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APPENDICES

12. BARREN-GROUND CARIBOU

12.1 INTRODUCTION

12.1.1 Context

This section of the Developer's Assessment Report (DAR) for the Taltson Hydroelectric Expansion Project (the Project) consists solely of the Key Line of Inquiry (KLOI) for barren-ground caribou. The three caribou populations that may interact with the Project include the Bathurst, Ahiak, and Beverly herds. In the Terms of Reference (TOR) for the Project's DAR issued on March 28, 2008, the Mackenzie Valley Environmental Impact Review Board (MVEIRB) identified caribou as one of three issues of top priority valued components requiring the highest level of consideration by the developer (MVEIRB 2008). The following rationale for selecting barren-ground caribou as a KLOI was provided within the TOR:

> *"Concerns regarding the potential impacts of industrial development on barren-ground caribou have been a key issue of environmental impact assessment in the Mackenzie Valley for a number of years. Aboriginal communities, in particular, have been quite vocal about their concerns for caribou. Caribou are not only an important food source for traditional land users, but also a key feature of Aboriginal culture. Sport hunting of caribou is also an important contributor to the Northwest Territories' economy."*
>
> *"Impacts on caribou are likely to result in corresponding economic, social and cultural impacts. Threats to caribou are seen not just from the proposed development alone but cumulatively from all other activities within their range."*

As identified within the TOR, this KLOI for caribou details any effects the Project may have on caribou abundance, distribution, behaviour, health, habitat, and human use of caribou. In addition, this KLOI addresses how the predicted changes to the abundance, health, distribution, and behavior of caribou as a result of the Project may affect the opportunity for use of caribou by people that value the animals as part of their culture and livelihood.

All effects on caribou are assessed in detail in this KLOI; however, issues addressed in the following other KLOI and Subjects of Note (SON) may overlap with this KLOI:

- Water Fluctuations within the Taltson River Watershed (Section 13)
- Access (Section 15.5)
- Tourism Potential and Wilderness Character (Section 15.10)
- Impacts on Harvesting and Land Use (Section 15.11)

Where there is overlap between this KLOI and another KLOI or SON, information is provided in both locations as required by the TOR (MVEIRB 2008). However, this section contains the primary substantive analysis of the effects of the Project on caribou, including effects on the human use of caribou. The overlapping KLOI and SON contain a summary of applicable information.

12.1.2 Content

In this section, the effects analysis and assessment are arranged according to the sequence of steps in the assessment. The following briefly describes the content under each heading of the KLOI for caribou.

- **Existing Environment** (Section 9.5.4) summarizes baseline information on caribou herds with annual or seasonal home ranges that may overlap with the Project. This begins with the general environmental setting in which the Project occurs, followed by methods used to collect baseline data, and the baseline results for caribou.
- **Pathway Analyses** (Section 12.2) identifies all potential pathways by which the Project could affect caribou, and traditional and non-traditional uses of caribou. The validity of each pathway is assessed after application of mitigation to reduce or eliminate Project-related effects.
- **Effects to the Caribou Population** (Section 12.3) presents the methods and results of the analysis of effects from the Project on caribou population size and distribution, including effects to habitat quantity and quality, behaviour and movement, and survival and reproduction.
- **Related Effects to People** (Section 12.3.6) presents the results of the analysis of effects to people that arise from effects on caribou. This includes human access to caribou, availability of caribou, and effects on human health.
- **Residual Effects Summary** (Section 12.4) summarizes the effects to caribou and people that are predicted to remain after all mitigation measures to eliminate or reduce negative effects have been incorporated into the Project design.
- **Residual Effect Classification** (Section 12.5) classifies residual effects according to standard criteria.
- **Determination of Significance** (Section 12.6) presents the overall significance of effects to the assessment endpoints for caribou.
- **Uncertainty** (Section 12.7) discusses sources of uncertainty surrounding the predictions of effects to caribou, and monitoring that may be used to verify predictions.
- **References** of all documents and other material used in the preparation of this and all chapters can be found in Chapter 21, References.

12.1.3 Study Area

12.1.3.1 Spatial Boundaries of the Assessment

General principles used to determine spatial boundaries are provided in Chapter 10 — Assessment Methods and Presentation. Using these principles, the study area for this KLOI was identified in the TOR (MVEIRB 2008) as follows:

"For potential impacts on caribou, the geographical scope includes the portion of the range of any herd that may be potentially affected by any component or activity of the Project."

The spatial scales and boundaries selected for the KLOI: Caribou effects assessment of the Project include:

- the Local Study Area (LSA),
- the seasonal home ranges, and
- the entire range of the caribou herd.

The local study area (LSA) was defined as the entire Project footprint (or area to be disturbed), plus a 100 metre (m) buffer on either side. The LSA was selected to assess existing (baseline) conditions, and the immediate direct and small-scale indirect effects of the Project on individual animals and wildlife habitat.

Seasonal home ranges of caribou represent the area where caribou are likely to be found during a particular biological season. Caribou display distinct seasonal movement patterns and habitat preferences (ENR 2008), which were described as: the northern migration (May 1 to 31); calving (June 1 to 15); post-calving aggregation (June 16 to July 1); summer dispersal (July 2 to August 31); rut and fall migration (September 1 to October 31); and winter dispersal (November 1 to April 30). These seasonal ranges were described geographically, using satellite-collar data (courtesy of the ENR, 2007a) and a 95% kernel density (i.e. probability density) estimate (Figure 12.1.1). Some effects (such as harvesting and winter roads) may have spatial or temporal overlap with specific seasonal home ranges only, while other effects (such as habitat loss) may affect caribou throughout the year and within all seasonal ranges. The seasonal ranges were used to quantify baseline conditions at a scale that was large enough to assess the maximum predicted geographic extent (i.e. maximum zone of influence) of direct and indirect effects from the Project on caribou. Effects that were limited to certain seasonal home ranges were considered regional in nature.

Beyond the seasonal home ranges, the spatial boundary for quantifying baseline conditions and assessing Project-specific (incremental) and cumulative effects from development was defined by the annual home range of the Bathurst caribou herd (Figure 12.1.2). Using the annual home range to define the area beyond RSA is appropriate because this area includes all of the natural factors, human activities, and additional developments that can produce cumulative effects on the Bathurst caribou herd. For example, the Bathurst caribou annual home range includes the Project, four operating diamond mines (Snap Lake Mine, Diavik Diamond Mine, Ekati Diamond Mine, and Jericho Diamond Mine (which was closed during the time of writing, but considered nonetheless), one proposed diamond mine (the Gahcho Kué Project) and the Tibbitt to Contwoyto winter road (Figure 12.1.1). Several communities in the Northwest Territories (NWT) are also within the Bathurst annual home range (e.g. Łutsel K'e, Yellowknife, Behchokö, Whatì, Wekweètì, and Gamètì).

