion of the toe due to wave or flow energy dominates the shore erosion process and can cause rapid short-term top-of-bank recession. The top of the bank recedes because erosion of the toe causes undercutting of the bank, which may allow the top of the bank to collapse in a **mass-wasting** failure. When water levels are low, weathered bank material, including vegetation (*e.g.,* trees and shrubs) shed by mass wasting, accumulates at the toe-of-bank, where it may be temporarily beached above water level. The dominant wave erosion process at times of low water level is progressive down cutting and flattening of the beach slope below the toe of the bank.

High water levels following a period of low water results in removal of failed bank material at the toe of the bank, including woody debris that may have accumulated. While it stays in place, the material accumulated at the toe of a bank provides some erosion protection at the toe when high water levels occur. However, if these levels are sustained, the failed bank material may be completely removed. This then allows the **nearshore** slope and toe of the bank to again be eroded due to waves and current. This is a cyclic process during which a riverbank gradually recedes, with erosion rates varying based on changes in seasonal and annual flow and weather conditions.

10.3.1.1.4 Forest Fires

From time to time forest fires have burned tracts of land right up to the shoreline of the study area, resulting in standing dead trees along the shoreline that can become debris. Loss of land cover due to fire may also cause underlying **permafrost** to start melting. The melting permafrost can cause shoreline bank failures, which may cause trees and other material to fall into the river.

10.3.1.2 Factors Contributing to Debris Movement

While a variety of factors contribute to the creation of debris, once it becomes debris it may be classified as either mobile, because it is floating in the water column or immobile because it is beached above the waterline or it is embedded in bottom **sediments**. Debris may go through many cycles of being mobilized and immobilized as conditions on the waterway change over time. For example, beached debris may be immobilized for years before it is remobilized due to an event that moves it off the beach. Once mobilized, debris may move around the waterbody, it may move downstream, it may sink or it may subsequently become immobilized again at a different location.

Prime factors affecting the mobilization and immobilization of debris are changes in water level and storm events that generate high waves. High water levels can mobilize beached and immobile debris while mobile debris may become beached above the water line when levels drop. Large wave events can both pull debris into the water and push debris above the normal water levels. Wind induced currents, which are important in lakes and larger water bodies where flow velocities are low, can move debris around a water body and can often cause greater amounts of debris to accumulate on or along shorelines downwind of the primary wind direction. Flow induced currents, which may vary based on water level and river morphology, can also move debris around a water body depositing it into sheltered bays or moving it downstream. On a river like the Nelson, the flow will sometimes transport debris a large distance downstream from its point of origin before the debris might again become immobilized. Mobile debris is not always in a state of **movement**; floating debris can accumulate in an area that is wind sheltered and has low flow-induced current and it may remain floating but essentially immobile for a considerable time before some large event (*e.g.,* severe storm) occurs to move it from its sheltered location.

Ice processes also affect debris movement. Woody debris embedded in ice may be mobilized when the ice moves in the spring and melts, subsequently releasing the debris. Conversely, where ice pushes up a shoreline, it may also push debris to a location where it might remain immobilized until high water levels or other significant events remobilize the material.

10.3.1.3 Woody Debris Mapping

Results of the 2003 Keeyask debris mapping are shown in Map 10.3-1 and Map 10.3-2 while 2008 mapping results are shown in Map 10.3-3. Mapping of 2003 conditions encompassed the entire study area from Clark Lake to Stephens Lake while the 2008 mapping only covered part of Gull Lake and Gull Rapids. The 2003 shoreline video was collected on August 19 and September 21, a period when Nelson River flows were between 1,500-2,000 m^3/s, the lowest or near the lowest flows observed since 1977, the post-LWR and CRD period. Conversely, the 2008 shoreline photos were obtained on September 1 when Nelson River flows were near 5,000 m^3/s, which is among the highest flows observed at this time of year since 1977. The highest open-water flows on this river reach occurred in 2005 when flow exceeded 6,000 m^3/s for more than 2 months and peaked in excess of 6,500 m^3/s.

The bulk of the shorelines in the study area were classified as having no debris in 2003 (Map 10.3-1 and Map 10.3-2). Among shorelines noted as having debris in 2003 the majority had low density and sparsely distributed debris (Class 1) along with some areas of moderately dense debris (Class 2). Only two locations had high density debris (Class 3); a backbay downstream of Two Goose Creek (Map 10.3-1) as well as both shores immediately downstream of Gull Rapids (Map 10.3-2). In the Clark Lake to Gull Lake reach the majority of classified debris is beached woody debris and standing dead trees, although leaning trees were not uncommon and often associated with beached debris. The majority of classified debris in the Gull Lake to Stephens Lake reach was standing dead trees and beached debris, although the shores downstream of Gull Rapids area were characterized by leaning trees.

The 2008 debris map (Map 10.3-3) shows that only a portion of the study area within Gull Lake and Gull Rapids could be classified based on shoreline photos obtained that year. In areas that were classified, the shoreline is generally classified as having greater densities of debris as compared with 2003. A substantial amount of submerged and floating debris was identified in 2008, which was not observed in 2003. These types of debris are often associated with shorelines also having standing dead and leaning trees. There was far less beached debris in 2008 than 2003. Some shoreline areas that had no debris in 2003 contained some debris in 2008.

Comparison of debris classes in 2003 and 2008 suggests that debris that might be classified as standing dead or beached during a low-flow period like 2003 may be classified as submerged or floating debris during a high-water period like 2008. Debris classifications from these 2 years indicate the high variability of shoreline debris conditions over time and illustrate the effect that flow and water level conditions may have with respect to the amount and types of debris that are present. Additionally, the change in debris conditions from 2003 to 2008 would be affected by the variable ice conditions that occurred each winter, any significant weather events such as windstorms, or the large 2005 forest fire on the south side of the Nelson River that likely increased debris generation along this shoreline as permafrost melting contributed to bank slumping.

Information collected by Manitoba Hydro's Waterways Management Program since 2002 (*i.e.,* records of debris removed) highlights changing debris conditions over time within the Nelson River reach between Split Lake and Stephens Lake. The Waterways Management Team has been involved in the removal of mobile debris that poses a risk to navigation safety and, since 2003, has categorized and counted the pieces of debris removed (Table 10.3-1). Of all the debris categorized from 2003-2008, only one piece or 0.2% of recovered debris was classified as being due to beaver activity, which suggests that this is an inconsequential source of debris.

In 2002 and 2003 the amount of debris removed by the weekly two-man boat patrols was low compared with subsequent years. In 2004, following the low-flow 2003 period, the amount of debris removed increased more than 10-fold and was high again in 2005. Subsequently, the amount of debris removed appears to be in a declining trend. It might have been expected that 2005 would see the highest level of debris removal because 2005 had the highest flows on record. However, water levels in 2004 were relatively high compared with 2003, which likely remobilized much of the available debris that was beached in 2003. This might then have reduced the amount of mobile debris available in 2005. The declining amounts of debris removed may indicate that the rate of new debris generation is less than the combined rate of removal by the Waterways Management Team, immobilization of mobile debris and downstream transport of debris.

Table 10.3-1: Mobilized Debris Removed From Study Area by Manitoba Hydro Waterways Management Program

Year	Large Debris[1]				Small[2] Debris	Total Number of Pieces (Large + Small)
	New[3]	Old	Beaver	Total		
2002	Unclassified					13
2003	4	7	0	11	3	14
2004	1	140	0	141	36	177
2005	6	103	0	109	2	111
2006	1	65	0	66	11	77
2007	3	81	0	84	0	84
2008	0	49	1	49	1	50
Total	15	445	1	461	53	526

1. Woody material >1 m in length and woody material >10 cm in diameter.
2. Woody material <1 m in length and woody material <10 cm in diameter.
3. Green woody material.

The years 2004 and 2005 had the most debris removed from the system which suggests that when water levels rise after a period of low water, greater quantities of debris may be generated and mobilized. This occurs because, as water levels rise, debris is mobilized that was previously beached when water levels were low, in addition to any new debris that may have accumulated on the beach while levels were low. Additionally, high water levels may create additional debris, as discussed in Section 10.3.1.1, that may be mobilized within that year or in subsequent years, which may have resulted in the high but declining levels of debris removed in the years since 2005.