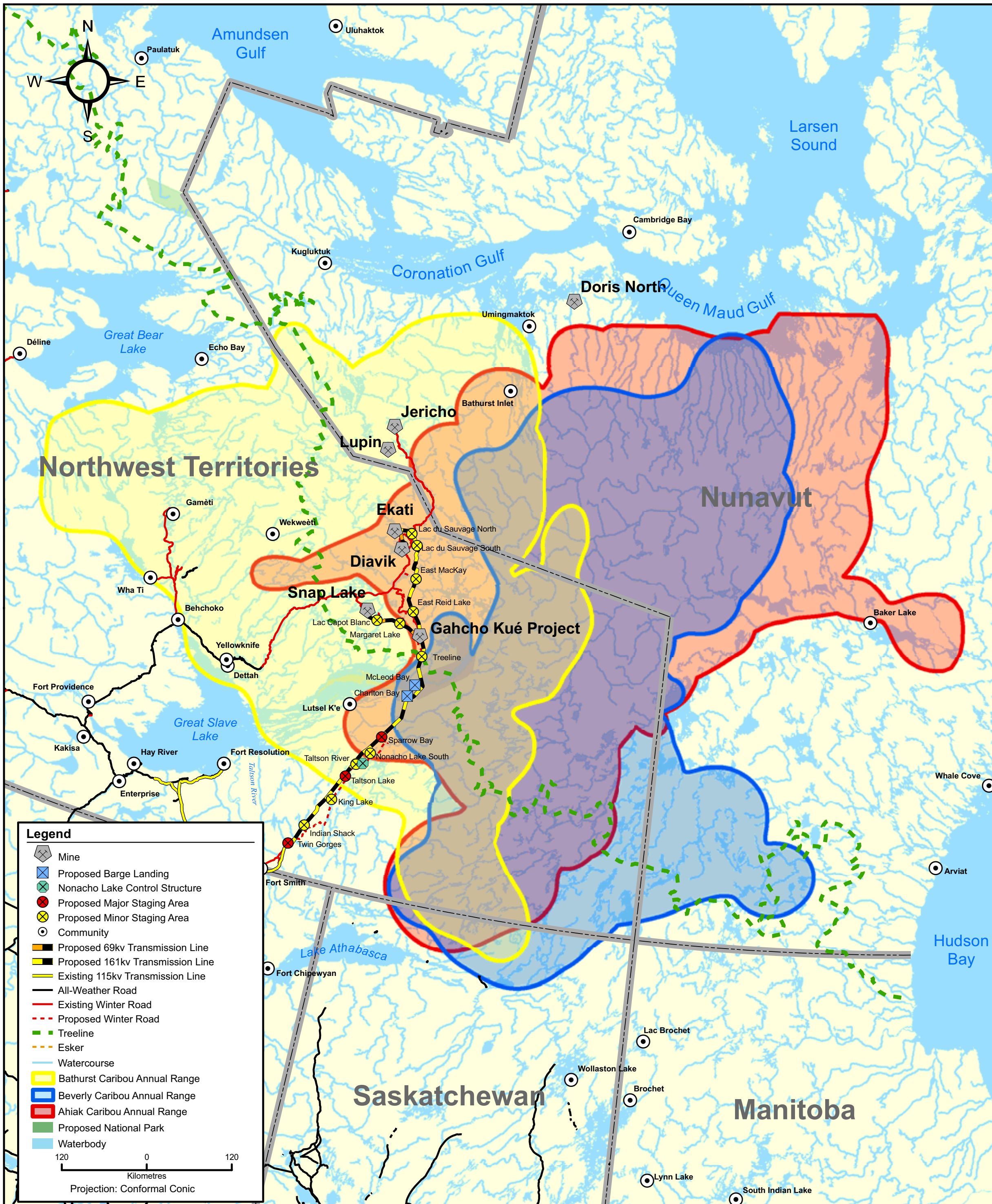
Range estimates for the Bathurst herd include satellite locations from January 1996 through October 2007. Estimates for the Ahiak and Beverly herds were generated from data collected from January 2001 through October 2007, and from January 1995 through October 2007, respectively. Natural factors, such as predation, insects, traditional and non-traditional harvesting, and habitat also can vary across the annual home ranges of the caribou herds. Thus, the annual home range provides an ecologically relevant spatial scale to assess the effects from the Project, other developments, and natural factors on caribou herds. The following annual home range of each herd was therefore used to define the spatial boundary for assessing Project-specific (incremental) and cumulative effects from development to each caribou population (Figure 12.1.2):

- annual range of the Bathurst herd (309,000 km^2);
- annual range of the Ahiak herd (345,000 km^2); and
- annual range of the Beverly herd (282,000 km^2).

TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Bathurst Caribou Seasonal Ranges**	**Figure 12.1.1**

Golder Associates Ltd./YK_143

Dezé energy



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Ahiak, Bathurst and Beverly Caribou Annual Ranges	Figure 12.1.2

12.1.3.2 TEMPORAL BOUNDARIES

In the DAR, temporal boundaries are linked to two concepts:

- The length of time that Project-related stressors would influence caribou during the different development phases of the Project (i.e. construction and operation).
- The predicted duration of effects from the Project on caribou, which may extend beyond operation.

The expected length of time that Project-related stressors would influence caribou during the construction phase is three years. Currently, the Project is expected to be in operation for 20 years to service the existing and proposed diamond mines. However, the infrastructure would have a lifespan of at least 40 years, and it is the intent of the Dezé Energy Corporation (Dezé) to solicit new customers to extend the Project beyond 20 years. Subsequently, the expected length of time that Project-related stressors would influence caribou during the operation phase is assumed to be 40 years. Although Dezé intends to operate the Project longer than 40 years if customers can be found, increasing the duration of the operation phase of the Project would increase the uncertainty in the effects predictions. For example, it is currently not known how much of the transmission line would be in operation after 40 years. Therefore, 40 years was defined as the longest reasonable duration of the operation phase for predicting and assessing effects from the Project.

The duration of some effects from the Project, such as changes to existing noise levels and dust deposition, are expected to stop soon after the end of construction. The transmission line, on the other hand, would generate stressors that would be present over a 40-year time span, and the duration of effects is expected to last beyond operations. An example of such an effect is the mortality of waterfowl caused by collisions with the transmission line. In this case, the assessment must predict if the effect on waterfowl populations during the 40-year operations phase is reversible. After removal of the stressor, reversibility is the likelihood and time required for a valued component or system to return to a state that is similar to the state of systems of the same type, area, and time that are not affected by the Project. Thus, the temporal boundary for caribou is defined as the amount of time between the start and end of a relevant Project activity or stressor (which is related to development phases), plus the duration required for the effect to be reversed.

12.1.4 Valued Components and Assessment Endpoints

This KLOI contains a single VC, the barren-ground caribou. As the Project does not overlap with high arctic or woodland caribou, these other caribou ecotypes were not included as VCs. Barren-ground caribou populations with ranges that overlap, or may overlap, with Project are the Bathurst, Ahiak, and Beverly herds. However, satellite-collar data from 1996 to 2007 indicates that the Bathurst herd has the greatest likelihood of interacting with, and being affected by, the Project during the northern migration, post-calving, summer, rut and winter seasons (Figure 12.1.1 and Figure 12.1.2).

The Bathurst herd is currently exposed to more mines and winter roads than either the Ahiak or Beverly herds, leading to greater potential for cumulative effects (see Section 19 – Cumulative Effects Analysis). The Bathurst herd is the most studied of the three herds (see ENR, 2008 and BQCMB, 2008), and is therefore the herd for which an effects assessment would have the least amount of uncertainty.

The effects analysis was completed for the Bathurst herd only and all Project-related effects predicted for the Bathurst herd are anticipated to be representative and provide conservative estimates of effects for the Ahiak and Beverly herds (i.e. the effects for the Bathurst herd would likely overestimate effects for the Ahiak and Beverly herds).

Assessment endpoints represent the key properties of the VC that should be protected for use by future human generations. Assessment endpoints are general statements about what is being protected. The assessment endpoints selected for caribou were:

- persistence of caribou abundance,
- persistence of caribou distribution,
- persistence of caribou health, and
- persistence of harvesting opportunities (for traditional and non-tradition land users).

12.2 PATHWAYS ANALYSIS

Pathway analysis identifies and screens the issues and linkages between Project components and activities, and the potential effects on caribou. A key component of the assessment process was to identify and focus on the areas where the Project may influence the physical and biological environment. This involved assessing how each of the Project components (e.g. Nonacho Lake control structure, canal, new powerhouse at Twin Gorges, winter roads, and the transmission line) may affect VCs (e.g. loss of vegetation, changes to caribou distribution, water quality). A linkage between a Project component and a VC is required to create a valid pathway. For example, vegetation clearing may cause changes to caribou distribution, but is unlikely to lead to caribou mortality. A pathway analysis was completed for caribou to identify valid, minor, and invalid Project-related pathways.

Some Project components do not lie within the Bathurst, Ahiak or Beverly herd ranges (Figures 12.1.1 and 12.1.2); therefore, these components were not considered in the pathway analysis. These Project components include the Twin Gorges facilities, the South Valley Spillway, and the Fort Smith to Twin Gorges winter road. Substations were also not considered, as they would be incorporated into the existing footprint of the mines to be serviced by the Project. Pathways to the availability of caribou for traditional and non-traditional harvesting are considered here, while pathways affecting the tourism industry that depends on caribou are assessed in Section 15.10 (Impacts on Tourism Potential and Wilderness Character).

The pathways presented in Table 15.7.4 were identified through reviewing concerns raised during:

- public information sessions in Fort Smith, Fort Resolution, and Hay River in March, 2004 (Rescan 2004);
- feedback received from Aboriginal organizations, as well as territorial and federal government departments, during the land use permit application to the Mackenzie Valley Land and Water Board (MVLWB) (2007); and
- public hearings hosted by the MVEIRB, and the MVEIRB TOR (MVEIRB 2008).