10.3.1.4 Peat Debris

As described in the Sedimentation section (Section 7), small amounts of organic sediment and floating peat are generated in the **existing environment** from shore erosion processes within the study area between Birthday Rapids and Gull Rapids. Based on the field observations, this area does not generate measureable mobile peat from the shore erosion processes under present conditions. However, infrequent short-term events such as ice damming, high water level and forest fire may cause disintegration of mobile peat from the shore.

In the study reach immediately downstream of Gull Rapids the shoreline is entirely mineral and therefore generates no peat debris (Section 6).

10.3.2 Future Conditions/Trends

Because shoreline erosion processes drive the generation of debris (Section 10.3.1.1), conclusions about future erosion conditions provide the basis for the assessment of potential future debris conditions both with and without the Project. The assessment of future shoreline erosion without the Project assumes that the range and statistical distribution of water levels, river flows, wind conditions, ice processes and overall bank material composition will remain effectively the same in the future as it has been throughout the period of past analysis (Section 6). The erosion section concludes that shoreline erosion along mineral shorelines will continue at rates similar to historical conditions, while peatland disintegration would continue to be negligible. Shoreline processes may be affected by events with a very low statistical probability of occurrence (*e.g.,* mass failure of a riverbank) that may cause large effects in localized areas; however, it is not possible to quantitatively determine where or when these types of events might occur.

Based on the assessment of future shoreline erosion processes, future debris conditions are expected to remain similar to existing conditions. Specifically, most of the shorelines would either have no debris or low-density debris that is sparsely distributed. Areas of dense debris would remain few and localized. Beached, floating, standing dead and leaning trees would remain the dominant types of debris, with the distribution among types varying over time. Similarly, since the future is expected to be essentially the same as the past, future debris conditions will be highly variable based upon variations in the major **drivers** causing and mobilizing debris.

10.4 PROJECT EFFECTS, MITIGATION AND MONITORING

This section describes how the proposed Keeyask GS is expected to alter current debris conditions in the study area and how these conditions can be expected to evolve with the Project.

The proposed Keeyask GS will inundate approximately 45 **km²** of land, largely resulting from **flooding** of low areas along the existing Gull Lake shoreline. This results because **impoundment** of the reservoir raises the water level on Gull Lake approximately 7 m above the current average level to an elevation of 159 m ASL. The land that would be flooded represents a range of vegetation cover (*e.g.,* moss, brush, sparse to dense forest) and a range of underlying soil types (*e.g.,* peat, mineral soil, **bedrock**). Flooding this land would result in the creation of large amounts of woody debris that would enter the Project's open water hydraulic zone of influence if preventative measures are not implemented. Erosion of mineral shorelines (*i.e.,* non-peat shorelines) would continue to cause woody debris to enter the water over time. Peatlands will also undergo disintegration along the shoreline of the new reservoir as well as resurfacing of peat inundated by the Project. These processes will result in the release of peat into the waterway, potentially creating floating peat islands and smaller floating peat blocks.

10.4.1 Construction Period

10.4.1.1 Reservoir Clearing

The 45 km^2 of land that will be flooded due to impoundment of the reservoir consists of mixed vegetation and soil types. Initial flooding for the Keeyask reservoir will increase the total Nelson River water surface area in the upstream hydraulic zone of influence from 46-47 km^2 to 93-94 km^2. Approximately 41 km^2 of the land being flooded contains woody vegetation comprised of 5.1 km^2 forest; 6.5 km^2 woodland; 4.0 km^2 sparsely treed; 3.0 km^2 mixed woodland and sparsely treed; 1.9 km^2 tall shrub; 4.0 km^2 low vegetation; 15.6 km^2 regenerating burn, which is an area recovering from forest fire (Terrestrial Environment Supporting Volume (TE SV)).

If the future flooded area of the Keeyask reservoir were not cleared prior to impoundment, inundated woody vegetation would become woody debris within the new reservoir. For this reason, the Reservoir Clearing Plan (JKDA, Schedule 11-1) will be implemented prior to impoundment to remove large woody vegetation, thus preventing it from becoming mobile debris after impoundment. As laid out in the JKDA, almost all of the clearing will be accomplished using mechanical means (shear blading) to level and pile the vegetation, which will subsequently be burned. Because this clearing method strips off all the surface material (trees, brush, etc.) loose and dead woody debris on the ground will also be removed. This minimizes the potential amount of small woody debris initially entering the reservoir when it is impounded. Because the potential source of large woody debris will be removed, no assessment has been made as to the amount or spatial distribution of large-woody vegetation within the flooded area, nor has the potential rate of debris generation been estimated in the event that this vegetation were flooded but not removed.

The Reservoir Clearing Plan (JKDA, Schedule 11-1) is a key component of the JKDA and was developed by the Keeyask Project Description Technical Committee, which is comprised of Manitoba Hydro and KCNs representatives. The plan describes the clearing plan objectives and details the recommended approach and methodologies for the clearing and removal of woody material from flooded areas (see also Section 10.4.3.1).

10.4.1.2 Stage I and Stage II Diversion

The Project is not expected to affect the generation or accumulation of debris upstream or downstream of Gull Rapids during Stage I and Stage IIA diversions. During construction, the effects of debris on the physical environment are considered to be small, short-term, localized in nature and capable of being mitigated under the current Waterways Management Program and the Reservoir Clearing Plan (Section 7.4.5).

During Stage I river diversion and the initial period of Stage II diversion, *i.e.*, Stage IIA (see PD SV), the change in water level on Gull Lake is expected to be less than 0.4 m during the open water period under a 95th **percentile** flow of 4,379 m^3/s (Section 4). This increase would be largely contained within the normal existing high water level. Therefore, new debris is not expected to arise from mineral or peat shorelines during Stage I and IIA of construction. Levels upstream of Birthday Rapids would not be affected under open water conditions. As such, the existing low levels of debris in the study area are likely to persist and remain unchanged throughout construction Stage I and IIA. Over a period of about 3 months in the latter part of Stage II diversion (Stage IIB) the reservoir will be impounded, with water levels on Gull Lake gradually increasing up to the 159 m **full supply level**. Debris conditions during the impoundment period are discussed in the following section.

Within Gull Rapids there will be changes to water levels that will result in shorelines being exposed to the erosive forces of water. Water level increases within Gull Rapids immediately upstream of the **spillway** during the open water period are expected to be about 0.7 m (Stage I) and 2.2 m (Stage IIA). During Stage I the staging would remain within existing shorelines and would not introduce new debris. During Stage IIA, water level increases during construction will inundate some lower lying shorelines. Areas within Gull Rapids that will be inundated will be cleared of trees according to the Reservoir Clearing Plan, thereby removing the potential to generate large woody debris during the construction phase. Some small woody material left over from clearing activities may be mobilized and move downstream, but the amount would be minimal and would not be expected to affect navigation or safety.

Peatlands within the new reservoir area will be disturbed by construction and reservoir clearing activities, and this disturbed peat may mobilize to become floating organic debris during reservoir impoundment. This mobilized peat will accumulate in backbays in the new reservoir and some peat will move downstream. This effect is expected to be small in **magnitude** and short term.

10.4.1.3 Reservoir Impoundment

As noted above, the reservoir will be impounded to full supply level during the latter part of Stage II diversion (Stage IIB). Water levels on Gull Lake will rise about 5.3 m above the existing open water level for the 95th percentile flow, bringing the reservoir to the full supply level of 159 m. Impoundment will flood shoreline areas that have been cleared of vegetation as specified in the Reservoir Clearing Plan, which is intended to remove all large woody material to prevent the mobilization of large woody debris during impoundment in order to prevent it from posing a navigation or safety hazard.

Most of the small woody debris and vegetation will also be removed through the mechanical clearing process; however, some small sized remnants left over from clearing will be mobilized. The quantity mobilized is expected to be small, and the influx of new small debris will be gradual as water levels rise over time and additional areas are flooded. Small debris mobilized from flooded areas along the existing shoreline may move downstream through the spillway. Small debris is not expected to impact navigation or safety downstream, and the effect will be short term and localized. Small debris in flooded backbays away from the main channel will remain largely within those areas because flow patterns would generally not move the material out of these bays. The material will likely accumulate on the shore or sink when water logged. In these areas it will not affect navigation, safety or operations. It is expected that Waterways Management crews will opportunistically remove small woody debris as they currently do within the study area (see Table 10.3-1).

While large woody debris can remain present as a hazard for many years, small woody debris is not as persistent in the waterway because it breaks down quickly due to decay, it is more easily broken up into smaller pieces and because it more readily becomes waterlogged and sinks. However, because the impoundment period is relatively short, small woody debris mobilized during impoundment will persist into the operating period.

As discussed in the Shoreline Erosion Processes Supporting Volume (Section 6), there will be immediate changes due to peat submergence and creation of new peat shorelines when the reservoir is impounded. Peatland disintegration has not been estimated for the impoundment period; however, it has been estimated for Year 1 of the operating period, although there is a relatively high **uncertainty** concerning the timing of **peat resurfacing** during the first year. For the purpose of debris considerations, it is assumed that peat mobilization during reservoir impoundment would be the same as the Year 1 conditions. Based on results from the shoreline erosion processes analyses (Section 6), approximately 5-6% of all submerged peat may become mobile due to resurfacing in Year 1, with an undeterminable portion of this amount being mobilized during impoundment. For the Year 1 period, which is assumed to be applicable to the impoundment period, it is predicted that most mobile peat will remain within the reservoir, particularly within Gull Lake, and only a small amount will move downstream of the generating station into Stephens Lake (Section 7). Most of the resurfaced peat will remain in the area in which it originates for a number of reasons such as subsequent sinking, hanging up along shorelines or grounding in shallow water.

10.4.2 Operating Period

The Project will alter the **water regime** and associated aquatic and terrestrial **ecosystems** on the Nelson River, upstream of Gull Rapids to Clark Lake, and downstream of Gull Rapids to Stephens Lake. Approximately 45 km^2 of land will be inundated initially during impoundment. Due to peatland disintegration and erosion of mineral shorelines, the reservoir area will increase by approximately 7-8 km^2 within the first 30 years after impoundment (Section 6). Shoreline erosion will continue beyond the first 30 years, but at a very low rate. If not mitigated through the Reservoir Clearing Plan, impoundment of the reservoir and shoreline erosion processes would provide a source of debris during the operating period.

10.4.2.1 Debris Due to Reservoir Expansion

Due to reservoir expansion there will be more debris generated in the study area in the future with the Project than would be expected without the Project. As described in the Shoreline Erosion Processes Section (Section 6), peatland disintegration and mineral shore erosion are predicted to expand the Keeyask reservoir area by 7-8 km^2 during the first 30 years of Project operation, which would result in more debris in the **Post-project** environment. The contributions of peatland disintegration and mineral shore erosion to reservoir expansion are approximately 6-7 km^2 and 1-2 km^2, respectively. Reservoir expansion is expected to be greater in the backbay areas formed by initial flooding. The conversion of **terrestrial habitat** to aquatic **habitat** would cause the woody vegetation and peat from those areas to accumulate on the shore and potentially mobilize and move into the waterway.

The Reservoir Clearing Plan specifies the removal of trees of 0.15 m diameter or larger and/or 1.5 m or more in length (JKDA, Schedule 11-1). It is expected that smaller woody debris would be mobilized in the reservoir due to impoundment, mineral shoreline erosion and peatland disintegration. As noted in

Section 10.4.1.3, compared with large woody debris the small woody debris is not persistent in the waterway because it easily breaks down and becomes waterlogged and sinks more readily. Smaller woody debris that remains floating and mobile is expected to collect as rafted and beached debris in backbay areas, particularly in bays along the south side of the reservoir since prevailing wind would tend to move the material to these areas over time in the same manner as floating peat (Section 7). Debris that accumulates in backbay areas is not anticipated to impact upon navigation or resource use on the reservoir as it will be out of the way from safe travel routes and landing sites. Boat patrols operating under the Waterways Management Program(JKDA, Schedule 11-2) during the operating period will remove large woody debris as required and it is expected that small woody debris would also be opportunistically removed as currently occurs (Table 10.3-1). Rafted debris that accumulates and impacts navigation routes and safe landing sites for boats will be managed and removed under the Waterways Management Program.

As described above (Section 10.4.1.3), it is estimated that about 5-6% of all flooded peat may become mobile due to resurfacing in Year 1. Approximately two-thirds of all resurfacing occurs in Year 1 while the remaining one-third of resurfacing takes place over the Year 2-10 period (Section 6). Over the Year 2-10 time period, approximately 4-5% of all flooded peat may be mobile, or about 0.5% each year. Mobilized peat may be transported to other locations in the reservoir.

Peatland disintegration along the shoreline is predicted to contribute 6-7 km^2 of reservoir expansion over the first 30 years of operation, representing a potential ongoing source of peat debris (Section 6). The rate of peatland disintegration is greatest in the early years of operation (Years 1-5) and gradually declines over time as shorelines stabilize: beyond 30 years the long-term rate is very low (Section 6). Mobile peat is attributed to resurfaced peat mats rather than material from shoreline breakdown (Section 7), which typically produces small peat chunks. Because the breakdown material is generally small in size, it would not be expected to have an appreciable impact in the waterway as a source of debris even if it were mobile in the larger reservoir area.

Overall, the mass of potentially mobile peat ranges from about 10-20% of the total peat loading into the reservoir (Section 6). While peat resurfacing is not anticipated to occur beyond Year 10 following impoundment, some of this peat will remain mobile. However, no mobile peat is expected beyond Year 15. The majority of potentially mobile peat is expected to sink or become beached near where it originates. Much of the mobilized peat that does move into the reservoir is expected to accumulate in bays along the southern shore of the reservoir because prevailing winds will tend to move the peat in that direction. Predictions of mobilized peat accumulation indicate the highest densities will occur in the areas of Box Bay Creek and Broken Boat Creek on the south side of the reservoir and the bulk of the peat is expected to accumulate in the near-shore area (Section 7).

There are no peat shorelines in the open water hydraulic zone of influence downstream of the Project. Therefore, the Project cannot cause any change in the generation of peat debris from this reach.

Some woody and peat debris generated in the reservoir is expected to move downstream into Stephens Lake; however, this can only occur when the Keeyask spillway is operational. Operation of the spillway will occur when inflows exceed the plant capacity of 4,000 m^3/s which, based on historical and predicted future flow conditions, occurs about 12% of the time (Section 4). The sedimentation study concluded that the amount of peat likely to be transported downstream into Stephens Lake is small (Section 7). Implementation of the Reservoir Clearing Plan and the Waterways Management Program will serve to limit and remove hazardous debris that could otherwise move downstream of the Project. It is anticipated that neither woody nor peat debris from the upstream hydraulic zone of influence would to have a measurable effect on downstream debris conditions during the operating period.

10.4.2.2 Debris Due to Ice Processes

Immediately downstream of the Keeyask GS, the amount of shoreline erosion and associated generation of new woody debris is predicted to decrease substantially once the Project is constructed. Debris is currently generated in the downstream reach because of the hanging ice dam that forms just downstream of Gull Rapids, which results in staging, redirection of flow and ice scouring along the shoreline. Once the Project is in operation the hanging ice dam will no longer form, which will remove this source of debris.

Ice processes in the Gull Lake area will be altered relative to conditions that would be expected without the Project (Section 4). Without the Project much of the Gull Lake shoreline exhibits ice scouring, a process that can create woody debris that would enter the river. Due to changes in the **ice regime** it is expected that physical ice scouring of the shoreline likely will not occur along much of the reservoir shorelines, thus removing this potential source of debris in the Project environment.

Upstream of Birthday Rapids ice processes are expected to remain similar to conditions without the Project (Section 4), therefore debris conditions upstream of Birthday Rapids are expected to remain similar to debris conditions without the Project.

10.4.3 Mitigation

Debris will be mitigated by clearing the flooded area of the reservoir prior to impoundment and by removing large woody debris during the operating period. The following text describes how these mitigation measures were incorporated into the design of the Project during the early stages of planning.

KCNs and Manitoba Hydro outlined some of the concerns and issues with debris as it relates to the Project.