12.2.1 Mitigation

Mitigation refers to the practices used to reduce or avoid environmental effects. Any effects remaining after mitigation are referred to as residual effects. Within this DAR, mitigation has been divided into two categories:

- Mitigation practices – refer to any activity, strategy, or practice (e.g. management plans, best management practices) used to reduce or avoid a negative effect.
- Mitigation design features – refer to designs incorporated into the Project to avoid or reduce a negative effect.

Mitigation measures incorporated into the Project to remove or limit effects on caribou are listed in Table 12.2.1.

Table 12.2.1 — Mitigation Practices and Design Features That Reduce or Eliminate Effects to Barren-Ground Caribou

Project Component	Pathway	Pathway Duration	Mitigation
Nonacho Lake Control Structure	Changes in the timing of freezing and break-up may lead to injury/mortality to individual animals, and alter movement and behaviour	Operations	Project would be compliant with the existing water license. The Nonacho Lake Control Structure is required to manage water flows for generation without excess spill or extended low-flow periods at Twin Gorges
Nonacho Lake Control Structure Twin Gorges facilities Winter Access Roads (including temporary access trails, Tibbitt to Contwoyto winter road spurs, and Twin Gorges to Nonacho Lake winter road) Staging Areas Transmission Line Barge Landing Areas	Hazardous substance spills (e.g. fuel and hydrocarbons, jet fuel, and explosives) may affect caribou health	Construction	Construction machinery and vehicles would be properly maintained Refueling of machinery and vehicles would be completed away from any watercourse Spill containment supplies would be available in designated areas where fuel and chemicals are stored Fuel storage tanks would be designed and constructed according to the American Petroleum Institute (API) 650 standard and placed within a lined and dyked containment area to contain any potential spills Aviation fuel for helicopters would be stored in sealed drums inside a lined berm area at the helipad All petroleum products would be stored in approved containers and in areas with secondary containment Separate areas would be established for the handling and temporary storage of hazardous wastes Implementation of Spill Contingency EMP Implementation of Materials and Waste Management EMP
Winter Access Roads Transmission line	Improved access leading to increased traditional and non-traditional harvesting of caribou	Construction Operations	Winter roads would not be maintained following construction Winter roads and temporary access trails would be allowed to naturally re-vegetate following construction Southern sector winter roads would be gated, and public use of the road would not be permitted

Project Component	Pathway	Pathway Duration	Mitigation
Winter Access Roads Transmission line	Recreational snowmobiles leading to disturbance of caribou	Construction	Southern sector winter roads would be gated and public use of the road would not be permitted Recreational use of construction vehicles would not be permitted All employees would undergo environmental awareness training Following construction, the winter roads would no longer be constructed or maintained, and slash would be placed across the lower portages to discourage human and predator use
Winter Access Roads	Vehicle collisions leading to caribou mortality	Construction	Human Wildlife Conflict EMP would be implemented Speed limits would be established and enforced Wildlife on roads would be given the right of way
Nonacho Lake Control Structure Winter Access Roads Staging Areas Transmission Line Barge Landing Areas	Project footprint leading to direct habitat loss and fragmentation Direct and indirect habitat loss leading to change in abundance	Construction Operations	Planning of the transmission line right of way route and tower placement has considered alternative routes to avoid areas of high-density historical caribou migration trails (e.g. Lac de Gras narrows and outflow of Mackay Lake Selective clearing and retention of shrub vegetation at a height of up to 3 m in certain areas along the transmission line (i.e. within the proposed East Arm National Park) Adjustments to tower locations would be made during construction to avoid sensitive areas Clearing for camps and staging areas would be limited to only those areas necessary to support the construction activities Substations would be placed within existing mine boundaries Smaller crew camps would be located at existing camps to reduce infrastructure needs Access roads would only be used for three construction seasons (years) Clearing for winter roads would be limited to only those areas necessary to support the construction activities Vegetation clearing above the treeline would be limited to requirements for tower foundations and staging areas Wherever topography would allow, the transmission line would span low-lying areas, leading to less vegetation clearing The following Environmental Management Plans would be implemented: - Vegetation Management - Human Wildlife Conflict Management

Project Component	Pathway	Pathway Duration	Mitigation
			Use of proven best management practices for road construction Adhering to the Vegetation Management Environmental Management Plan Width of transmission line right of way and winter access roads would be limited, while maintaining safe construction practices Following construction, winter roads and temporary access trails would be allowed to re-vegetate naturally Adhere to the Human Wildlife Conflict Management Plan
Nonacho Lake Control Structure Winter Access Roads Staging Areas Transmission Line Barge Landing	Sensory disturbance leading to changes in habitat quality and movement and behaviour (e.g. combined effects from noise, dust, air emissions, physical presence of the Project, human activity) leading to change in habitat quality Direct and indirect habitat loss leading to change in abundance and distribution	Construction Operations	Planning of the transmission line right of way route and tower placement has considered alternative routes to avoid areas of high-density historical caribou migration trails (e.g. Lac de Gras narrows and outflow of Mackay Lake Electromagnetic noise from the transmission line would be below US Environmental Protection Agency guidelines, and would likely be inaudible (Teshmont 2008) Construction activities are planned to occur during periods that would be least disruptive to caribou in the area The Human Wildlife Conflict Management Plan would be implemented Winter roads constructed for the southern portion of the Project would be temporary and used for three winter seasons and would not be maintained following construction Access to the winter roads would be limited to vehicles involved in Project construction (i.e. public use of the southern sector winter roads would not be permitted) Substations would be placed within existing mine boundaries Blasting activities would only occur during the construction phase and would not involve substantial re-handling of material Construction would mainly occur in winter, using winter roads which do not produce dust All employees would provided with environmental awareness training Speed limits for the Project winter access road would be established and enforced

Project Component	Pathway	Pathway Duration	Mitigation
Winter Access Roads Transmission Line	Use of linear corridors by Wolves leading to change in predation rate	Construction Operations	Selective clearing and retention of shrub vegetation at a height of up to 3 m in certain areas along the transmission line (i.e. where terrain is too difficult for machinery to access and within East Arm National Park) Use of existing winter access roads where possible (e.g. northern access roads, upgrading of existing Fort Smith to Twin Gorges winter road) Following construction, winter roads and temporary access trails would be allowed to naturally re-vegetate

12.2.2 Pathway Validation

Potential pathways leading to effects on caribou include direct and indirect effects on individuals and their habitat (Table 12.2.2). These changes may ultimately affect the population size and distribution of caribou. In the pathway validation, each potential pathway is screened to assess its validity for the Project after mitigation practices and design features have been incorporated and characterized, as follows:

- Invalid – pathway does not exist, is removed by mitigation, or mitigation results in no detectable (measurable) change and residual effect relative to baseline or guideline values.
- Minor – mitigation results in a minor change from the pathway, but has a negligible residual effect (e.g. the loss of a small amount of habitat, but has little effect on the population).
- Valid – a pathway that likely contributes to residual effects to caribou.

Valid, minor, and invalid pathways are determined using scientific knowledge, logic, and experience with similar developments. Invalid and minor pathways were not carried forward into the effects assessment. A pathway is categorized as valid if a more detailed analysis is required to assess the effects.

Table 12.2.2 provides a summary of the pathways identified and their validity. Justification for the pathway validation is provided in the sections below.

Table 12.2.2 — Pathways to Caribou

Project Component	Pathway	Pathway Duration	Valued Component	Pathway Validation
Nonacho Lake Control Structure	Changes in the timing of freezing and break-up leading to injury or mortality to individual animals, and alter movement and behaviour	Operations	Caribou	Invalid
Nonacho Lake Control Structure Twin Gorges facilities Winter Access Roads Staging Areas Transmission Line Barge Landing Areas	Hazardous substance spills may affect caribou health	Construction	Caribou	Invalid
Winter Access Roads Transmission Line	Improved access leading to increased harvesting of caribou	Construction Operations	Caribou	Minor
Winter Access Roads Transmission Line	Recreational snowmobiles leading to disturbance of caribou	Construction	Caribou	Minor
Winter Access Roads	Vehicle collisions leading to caribou mortality	Construction	Caribou	Minor

Project Component	Pathway	Pathway Duration	Valued Component	Pathway Validation
Nonacho Lake Control Structure Winter Access Roads (including temporary access trails, Tibbitt to Contwoyto winter road spurs, and Twin Gorges to Nonacho Lake winter road) Staging Areas Transmission Line Barge Landing Areas	Project footprint leading to direct habitat loss and fragmentation	Construction Operations	Caribou	Valid
Nonacho Lake Control Structure Winter Access Roads Staging Areas Transmission Line Barge Landing Areas	Sensory disturbance leading to changes in habitat quality and movement and behaviour	Construction Operations	Caribou	Valid
Nonacho Lake Control Structure Winter Access Roads Staging Areas Transmission Line Barge Landing Areas	Direct and indirect habitat loss leading to change in abundance and distribution	Operations	Caribou	Valid
Winter Access Roads Transmission Line	Use of linear corridors by wolves leading to change in predation rate	Construction Operations	Caribou	Valid

12.2.2.1 INVALID PATHWAYS

Pathways are invalid if the activity does not occur, the pathway does not lead to barren-ground caribou, or has no residual effect. The pathways presented below were determined to be invalid for linking Project-related activities to effects on caribou. Invalid pathways were not assessed in the effects analysis.