KCNs view debris as an issue with respect to:

- Boating safety.
- Potential adverse effects on fishing due to increased effort to clean nets and damage to equipment.
- Difficulties in access to and from the water.
- Aesthetics.

The study team members also raised concerns about the increased potential for boater-related debris issues in the Post-project time period. Currently, Gull Lake is typically accessed by boat from Split Lake, which is difficult because it requires navigation of Gull Rapids, or by slinging a boat by helicopter from

Gillam. The Project will result in road access to Gull Lake, making the lake more readily accessible, which creates the potential for increased boating activity on the lake.

In order to address these issues and concerns, the KCNs and Manitoba Hydro agreed that debris during the operating period would need to be prevented, minimized and managed. To prevent and minimize Post-project debris, KCNs and Manitoba Hydro jointly developed the Reservoir Clearing Plan, which was a key component of the JKDA. Additionally, the parties agreed that the existing Waterways Management Program would continue to operate during both the construction and operational phases of the Project, and this program is also a key component of the JKDA.

The effects of mobile peat on the environment, navigation safety and other potential uses of the waterway such as **commercial fishing** will be monitored on a continual basis both upstream and downstream of the Keeyask GS. Boat patrols performing woody-debris management under the Waterways Management Program will monitor the presence of hazardous or problematic peat debris. KCNs and Manitoba Hydro could determine the need for peat-debris management strategies based on reports from boat patrols and resource users. Mitigation of peat debris could include measures such as:

- Installing debris booms to collect peat and woody debris, preventing it from moving downstream into Stephens Lake.
- Towing peat islands that create a navigation safety issue to shore and anchoring them to the shore.

10.4.3.1 Reservoir Clearing Plan

This Reservoir Clearing Plan reflects current conditions in the area of the Keeyask Project. The amount of vegetation requiring clearing can change quickly, as has been evidenced by numerous forest fires over the last decade, affecting the northeast part of the reservoir area, Caribou Island and most of the reservoir area on the south side of the Nelson River. The Reservoir Clearing Plan is subject to the provisions of any license issued by a regulatory authority affecting the Keeyask Project, including the closing licenses, and will be modified, as necessary, in order to comply with the terms of any such license.

10.4.3.1.1 Reservoir Clearing Plan Objectives and Activities

The objectives of the Reservoir Clearing Plan for the Keeyask Project are as follows:

- Minimize impacts of reservoir creation and operation on the fishery by minimizing the effects of standing trees and shrubs on fishing in selected areas within the reservoir.
- Minimize the impacts of reservoir creation and operation on human access to shore locations by creating shore access locations through selective clearing of trees and shrubs.
- Minimize hazards to boating safety and fishing resulting from large floating debris by minimizing the source of such debris.
- Minimize aesthetically offensive landscapes.

The clearing of vegetation from the reservoir area is divided into two phases:

- Pre-flooding which affects the area within the 159 m ASL flood elevation at the **dam**.

- Post-flooding, which includes areas that may be affected by erosion or peat land disintegration after the reservoir has been filled with water.

10.4.3.1.2 Pre-Flooding Reservoir Clearing

Clearing of the reservoir area prior to flooding will address many of the safety and environmental objectives of the Project with respect to debris. Recommended clearing methods and associated activities include areas for hand clearing, areas where hand or machine clearing are suitable, and the creation of access and safe landing sites along the reservoir shoreline. Consideration is given to both wood salvage and environmentally sensitive areas that may require specific treatment during clearing operations. Flagging of clearing boundaries and on-site supervision are critical to the successful implementation of all aspects of the reservoir-clearing plan.

The surface elevation of the reservoir up to at least 159.0 m ASL, and some level above as a buffer, will be surveyed and staked to define the extent of area to be cleared. This area is shown on Map 10.4-1.

All standing woody material, which includes dead and living trees and shrubs 1.5 m tall or taller, as well as all fallen trees 1.5 m or more in length with a diameter of 15 cm or greater at its largest point will be cleared. Reservoir clearing will be undertaken in the 3 years preceding reservoir impoundment, except for areas that will be underwater as a result of **cofferdam** construction. These areas will be cleared prior to the flooding caused by these works. The preferred method of clearing is mechanical clearing by shear blading during the winter when the ground is frozen. Using this method, the cleared material is deposited in windrows or piles and left to dry. Cleared material is burned during the following winter season.

Machine clearing has the advantage of shearing stumps off at ground level, along with all other vegetation that is there. It also accumulates much of the loose and dead woody debris that is on the forest floor, along with hummocks of sphagnum moss, resulting in a very efficient and effective operation. Maximizing machine clearing will minimize the amount of woody and organic debris that would remain on site and enter the water following flooding.

All areas designated for mechanical clearing on Map 10.4-1 will be cleared using this method, with the following exceptions:

- Cultural or heritage sites known or discovered to exist within the areas identified for mechanical clearing will receive special treatment, as appropriate, as determined on a case by case basis.
- Selected mainland locations as may be designated by the Project Manager, where practical, for tree salvage (for use as firewood, saw-logs, cabins, etc.) will be hand cleared.
- Selected locations as may be identified by the Project Manager, where tree and shrub density is sufficient to reduce wave energy, may not be cleared, leaving trees and shrubs standing in shallow water to provide protection to the shoreline from wave energy, thereby reducing erosion rates and providing a more stable shoreline for the new growth of **riparian** shrubs and trees.

The areas requiring hand clearing are approximately as shown on Map 10.4-1. Clearing will be done using chain saws and brush cutters and other tools as may be appropriate in the circumstances.

Generally, hand clearing will take place at locations within 10 m (33 ft) of the existing normal high water mark on the Nelson River and within 5 m (16 ft) of tributary stream banks, due to the higher potential for disturbance of sensitive sites in these areas (for example, riparian areas and heritage sites).

In addition, hand-clearing methods will be used where it is not possible to operate mechanical clearing equipment because of site location (inaccessible islands) or condition (steep slopes).

Typically, areas cleared by hand will contain stumps of trees and shrubs approximately 15 cm (6 in.) in height. In addition, most of the smaller shrubs and forest floor debris (if covered by snow) will remain on site.

The final extent of each area to be cleared using hand clearing methods will be determined in the field and will be clearly marked, within 1 km (0.6 mi.) of the area to be cleared by hand, prior to mechanical clearing taking place.

10.4.3.1.3 Post-Flooding Reservoir Clearing

Areas beyond the initial impoundment, as shown on Map 10.4-2 are at risk of erosion after flooding. It is also anticipated that erosion and peatland disintegration will continue over a prolonged period of time after reservoir impoundment and if left unchecked has the potential to contribute substantial amounts of woody debris into the reservoir, thereby creating a risk to human safety and resulting in negative impacts to the KCNs.

Areas that will convert from land to water over time as a result of peat land disintegration and shoreline erosion will be cleared on an ongoing basis through the implementation of the Waterways Management Program.

The objective of the debris prevention work set out in the Waterways Management Program is to prevent trees and other large woody debris from entering the water by removing them before they fall into the water dragging soil material with them.

10.4.3.2 Waterways Management Program

One of the primary sources of information for the monitoring and management of debris is Manitoba Hydro's Waterways Management Program, also commonly referred to as the Debris Management Program. This program evolved through post-CRD negotiations with affected communities whereby Manitoba Hydro made a commitment to patrol affected waterways and remove debris. It was generally agreed that the failure to control debris would likely result in increased operating costs, reduced safety during river navigation, a reduced ability to harvest resources, a negative impact on the surrounding environment, and the creation of unappealing landscapes. Efforts were made through collaboration of Manitoba Hydro staff and representatives from local communities. This program has resulted in several decades of knowledge about the behaviour of debris in the Nelson River.

The Waterways Management Program (JKDA, Schedule 11-2) is comprised of several components including; boat patrols, debris clearing, and shoreline stabilization. Boat patrols currently travel the entire reach between Split Lake and Gull Rapids once per week. Using a GPS, the patrols map and record the routes travelled by boat, mark deadheads and reefs, identify debris work areas, place hazard markers identifying safe travel routes for resource users, gather floating debris, deadheads, old nets etc. and relocate them to safe areas. Debris that is collected is piled on the shore where it is burned after first snowfall. If a camp is situated near a debris pile the debris will not be burned so that it can be used by campers for firewood. Since 2003 the program has recorded information including shoreline classification, locations of the floating debris, number of floating debris pieces removed and deadheads and reefs marked or removed, and locations are recorded using a GPS where appropriate. For this assessment this information provided the basis for characterizing the amount and spatial distribution of floating debris that presents a navigation hazard.

This section will only describe the Waterways Management Program activities related to debris management (see PD SV for more details).

The objective of the Waterways Management Program is to contribute to the safe use and enjoyment of the waterway from Split Lake to Stephens Lake throughout the pre-flooding and operation stages of the Keeyask Project, in a manner consistent with Sections 7.2.1 through to 7.2.7 of the PD SV (drafting note 30/05/12: PD SV reference to be updated when PD SV completed).

10.4.3.2.1 Phase One – Pre-Flooding

The first phase of the Waterways Management Program will consist of implementing the measures outlined in Section 7.2 of the PD SV, (drafting note 30/05/12: PD SV reference to be updated when PD SV completed), in the pre-flooding period (*i.e.,* construction period), including providing support for activities carried out under the Reservoir Clearing Plan before impoundment of the reservoir. Other activities will include the operation of a multi-purpose boat patrol to manage debris, monitoring waterway activities and liaising with individuals and groups using the Nelson River to share information on waterway safety issues.

10.4.3.2.2 Phase Two – Post Flooding

The second phase of the Waterways Management Program will consist of implementing waterways management activities after flooding. The Waterways Management Program will deliver the services outlined in Schedule 11-2 of the JKDA and will also provide support services, as required, for protection and preservation measures at spiritually and culturally significant historical or heritage sites along shorelines. Activities pertaining to debris management include:

- Collection of floating debris.
- Clear areas that will convert from land to water over time as a result of peatland disintegration and shoreline erosion.
- Marking safe travel routes, by installing and maintaining navigation and hazard markers.

Downstream of the powerhouse, waterway users may have concerns with respect to the effects of Keeyask on downstream flows. To help manage downstream issues one of the boat patrol crews will operate temporarily in this area for the first 3 years of operations. The primary function of this boat patrol will be to implement safety measures, deliver information to downstream resource users, and assist in explaining the operations of the powerhouse.

The future requirement for this measure would be evaluated thereafter.

10.4.4 Residual Effects

Assessment of the **significance** of residual debris effects following the implementation of the Reservoir Clearing Plan and ongoing operation of the Waterways Management Program upon other environmental characteristics are considered in the Aquatic, Terrestrial and Socio-Economic Supporting Volumes.

A number of mitigation activities under the Reservoir Clearing Plan and the Waterways Management Program will substantially reduce residual debris effects. Reservoir clearing prior to impoundment will prevent large woody debris and minimize small woody debris as a result of impoundment. Some small sized remnants left over from reservoir clearing activities (*e.g.,* branches and twigs) will be mobilized to become floating debris in the reservoir, some of which may be transported downstream. This small debris is not anticipated to pose any risks to navigation safety or operation of the Keeyask GS. The waterway will be monitored and any large woody debris that poses a risk to navigation safety, resource use and operations will be removed. During operation, small debris will accumulate in the reservoir area and some will move downstream into Stephens Lake. This effect will be short term as it will be limited to short periods during reservoir impoundment and will be limited to the reservoir and Stephens Lake.

Table 10.4-1: Summary of Debris Residual Effects

PHYSICAL ENVIRONMENT DEBRIS RESIDUAL EFFECTS	Magnitude	Extent	Duration	Frequency
Upstream of the Project				
Small woody debris due to impoundment and shoreline erosion that may be mobile in waterway or immobilized on shorelines will not impact navigation safety or operations. Because it readily breaks down it will generally not persist in the waterway. Small woody debris will be opportunistically removed along with large woody debris.	Small	Medium	Long-term	Continuous

PHYSICAL ENVIRONMENT DEBRIS RESIDUAL EFFECTS	Magnitude	Extent	Duration	Frequency
Large woody debris and floating peat is expected to accumulate in backbays away from safe travel routes and landing sites where it is not expected to affect navigation safety, resource use or operations. Accumulated debris will be monitored through the Waterways Management Program.	Small	Medium	Long-term	Continuous
Woody debris removed from the reservoir will be stockpiled above the high water mark where it will not be able to re-mobilize in the reservoir.	No Effect			
Downstream of the Project				
Small woody debris will move downstream into Stephens Lake during impoundment. The amount will be limited and is not expected to impact navigation safety, resource use or operations	Small	Medium	Short-Term	Infrequent
Small quantities of small peat and woody debris will be transported downstream into Stephens Lake during the operating period when the spillway is in use. Upstream management of large debris will mitigate its movement downstream. No measureable effect on the downstream debris environment is expected.	Small	Medium	Long-term	Continuous
Elimination of the ice dam downstream of Gull Rapids and resultant elimination of shoreline erosion due to ice processes will substantially reduce the amount of debris entering Stephens Lake from these shorelines.	Small	Medium	Long-term	Continuous

10.4.5 Interaction with Future Projects

This section will consider the interactions of the Project effects with reasonably foreseen and relevant future projects and activities and their effects.

There are several foreseeable projects in the area, including the following:

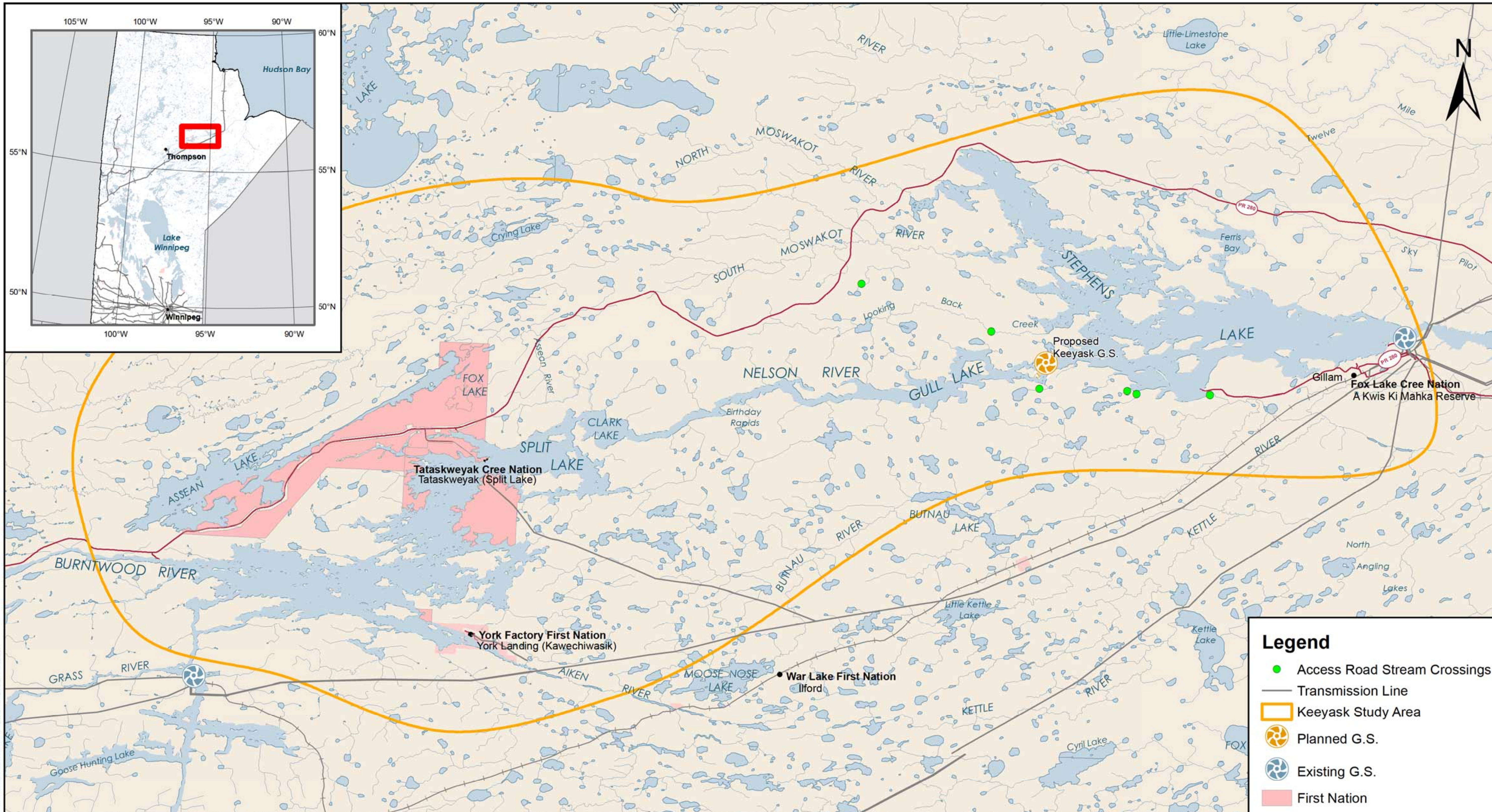
- Proposed Bipole III **Transmission Line**.
- Proposed Keeyask Construction Power and Generation Outlet Transmission Lines.
- Potential Conawapa Generation Project.