12.2.2.1.1 Changes in the Timing of Freezing and Break-up Leading to Injury or Mortality to Individual Animals and Altered Movement and Behaviour

During Project operations, water would be managed to maximize power generation at Twin Gorges. The resulting Taltson River hydrograph would be a "flattened" version of the baseline hydrograph. Winter low flows would be increased as stored water is released from the Nonacho control structure to supply the water necessary to meet power requirements. Summer high flows would be stored within the Nonacho reservoir as water demand is met by other sub-basins of the Taltson basin (i.e. Tazin River).

The operations hydrograph would have an influence on ice forming and break-up processes within the basin. Winter flows under both expansion scenarios (36 and 56 MW expansions) would on average be greater than baseline flows. Increased flows could delay the ice-forming process. However, winter flows during operations are expected to have less seasonal variation relative to baseline and thus result in a more constant ice cover. During the spring/summer freshet period, peaks would be dampened and thus the ice cover would break up more slowly relative to baseline. Both of these changes are predicted to be negligible compared to baseline (see Section 13.5 - Alteration of Ice Structure). Operation flows during the ice forming process (October to November) are also expected to be similar to baseline. Therefore, the frequency of either injury or mortality of individual animals, as well as altered movement and behaviour from changes in the freezing and break-up, are anticipated to be within the range of natural variation. Therefore, this pathway was considered invalid.

12.2.2.1.2 Hazardous Substance Spills May Affect Caribou Health

Hazardous substances (e.g. fuel, lubricants or explosives) would be used during Project construction and operation. These substances would be contained and stored according to the relevant standards for each (for example, fuel storage tanks are designed according to American Petroleum Institute standard 650). However, through accidental spills, these hazardous substances may be released into the environment, where they may cause injury or negative changes to the health or mortality of individual animals. Generally, chemical spills have not been reported as the cause of wildlife health issues or mortality at existing large-scale projects or mines in the NWT or Nunavut (i.e. Ekati Diamond Mine, Diavik Diamond Mine, Jericho Diamond Project, Snap Lake Mine; BHPB 2007; Tahera 2007; DDMI 2008; De Beers 2008). Chemical spills are usually localized and are quickly reported and managed. The implementation of the Materials and Waste Management Plan and the Preliminary Spill Contingency and Response Plan for the Project are anticipated to limit potential effects on caribou from chemicals during construction. Some of the mitigation practices proposed in these Environmental Management Plans include:

- hazardous waste storage in secure locations at work sites and transport off-site for disposal;
- relevant guidelines and laws, such as those governing the transportation of dangerous goods, would be adhered to;
- provide spill containment supplies in designated areas;
- isolate and immediately clean-up any spills;
- fuel storage tanks would be designed and constructed according to the American Petroleum Institute (API) 650 standard, and placed within a lined and dyked containment area, which would contain any potential fuel spills;
- aviation fuel would be stored in self-contained Underwriters' Laboratories of Canada (ULC) rated envirotanks mounted on an elevated pad at the air terminal shelter; and
- aviation fuel for helicopters would be stored in sealed drums inside a lined berm area at the helipad.

Based on the proposed mitigation and past experience at other developments within the range of caribou, exposure of caribou to hazardous chemicals use is not anticipated to occur. Therefore, this pathway was determined to be invalid.

12.2.2.2 MINOR PATHWAYS

In some cases, both a source and a pathway exist, but the change caused by the Project is anticipated to be minor. Pathways presented below were determined to be minor pathways for caribou. Minor pathways are not assessed in the effects analysis.

12.2.2.2.1 Improved Access Leading to Increased Caribou Harvesting

The proposed southern sector winter roads could open new areas that were previously inaccessible to hunters. However, Dezé intends to control the use of the proposed winter roads to maintain their private road status. By limiting the use of the roads to vehicles involved in Project construction, restricting public assess to these roads, and implementing access control structures, many of the effects due to improved access for hunters should be mitigated. Despite mitigation, it is anticipated that unauthorized use of the winter roads may occur, potentially leading to some hunting in previously inaccessible areas. Considering that the existing winter road alignment from Fort Smith to Twin Gorges is currently passable with a snow machine (prior to the proposed upgrades), accessing new areas (i.e. winter road from Twin Gorges to Nonacho Lake and spur roads) would require travel along approximately 60 km of a private road and crossing two control gates.

In addition to the proposed mitigation practices, information on the densities and distribution of caribou indicate that there would be no clear advantage to using the Twin Gorges to Nonacho Lake winter road for hunting. The southern extent of the Bathurst caribou range (determined using movements of satellite-collared caribou, ENR 2007a) ends near the southern end of Taltson Lake (approximately 180 km driving distance from Fort Smith). Collared caribou movements indicate that Bathurst caribou do not frequent this area. Since 2002, collared caribou have been present within the RSA south of the Snowdrift River in only one winter (ENR, 2008). Figure 12.1.1 illustrates the southern extent of the Bathurst range (see also ENR 2008).

At the end of the hauling season, the Twin Gorges to Nonacho Lake winter road and the transmission line winter roads would be blocked through the use of gates, snow berms, and slash. Access to the southern sector winter roads would be limited by the ice conditions on the Slave River, which provides the only point of ground access to these winter roads. Winter roads are anticipated to be required for three consecutive construction seasons. At the end of construction, the start of the Fort Smith to Twin Gorges winter road would be permanently blocked by placing slash across the entrance. This would close access to all proposed winter roads in future years.

Improvements to access in the northern sector (i.e. via the Tibbitt to Contwoyto winter road) would be negligible. Spur roads would be constructed to connect the Tibbitt to Contwoyto winter road with the six laydown areas required in the northern sector of the transmission line. Some of these spur roads may be extensions of existing spur roads (e.g. those to the Snap Lake Mine and the Gahcho Kué Project), or connect directly to the Tibbitt to Contwoyto winter road. The nearest of these would be over 300 km from Yellowknife. Considering this distance, and the winter range of caribou (near or below the treeline), there would be little benefit to using the Project spur roads to harvest caribou. Further, these roads often do not require clearing of vegetation, and would not be operable during the sport hunting season for caribou, which only occurs between 15 August and 30 November (ENR 2007c).

Access is therefore not anticipated to affect either domestic or sport caribou hunting. Aboriginal hunters may harvest caribou at any time of year. However, access to the herd would not be improved, because, as outlined above, the southern sector winter roads would not be available for public use, and the Project would not provide substantial improvement on the access already available from the Tibbitt to Contwoyto winter road.

Increased human access is expected to result in a minor change in caribou abundance and distribution. Mitigation should limit access to winter roads. Unauthorized access would likely be associated with the periodic harvesting of caribou. However, the number of animals harvested should be within the range of current (baseline) conditions, and have a negligible effect on the persistence of populations and their distributions. Therefore, this pathway was determined to be minor. Effects to the tourism industry that depend on caribou are assessed in Section 15.10 (Impacts on Tourism Potential and Wilderness Character).

12.2.2.2.2 Recreational Snowmobile Use Leading to Disturbance of Caribou

As outlined above, Dezé intends to control use of the proposed winter roads, and maintain their private road status. Despite mitigation, it is anticipated that unauthorized use of the winter roads may occur, leading to some disturbance in previously inaccessible areas. However, accessing new winter roads would require travel along approximately 60 km of a private road and crossing two control gates. Further, the southern extent of the Bathurst caribou range ends near the southern end of Taltson Lake (approximately 180 km driving distance from Fort Smith). Collared caribou movements indicate that Bathurst caribou do not frequent this area. Since 2002, collared caribou have been present within the RSA south of the Snowdrift River in only one winter (ENR, 2008). Finally, access to the southern sector winter roads would be limited by the ice conditions on the Slave River, which provides the only point of ground access to these winter roads.