A brief description of these projects is provided in the Keeyask EIS: Response to Guidelines document (Chapter 7).

None of these proposed future projects would have an effect on the assessment of the debris environment because they do not have a bearing upon the processes driving the generation of debris within the Keeyask Project's open water hydraulic zone of influence.

10.4.6 Environmental Monitoring and Follow-Up

Through Manitoba Hydro's ongoing Waterways Management Program all debris that poses a potential threat to the safety of river travel and other activities will continue to be cleared from the waterway. Waterway management work crews will also monitor the amount of debris being removed and the locations from which it was removed.



KEEYASK Hydropower Limited Partnership

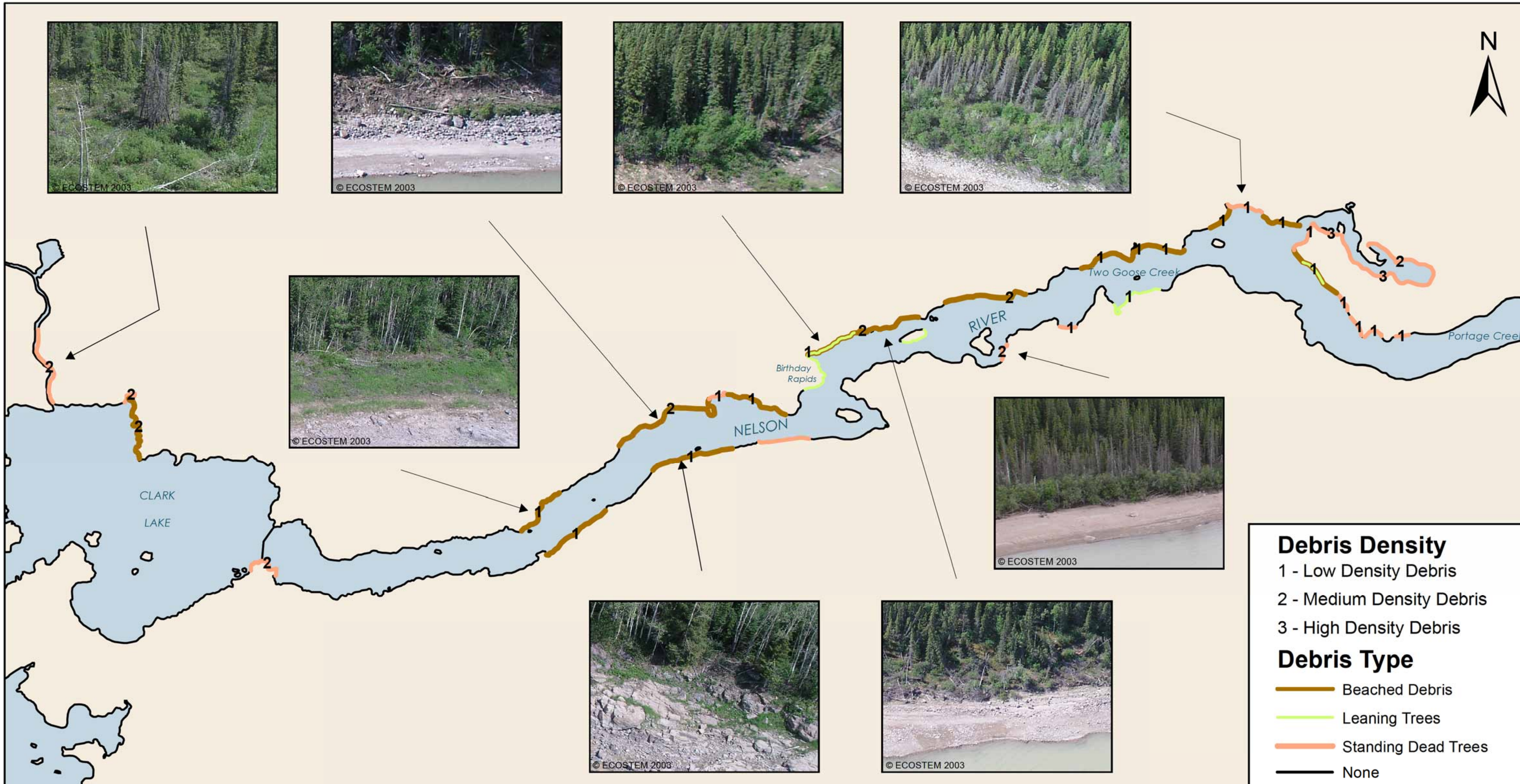
0 7.5 15 Kilometres

0 7.5 15 Miles

Coordinate System: NAD_1983_UTM_Zone_15N
Data Source: Manitoba Hydro, NRCan, NTDB
Date Created: June 27th, 2011