Sensory disturbance from snow machines is expected to result in minor, periodic, and localized disturbance to caribou. Relative to natural factors that affect movement and behaviour of caribou (e.g. snow depth, food accessibility, and predation risk), effects from snow machines are predicted to have a negligible influence on caribou abundance and distribution. Therefore, this pathway was determined to be minor.

12.2.2.2.3 Vehicle Collisions Leading to Caribou Mortality

Access to the Project would be by the re-commissioned Fort Smith to Twin Gorges winter road and the proposed Twin Gorges to Nonacho Lake winter road. In addition, narrow spur winter roads following the transmission line and extending to the staging areas (i.e. temporary access trails), and spur roads connecting the northern sector substations to the Tibbitt to Contwoyto winter road are also proposed as part of the Project.

Mortality of caribou from collision with vehicles has been a concern for most developments. The predominant factors that contribute to road-related wildlife deaths are traffic volume and vehicle speed (EBA, 2001). Implementation of the Winter Road Policy, Rules, and Procedures for the Tibbitt to Contwoyto winter road is anticipated to reduce the potential for injury or mortality of caribou from vehicle collisions (Echo Bay 2000). For example, from 1996 to 2001, there was one reported road-related caribou mortality incident along the Tibbitt to Contwoyto winter road. In March 1999, five caribou were killed by a grocery (meat) truck on a portage near Gordon Lake (EBA 2001). There were no vehicle-animal collisions reported on the Tibbitt to Contwoyto winter from 2000 to 2007 (E Madsen. pers. comm.)

The following mitigation practices are expected to limit the risk from vehicle collisions with individual animals:

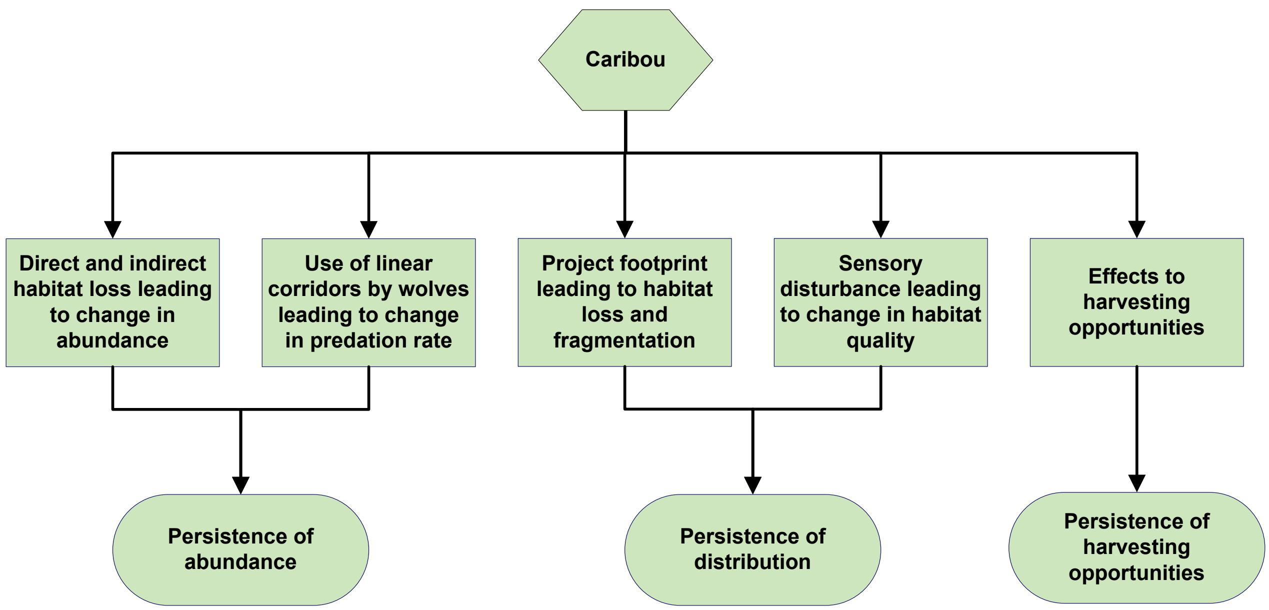
- Project access roads would be private roads, and access would be limited to vehicles involved in Project construction;
- transmission line winter roads would be accessible only from the Twin Gorges to Nonacho Lake winter road; and
- speed limits for the Project winter access road would be established and enforced.

During the three-year construction period, haul trucks are expected to arrive at various staging areas for the offloading of construction equipment and supplies. The mitigation proposed in the Human Wildlife Conflict Management Plan is anticipated to result in a minor effect on caribou from vehicle collisions. In addition, use of winter roads would be limited to the winter months (i.e. January to March) and only for the three-year construction period, after which time Project-related roads would not be maintained. Therefore, this pathway is considered minor.

12.2.2.3 VALID PATHWAYS

The following pathways were determined to be valid for linking Project-related activities to effects on caribou and are carried forward and assessed in the effects analysis. Figure 12.2.1 provides a schematic of these pathways.

- Project footprint leading to habitat loss and fragmentation.
- Sensory disturbance leading to changes in habitat quality, movement and behaviour.
- Direct and indirect habitat loss leading to change in abundance and distribution.
- Use of linear corridors by predators leading to change in predation rate.



Pathways of Project Effects to Caribou

Figure 12.2.1

12.3 EFFECTS ASSESSMENT FOR BARREN-GROUND CARIBOU

12.3.1 General Approach

Caribou are considered a key species in the northern ecosystem, and have great cultural and economic value to residents of the NWT. As such, caribou have been selected as a VC species. Concern has been raised regarding the effect of the transmission line and right of way (ROW) clearing to caribou migratory movements (MVEIRB 2008). The Project overlaps with caribou ranges from the Bathurst, Ahiak, and Beverly herds. Surveys completed since 2000 indicate that the Bathurst herd is declining while the status of the Beverly and Ahiak herds is unknown. Population declines in many of the mainland herds (most accurately documented in the Bathurst herd, see ENR 2008) also warrant inclusion of this species as a VC.

As discussed in Section 12.1.4 – Valued Components and Assessment Endpints, the effects assessment focused only on the Bathurst caribou herd. The reasons for this are as follows:

- of the three caribou herds that would likely interact with the Project, the Bathurst herd has the greatest degree of spatial overlap, leading to greater potential for incremental effects;
- the Bathurst herd is currently exposed to more mines and winter roads than either the Ahiak or Beverly herds, leading to greater potential for cumulative effects; and
- the Bathurst herd is the most studied of the three herds (see ENR, 2008 and BQCMB, 2008) and is therefore the herd for which an effects assessment would have the least amount of uncertainty.

Residual changes to caribou are analyzed using the assessment endpoints (Section 12.1.4) and are expressed as effects statements. The following effects statements encompass the valid pathways for linking Project-related activities to effects on caribou:

- Direct effects to habitat loss and fragmentation from the physical footprint of the Project and winter roads leading to changes in caribou abundance and distribution.
- Sensory effects from construction and operational activities (e.g. noise, helicopters, presence of buildings, people, lights, smells, and vehicles) leading to alterations in habitat quality, distribution, movement and the amount of available caribou habitat which may lead to changes in caribou abundance and distribution.
- Increased use of linear corridors by predators (i.e. wolves) and subsequent changes in predation rate, resulting in a change to caribou abundance.

Effects statements may have more than one valid pathway that link a Project activity with a change in caribou population size and distribution. For example, the pathways for effects to habitat quality, movement, and behaviour include changes due to noise, dust deposition, the presence of vehicles, and Project infrastructure. The combination of direct (physical footprint) and indirect (noise, dust, and other sensory disturbances) effects can create a zone of influence (ZOI) around the Project that can modify the behaviour and occurrence of caribou.

Changes in the quantity and quality of habitat within the ZOI can influence the number of animals that the landscape is able to support (i.e. carrying capacity). If animals strongly avoid human development, then the use of less disturbed areas may increase and become more concentrated. Changes to behaviour (e.g. decreased time spent feeding or increased time spent moving away from disturbance) within the ZOI can influence the energetic balance of caribou, and alter survival and reproduction. All of these changes can ultimately affect caribou population size and distribution.