Keeyask Debris Study Area

Map 10.2-1

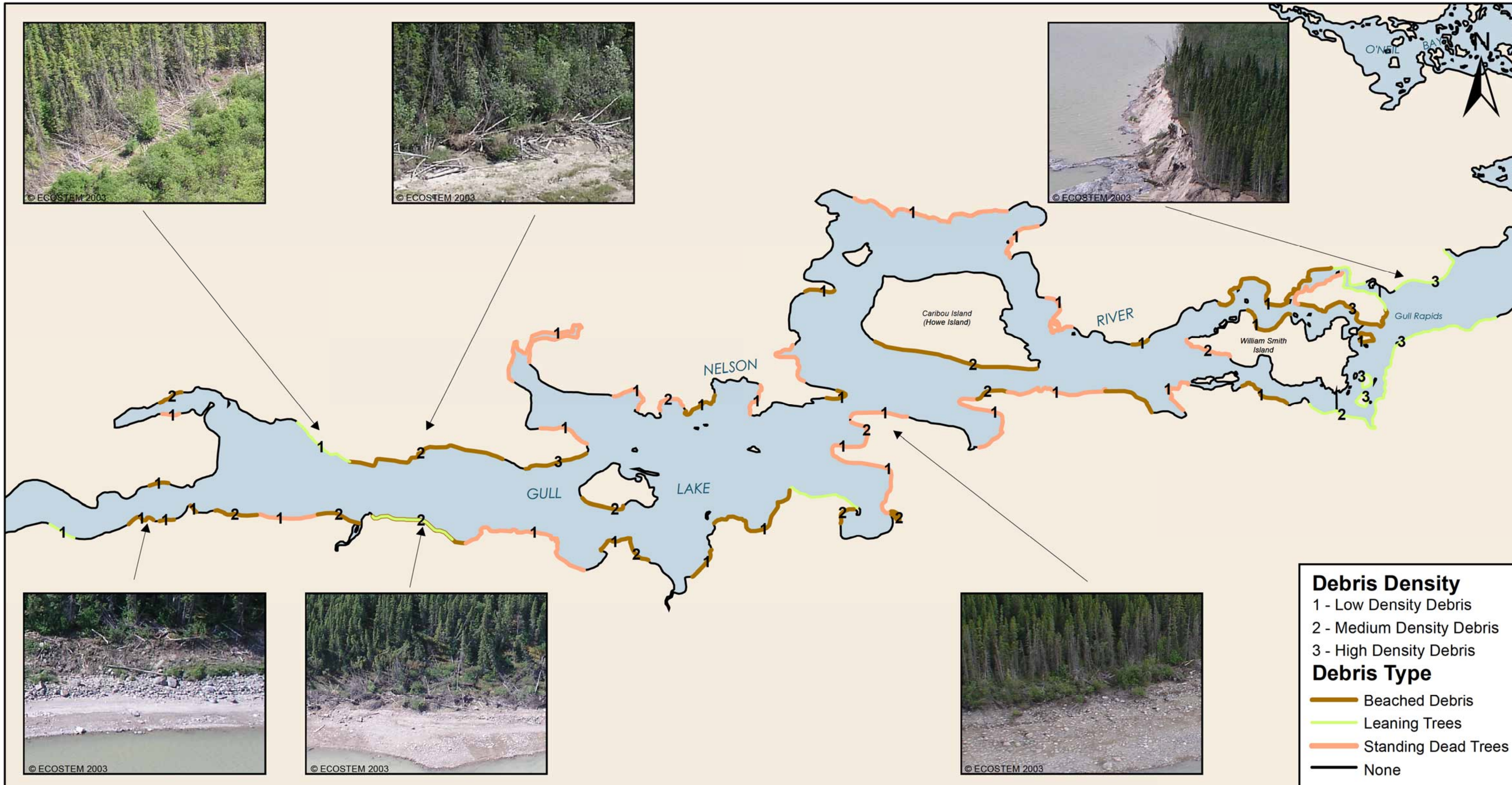


0 0.75 1.5 3 Kilometres
0 0.5 1 2 Miles

Projection: UTM, NAD83, Z15
Data Source: 2003 Nelson River Investigation
Date Created: August 11, 2009
Created By: MB Hydro

Shoreline Debris - Summer 2003

Reach 1: Clark Lake to Gull Lake



KEEYASK
Hydropower Limited Partnership

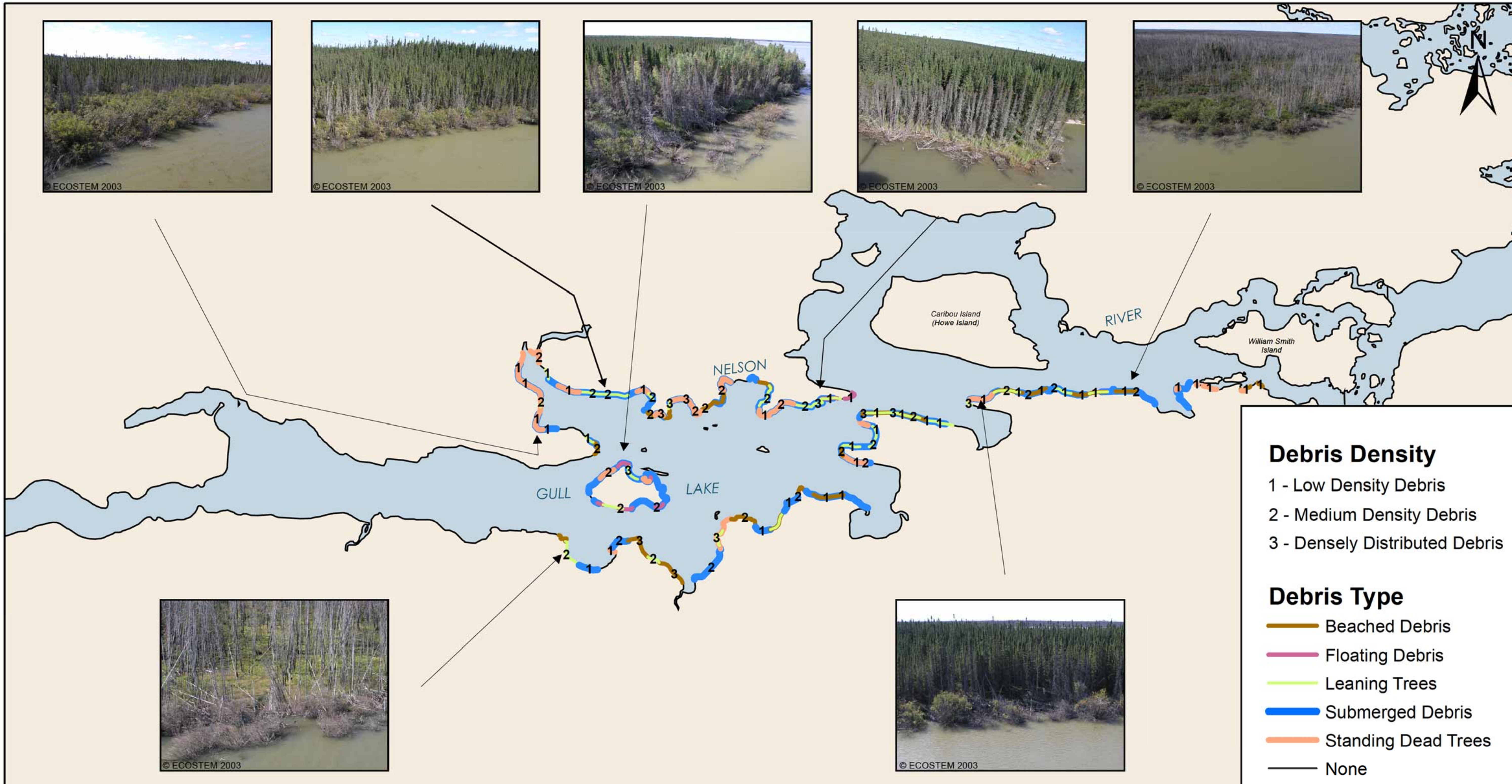
0 0.475 0.95 1.9 Kilometres
0 0.5 1 2 Miles

Projection: UTM, NAD83, Z15
Data Source: 2003 Nelson River Investigation
Date Created: August 11, 2009
Created By: MB Hydro

Shoreline Debris - Summer 2003

Reach 2: Gull Lake to Stephens Lake

Map 10.3-2

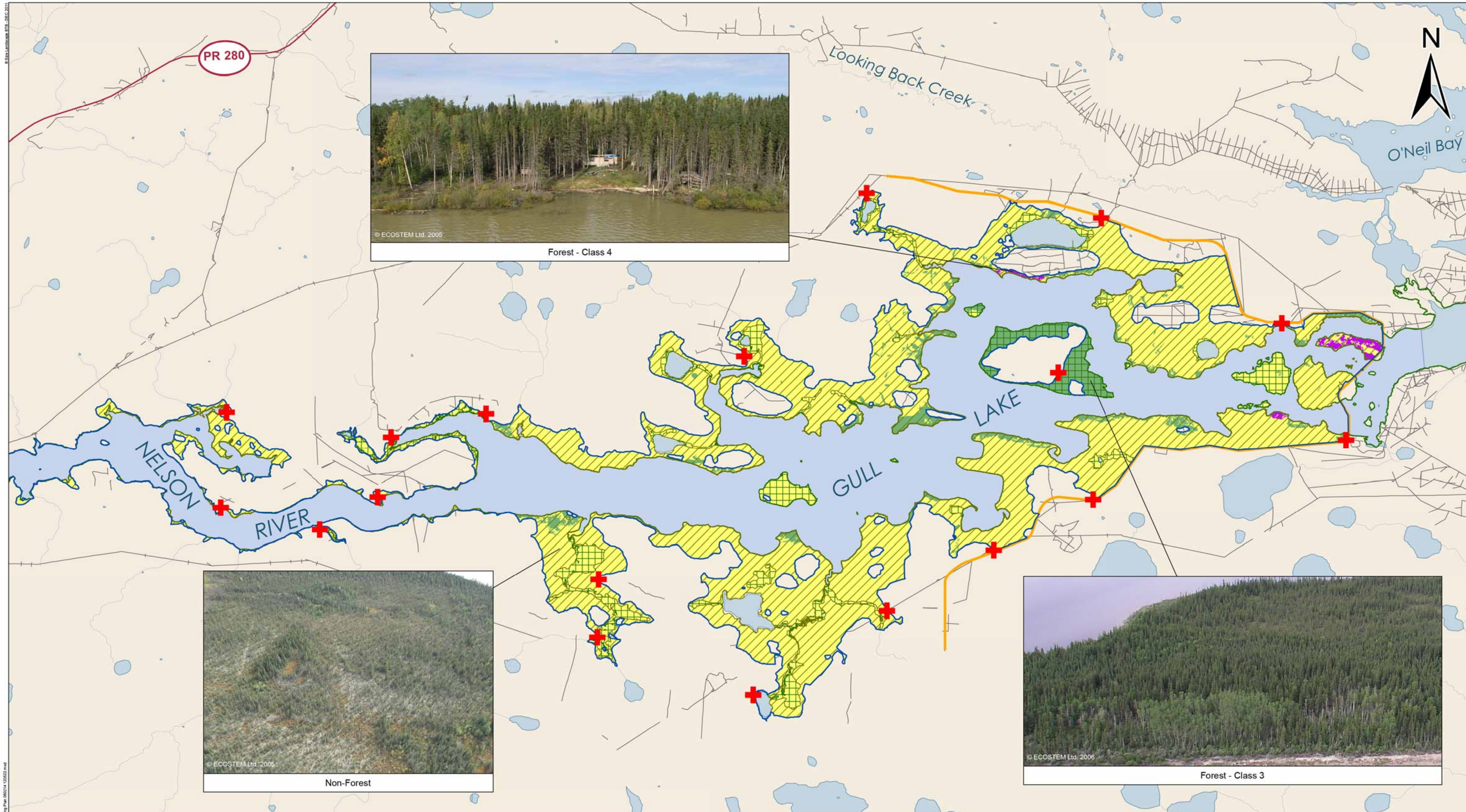


KEEYASK
Hydropower Limited Partnership

0 0.75 1.5 3 Kilometres
0 0.5 1 2 Miles

Projection: UTM, NAD83, Z15
Data Source: 2008-09-01 ECOSTEM: Shoreline Photos
Date Created: August 11, 2009
Created By: MB Hydro

Shoreline Debris - Sept. 1, 2008



KEEYASK
Hydropower Limited Partnership

DATA SOURCE:
Clearing methods, landing locations, cutlines and forest type - ECOSTEM Ltd.; Existing water (gull-ee-95perc-4327cms), flooded area (pp-95perc-4327-159-shore) and principal structures - Manitoba Hydro; Water - NTS; Roads - Manitoba Conservation.

CREATED BY:
ECOSTEM Ltd.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	22-MAY-12	22-MAY-12
0 – 0.7 – 1.4 Kilometres; 0 – 0.7 – 1.4 Miles	VERSION NO: 1.0	QA/QC: APPROVED

Legend

Potential Landing Location

Clearing Method
- Hand
- Hand or Machine

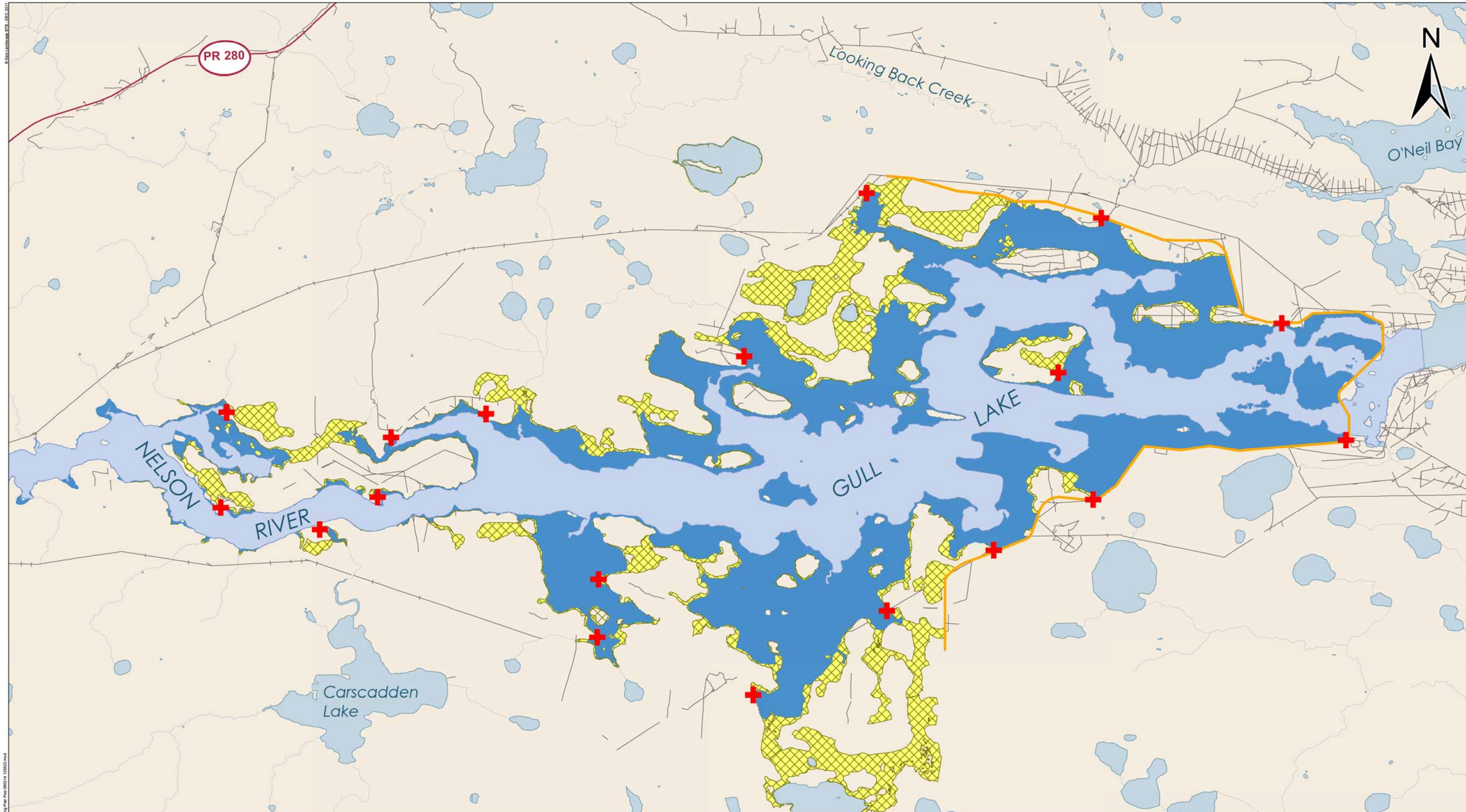
Forest Type
- Forest - Class 3
- Forest - Class 4
- Non-Forest

- Post-Flooding Shore
- Keeyask Principal Structures
- Cutline or Trail
- Highway

Notes: 1) All areas are preliminary 2) There are a few small bays upstream that would be hand cleared
3) Cutting Class - based on provincial forest resource inventory; uses a six-class system to describe forest maturity; class 3 = immature stand with merchantable volume; class 4 = mature stand

Keeyask Reservoir Clearing Plan: Pre-Flooding

Map 10.4-1



KEEYASK
Hydropower Limited Partnership

DATA SOURCE:
Clearing methods, landing locations and cutlines - ECOSTEM Ltd.; Existing water (gull-ee-95perc-4327cms), flooded area (pp-95perc-4327-159-shore) and principal structures - Manitoba Hydro; Water - NTS; Roads - Manitoba Conservation.

CREATED BY:
ECOSTEM Ltd.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	22-MAY-12	22-MAY-12
0 — 0.7 — 1.4 Kilometres 0 — 0.7 — 1.4 Miles	VERSION NO: 1.0	QA/QC: APPROVED

Legend

- Potential Landing Location

Clearing Method

- Hand

Debris Prevention Areas

- Peatland Disintegration - Potential

- Flooding
- Keeyask Principal Structures
- Cutline or Trail
- Highway

Notes: 1) All areas are preliminary 2) There are a few small bays upstream that would be hand cleared
3) Peatland disintegration occurs over many years; some of the potential areas may not disintegrate

Keeyask Reservoir Clearing Plan: Post-Flooding

Map 10.4-2