The spatial scale of the analysis considers natural and human-related effects that occur within the seasonal ranges of the Bathurst caribou herd. The temporal scale looks at natural and development-related changes from baseline conditions through application of the Project. Baseline conditions represent a range of temporal values on the landscape from pristine (i.e. little to no development) to existing conditions (i.e. year 2007). Environmental conditions on the landscape before development (i.e. pristine conditions) are considered part of the baseline. This is because the baseline represents a range of conditions over time, and not just a single point in time. Analyzing a range of temporal conditions on the landscape is fundamental to understanding the cumulative effects of increases in development on caribou populations.

The effects analyses determine both the incremental and cumulative changes from the Project on the landscape, caribou, and the use of caribou by people. Incremental effects represent the Project-specific changes relative to baseline values in 2007 (current or existing conditions). Project-specific effects typically occur at the local scale (e.g. habitat loss due to the Project footprint) and regional scale (e.g. combined habitat loss, dust, noise, and sensory disturbance from Project activities.).

Cumulative effects are the sum of all changes from baseline conditions to the application of the Project. In contrast to Project-specific (incremental) effects, cumulative effects occur across the range of the population (i.e. beyond local and regional scales). This is because caribou travel large distances during their seasonal and annual movements, and can be affected by the Project, as well as several other developments. In other words, the combined local and regional effects from the Project and other developments overlap with the distribution of the population.

Cumulative effects do not just include the combined effects from human development on caribou populations. Cumulative effects represent the sum of all natural and human-induced influences on the landscape and caribou populations through time and across space. Some changes may be human-related, such as increasing development or hunting pressure. Other changes may be associated with natural phenomenon, such as periodic harsh and mild winters. The objective of the cumulative effects analysis is to estimate the relative contribution of both natural and human-related influences on the observed and expected changes to caribou population size and distribution.

Detailed descriptions of the spatial and temporal boundaries, as well as methods used to analyze residual effects from the Project on caribou, are provided in the following sections. The analyses were quantitative, where possible, and included data from field studies, scientific literature, government publications, effects monitoring reports, and personal communications. Due to the amount and type of data available, some analyses were qualitative and included professional judgement or experienced opinion.

12.3.2 Project Footprint Leading to Habitat Loss and Fragmentation

Construction of the Project would lead to direct loss of habitat, and separation of habitat patches. The incremental and cumulative direct effects on habitat loss and fragmentation from the Project footprint and other previous and existing developments in the study area were analyzed through changes in the area, composition, and spatial configuration of habitat types on the landscape (i.e. landscape metrics). Landscape metrics for each habitat included total area, number of patches, mean area of patches, mean distance to the nearest similar patch, and coefficient of variation of mean distance to the nearest similar patch. Effects of fragmentation and direct loss of habitat in the study area can influence population size (by reducing carrying capacities), as well as the distribution of caribou.

Effects of habitat loss and fragmentation were investigated over three development scenarios (or points in time); the pristine (or pre-development) environment, the existing environment in 2007, and the application scenario, which considers the existing environment with the addition of the Project to the landscape. The relative change in measures of direct habitat loss and habitat fragmentation were calculated over these three scenarios to investigate how habitat loss and fragmentation has changed over time, and the further changes that would be introduced by the Project.

12.3.2.1 Methods

The incremental and cumulative direct effects to habitat loss and fragmentation from the Project footprint, as well as other previous and existing developments in the Project footprint, were analyzed through changes in the area, composition, and spatial configuration of habitat types on the landscape (i.e. landscape metrics). This analysis required the following spatial data sets:

- the anticipated Project footprint area;
- information on the historic and current land use activities within the Bathurst caribou range (to estimate cumulative effects); and
- landscape classification for the range of the Bathurst herd, separated into the four seasonal ranges that overlap with the Project (i.e. the northern migration, post-calving, rut, and winter ranges).

These three items were combined within a Geographic Information System (GIS) platform, and were used to determine how previous and existing developments in combination with the Project have affected the pristine landscape. The study areas for the assessment of effects were the four seasonal ranges of the Bathurst herd (Figure 12.1.1).

The number and type of previous and existing developments in the study area for the Bathurst caribou herd are listed in Table 12.3.1 (see also Section 19 Cumulative Effects Analysis). Data on the location and type of developments were obtained from the following sources:

- Mackenzie Valley Land and Water Board (MVLWB): permitted and licensed activities within the NWT;
- Indian and Northern Affairs Canada (INAC): permitted and licensed activities within the NWT and Nunavut;
- Natural Resources Canada (NRCAN): GIS file of community locations from NRCan's GeoGratis website;
- GNWT: location of parks within the NWT;
- websites of companies holding land use permits; and
- knowledge of the area and Project status.

Table 12.3.1 — Previous and Existing Developments in the Bathurst Caribou Range

Activity	Number	Status	Footprint Area (ha)[1]
All season road	2	Active	3,154
Winter road	22	Active	45,217
Mineral exploration and camps	116	Active	37,556
Mineral exploration and camps	214	Inactive	62,128
Communications	2	Active	27
Communications	2	Inactive	24
Community	9	Active	5,908
Fuel storage	4	Inactive	40
Lodge	13	Active	161
Lodge	10	Inactive	120
Mine	3	Active	6,290
Mine	5	Inactive	874
Miscellaneous	12	Active	139
Miscellaneous	33	Inactive	340
Power	3	Active	1,003
Power	1	Inactive	334
Quarrying	6	Active	40
Quarrying	19	Inactive	140
Seismic	2	Active	1,428
Staging area	1	Active	13
Staging area	1	Inactive	12

Activity	Number	Status	Footprint Area (ha)[1]
Woods operation	1	Inactive	13
Gahcho Kué mine	1	Active	1,310
Gahcho Kué winter road	1	Active	2,399
Taltson Proposal	1	Proposed	2,113

[1] ha = hectare

Initially, information on land use permits was obtained in spreadsheet format. Some temporal data were available prior to 1996, but most of the known start and end dates of land use permits for developments were available from 1996 through 2007. The file was examined for duplication of information (e.g. a water license and a land use permit for the same development). In cases where two or more permits for overlapping activities were issued (e.g. a camp and associated airstrip), the extra information was deleted from the file so that it contained only one location per development or project. As the database contained no information on the size of the footprint for communities and closed and operating mines, the footprint was digitized from Landsat 7 imagery from the Government of Canada (CanImage 2007, internet site). For all closed mines and inactive land use permits, the Project footprint was carried through the entire effects analysis as it was assumed that direct disturbance to the landscape had not yet been reversed. Footprints with overlapping areas on the landscape were not counted twice. For all other developments (e.g. exploration), the area of the footprint was estimated using a number of assumptions (Table 12.3.2). For example, a 1,000 m radius (314 ha) was used to estimate the area of the footprint for exploration sites. This likely overestimates the amount of habitat directly disturbed by exploration activities. Exploration programs typically contain temporary shelters for accommodations and storage of equipment, and are elevated to limit the amount of disturbance to the soil and vegetation. Drilling is usually carried out with portable drill rigs (5 m x 5 m area) at one location at a time.

Table 12.3.2 — Footprints for Previous and Existing Developments in the Study Area

Type	Feature Type[2]	Footprint Extent (m^2)
Communications (e.g. microwave towers)	Point	200
Community[1]	Polygon	Actual
Fuel storage	Point	200
Lodge (outfitters, tourism)	Point	200
Mine[1]	Polygon	Actual
Mineral exploration[1] and Camps	Point	1,000
Miscellaneous (e.g. bridge, culvert installation)	Point	200
Power plant	Point	1,000
Quarry	Point	200

Type	Feature Type[2]	Footprint Extent (m^2)
Staging area	Point	200
All season road	Line	200
Seismic	Line	200
Winter roads	Line	200

[1] Major disturbance type

[2] Footprint estimated with the exception of mine operations and communities, which were delineated and digitized from remote sensing imagery. Footprints for point features were based on a hypothetical radius. Footprints for linear features were based on a hypothetical corridor.

Land cover within the Bathurst range was classified using a remotely-sensed Land Cover Classification of Canada (1985 to 2000) dataset provided by the Government of Canada in a GIS platform. The land cover dataset was modified from 1,000 m cell sizes to a 25 m resolution, and then joined with esker habitat in 1:50,000 scale national topographic database (NTDB) layers. The merged database was similar to the Slave Geological Province dataset used in Johnson et al. (2005).

To estimate land cover disturbance from the Project, GIS shapefiles were created to determine the layout and extent of all components of the Project (including the transmission line, winter roads, staging areas, barge landing sites, and improvements to the facilities at Nonacho Lake). The location and geographic extent of these components were determined using the most recent engineering plans where available. Estimates were used where no engineering plans were available. The transmission line ROW was given a width of 30 m, winter roads were 15 m wide, temporary access trails were 5 m wide, and each staging area was estimated at 5 hectares (ha). Where uncertainty existed in the geographic extent of the Project components, the maximum expected extent was used. For example, in practice, the transmission line ROW clearing would likely range from 15 m to 30 m wide in boreal regions, and no clearing for the ROW is anticipated in treeless areas (i.e. above the treeline), and staging areas are expected to range from 2 to 5 ha. These Project components were overlaid with the Land Cover of Canada classification and the resulting disturbance for each Project component by land cover class was estimated.

Habitat fragmentation was measured at three points in time:

- pristine environment;
- existing (2007) environment (including the proposed Gahcho Kué Project); and
- existing environment with the Project on the landscape.

The span between pristine and existing environments is referred to as the baseline. The change in landscape metrics due to development was determined for four separate seasonal ranges of the Bathurst herd that overlap with the Project; northern migration (spring), post-calving (summer), rut (autumn), and winter (see Figure 12.1.1). Fragmentation analysis included the Twin Gorges to Nonacho Lake winter road and the Tibbitt to Contwoyto winter road for the winter range only.

Upon joining layers for the habitat fragmentation analysis, the dataset was re-sampled to 200 m cell sizes using a nearest neighbour algorithm (versus 100 m in Johnson et al. [2005]) because of computational constraints with generating habitat rasters over each seasonal home range. Tests for accuracy suggested there were marginal differences in the overall areas per cover type between a 100 m re-sampled dataset, versus a 200 m re-sampled dataset (i.e. less than 0.1%). Finally, the Land Cover of Canada dataset was reclassified into 12 classes similar to Johnson et al. (2005). Visual inspections of the distribution of land cover data in the areas that overlapped the Slave Geological Province and Land Cover of Canada guided the reclassification process.

Landscape metrics were determined using the program FRAGSTATS (Version 3.0) within a GIS platform for the pristine, existing, and application development scenarios. The cumulative effect of the Project on the loss and fragmentation of habitat was estimated by calculating the relative difference between the existing and pristine conditions, and between the application and existing conditions. The following equations were used:

baseline = (existing value – pristine value) / pristine value
application = ([existing value + the Project] – [existing value]) / existing value

The resulting value was then multiplied by 100 to give the percent change in a landscape metric for each comparison, and provides both direction and magnitude of the effect. For example, a high negative value for habitat area would indicate a substantial loss of that habitat type. Absolute values in landscape metrics are provided in Appendix 12A.

The temporal boundary for cumulative effects from future developments is a function of the duration of effects from the Project on habitat loss and fragmentation. Effects analyses for the future case are qualitative due to the large degree and number of uncertainties associated with the rate, type, and location of developments in the study area. Potential cumulative effects from reasonably foreseeable developments are discussed in Section 12.6.

12.3.2.2 HABITAT LOSS RESULTS

During Project construction, direct habitat losses to caribou would result from the clearing of trees along the 30 m wide transmission line ROW, at the Twin Gorges to Nonacho Lake winter road portages (expected to be approximately 15 m wide), and at the staging areas along the winter road (estimated to be in the order of 5 ha).

The physical footprint of the Project within all seasonal ranges of the Bathurst caribou herd is predicted to be 2,113 ha, of which 255 ha is winter roads over lakes (present only during construction) and 272 ha is transmission line ROW over lakes, leaving a total terrestrial footprint of 1,586 ha. Of this, 1,019 ha is transmission line ROW over the tundra, where no vegetation clearing is required (although some minor habitat loss would be required for the tower foundations). At the scale of the seasonal ranges, the analysis classified 12 habitat types for the Bathurst herd within four seasonal ranges that would overlap with the Project (i.e. the northern migration, post-calving, rut, and winter seasonal ranges).

Under pristine conditions (i.e. no development), heath tundra, rock association, forest and non-vegetated dominate the landscape for northern migration, summer, and autumn ranges of the Bathurst herd (Appendix 12A, Tables 12A.1 to Table 12A.3). Forest is the dominant cover type in the winter range of Bathurst caribou (approximately 45%, Table 12A.4). Sedge association, lichen veneer, and low shrub habitats each represent less than 5% of the seasonal ranges for the Bathurst herds, and eskers represent less than 1% of any seasonal range.

When considering the cumulative change of development from pristine to existing conditions, habitat-specific decreases from pristine to existing conditions among seasonal ranges varied from 0.0% to 1.0 % (Table 12.3.3 to Table 12.3.6). Decreases in the amount of quality habitat (i.e. heath tundra, sedge association, and lichen veneer) for caribou during the non-winter seasons ranged from 0.2% to 0.7%. During winter, forest habitat decreased by 0.4% from pristine conditions (Table 12.3.6).

Table 12.3.3 — Proportional Change in Landscape Metrics from Development Relative to Pristine and 2007 Baseline Conditions for the Bathurst Caribou Herd in the Spring Range

Land Cover Class	Total Area		Number of Patches		Total Edge		Mean Area of Patch		Coefficient of Variation for Patch Area		Mean Distance to Nearest Neighbour	
	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application
Esker	-0.7	< -0.1	-0.6	< -0.1	-0.7	< -0.1	< -0.1	< 0.1	< -0.1	< 0.1	0.3	< 0.1
Lichen veneer	-0.4	0.0	1.4	0.01.4	0.2	0.0	-1.9	2.0	0.3	0.0	-3.0	3.1
Rock association	-0.4	< -0.1	2.2	1.7	0.3	0.2	-2.6	-1.7	1.3	0.7	-2.8	-2.3
Heath tundra	-0.4	< -0.1	4.4	10.2	0.5	0.5	-4.7	10.2	2.2	-23.7	-3.6	7.9
Heath rock	-0.4	< -0.1	1.5	0.0	< -0.1	< -0.1	-1.8	< -0.1	0.7	< 0.1	-2.1	< -0.1
Sedge association	-0.4	< -0.1	2.9	4.0	-0.1	0.1	-3.3		3.6	1.1	-11.6	12.9
Riparian shrub	-0.3	< -0.1	0.8	1.3	-0.1	0.3	-1.1	-1.4	0.8	0.6	-1.1	-1.8
Low shrub	0.0	0.0	0.0	0.0	0.0	0.0	< -0.1	< 0.1	0.0	0.0	< 0.1	< -0.1
Forest	-0.3	< -0.1	2.8	4.4	0.4	0.5	-3.1	-4.3	1.5	-3.1	-1.5	-3.9
Young burn	-0.3	< -0.1	2.1	1.0	0.1	0.2	-2.3	-1.0	1.2	0.3	-8.3	-1.0
Old burn	-0.1	-0.2	0.5	3.0	< 0.1	0.9	-0.6	-3.1	0.4	-3.2	-0.5	-3.3
Nonvegetated	-0.5	< -0.1	1.2	1.1	0.7	0.1	-1.7	-1.1	0.9	0.4	-1.5	-1.6

Note: Baseline = relative change from Pristine to Existing Conditions in 2007; Application = relative change from Existing Conditions to Application Conditions. Values used for these estimates were more precise than those presented in Appendix 12A. All values are percent (%).

Absolute values for Reference, Baseline, and Application Landscape Metrics presented in Appendix 12A.

Table 12.3.4 — Proportional Change in Landscape Metrics from Development Relative to Pristine and 2007 Baseline Conditions for the Bathurst Caribou Herd in the Summer Range

Land Cover Class	Total Area		Number of Patches		Total Edge		Mean Area of Patch		Coefficient of Variation for Patch Area		Mean Distance to Nearest Neighbour	
	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application
Esker	-1.0	< -0.1	-0.9	-0.1	-1.0	-0.1	< -0.1	< 0.1	-0.2	0.1	0.3	< 0.1
Lichen veneer	-0.5	0.0	1.7	1.7	< 0.1	0.0	-2.2	2.2	0.4	0.0	-4.8	4.8
Rock association	-0.6	< -0.1	3.4	2.6	0.6	0.3	-3.9	-2.6	1.9	0.9	-3.3	-4.4
Heath tundra	-0.5	< -0.1	6.6	16.4	0.6	0.6	-6.7	15.7	3.3	-21.6	-4.0	10.4
Heath rock	-0.5	< -0.1	2.3	0.0	-0.1	< -0.1	-2.7	< -0.1	1.3	< 0.1	-3.3	0.0
Sedge association	-0.3	< -0.1	2.0	3.0	< -0.1	0.1	-2.3	3.3	2.0	0.8	-1.6	2.8
Riparian shrub	-0.3	-0.1	0.7	1.9	-0.2	0.5	-1.0	-2.0	0.8	0.6	-0.9	-2.3
Low shrub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forest	-0.6	-0.1	3.7	5.1	0.1	0.6	-4.1	-5.0	2.3	2.5	-1.8	-4.7
Young burn	-1.0	0.0	18.2	0.0	0.6	0.0	-16.3	0.0	14.5	0.0	-32.2	0.0
Old burn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nonvegetated	-0.7	< -0.1	1.6	2.3	1.2	0.2	-2.3	-2.3	0.9	0.8	-1.6	-3.2

Note: Baseline = relative change from Pristine to Existing Conditions in 2007; Application = relative change from Existing Conditions to Application Conditions. Values used for these estimates were more precise than those presented in Appendix 12A . All values are percent (%).

Absolute values for Reference, Baseline, and Application Landscape Metrics presented in Appendix 12A.

Table 12.3.5 — Proportional Change in Landscape Metrics from Development Relative to Pristine and 2007 Baseline Conditions for the Bathurst Caribou Herd in the Autumn Range

Land Cover Class	Total Area		Number of Patches		Total Edge		Mean Area of Patch		Coefficient of Variation for Patch Area		Mean Distance to Nearest Neighbour	
	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application
Esker	-0.8	< -0.1	-0.7	< -0.1	-0.8	< -0.1	< -0.1	< 0.1	-0.2	< 0.1	0.4	< 0.1
Lichen veneer	-0.7	0.0	1.7	1.7	0.3	0.0	-2.4	2.4	0.8	0.0	-5.9	5.
Rock association	-0.6	< -0.1	2.4	2.3	0.3	0.2	-2.9	-2.3	1.5	0.5	-2.8	-3.0
Heath tundra	-0.5	< -0.1	5.1	11.5	0.6	0.6	-5.3	11.4	2.5	-29.0	-4.1	8.8
Heath rock	-0.5	< -0.1	2.3	0.0	-0.2	< -0.1	-2.8	< -0.1	1.2	< 0.1	-3.4	0.0
Sedge association	-0.2	< -0.1	2.0	2.8	< -0.1	< 0.1	-2.2	3.0	1.8	0.6	-10.3	11.2
Riparian shrub	-0.3	< -0.1	1.1	1.2	< -0.1	0.2	-1.4	-1.3	0.8	0.7	-1.5	-1.7
Low shrub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forest	-0.4	< -0.1	3.6	4.5	0.6	0.5	-3.9	-4.4	1.9	-5.9	-1.6	-4.0
Young burn	-0.6	< -0.1	3.0	1.2	0.1	0.3	-3.5	-1.2	1.5	0.3	-9.1	-1.1
Old burn	-0.2	-0.2	0.8	3.1	< 0.1	0.8	-1.0	-3.1	0.7	0.8	-0.8	-3.4
Nonvegetated	-0.6	< -0.1	1.2	1.2	0.9	0.1	-1.9	-1.2	0.9	0.5	-1.2	-1.8

Note: Baseline = relative change from Pristine to Existing Conditions in 2007; Application = relative change from Existing Conditions to Application Conditions. Values used for these estimates were more precise than those presented in Appendix 12A . All values are percent (%).

Absolute values for Reference, Baseline, and Application Landscape Metrics presented in Appendix 12A

Table 12.3.6 — Proportional Change in Landscape Metrics from Development Relative to Pristine and 2007 Baseline Conditions for the Bathurst Caribou Herd in the Winter Range

Land Cover Class	Total Area		Number of Patches		Total Edge		Mean Area of Patch		Coefficient of Variation for Patch Area		Mean Distance to Nearest Neighbour	
	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application
Esker	-0.4	< -0.1	-0.3	< -0.1	-0.4	< -0.1	< -0.1	< 0.1	< -0.1	< 0.1	0.3	< 0.1
Lichen veneer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rock association	-0.5	< -0.1	5.1	1.7	0.2	0.2	-5.3	-1.7	-1.0	-0.5	-6.6	-1.7
Heath tundra	-0.4	< -0.1	5.3	10.9	0.7	0.5	-5.4	10.7	2.1	-5.0	-6.7	11.2
Heath rock	< -0.1	0.0	0.0	0.0	< -0.1	0.0	< -0.1	0.0	0.1	0.0	0.1	0.0
Sedge association	-0.1	0.0	0.8	0.8	< -0.1	0.0	-0.9	0.9	0.7	0.0	-11.7	11.7
Riparian shrub	-0.2	< -0.1	2.9	1.3	0.2	0.3	-3.0	-1.3	1.8	-2.5	-4.0	-1.3
Low shrub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forest	-0.4	< -0.1	11.0	15.5	2.0	0.4	-10.4	14.7	-51.1	-1.2	-6.5	9.7
Young burn	-0.3	-0.1	6.2	4.1	0.6	0.8	-6.1	-4.0	3.4	-0.6	-6.1	-3.7
Old burn	-0.1	-0.1	1.3	3.0	< 0.1	0.5	-1.4	-3.0	0.9	0.1	-1.3	-3.6
Nonvegetated	-0.8	< -0.1	10.9	3.1	4.1	0.9	-10.6	-3.1	4.7	1.4	-9.4	-3.3

Note: Baseline = relative change from Pristine to Existing Conditions in 2007; Application = relative change from Existing Conditions to Application Conditions. Values used for these estimates were more precise than those presented in Appendix 12A . All values are percent (%). Winter fragmentation analysis included winter access roads, Tibbitt to Contwoyto winter road spurs and the Twin Gorges to Nonacho Lake Winter Road.

Absolute values for Reference, Baseline, and Application Landscape Metrics presented in Appendix 12A

Comparison of existing and application landscapes indicated that habitat-specific incremental changes from the Project footprint were approximately 0.2% or less per seasonal range for the Bathurst herd (Table 12.3.3 to Table 12.3.6). For about half the habitat types, the change from the Project was less than 0.1%. In total, the Project footprint includes less than 1% of any seasonal range. Absolute values are provided in Appendix 12A.

12.3.2.3 HABITAT FRAGMENTATION RESULTS

The physical footprint of the Project within all seasonal ranges of the Bathurst caribou herd is predicted to be 2,113 ha, assuming a 30 m wide ROW for the entire length of the transmission line and all access roads and trails. The Project footprint used for the fragmentation analysis was 22,072 ha within the Bathurst range (this was associated with the 200 m by 200 m raster cell size [see Section 12.3.2.1]). Subsequently, the results of the fragmentation analysis for the development of the Project overestimated the changes to habitat fragmentation indices; therefore, these results are conservative.

Increasing development from pristine to 2007 existing conditions has resulted in habitat fragmentation or changes to the size, number, and distribution of habitat patches in the seasonal ranges of caribou. For example, decreases in habitat patch size and increases in the number of habitat patches ranged from 0.8% to 6.7% for quality habitats (e.g. heath tundra, sedge association, riparian shrub, and lichen veneer) within the spring, summer, and autumn ranges of the Bathurst herd (Table 12.3.3 to Table 12.3.5). Decreases in the mean distance to nearest neighbour for these habitats ranged from less than 1% to about 12%. Thus, development has resulted in the fragmentation of the landscape by decreasing the size and distance between some habitat patches while increasing the number of habitat patches for caribou.

In the winter range, development (which includes the Tibbitt to Contwoyto winter road) has also changed the configuration of habitats on the existing landscape for the Bathurst herd. For example, the decreases in the size of quality habitat patches (e.g. heath tundra, sedge association, and forest) ranged from 0.9% to 10.4%, while increases in the number of quality patches ranged from 0.8% to 11% (Table 12.3.6). Decreases in the mean distance to nearest neighbour for quality habitat patches ranged from 6.5% to 11.7%.

Addition of the Project resulted in incremental changes to the size, number, and distribution of similar habitats within caribou seasonal ranges. The increase in the number of patches for quality habitats within seasonal ranges varied from 0% to 9.8% relative to existing conditions, while the decrease in patch size ranged from 0% to about 6% (Table 12.3.3 to Table 12.3.6).

Relative to pristine conditions, cumulative changes from the Project and previous and existing developments on the location, size, and number of quality habitat patches within caribou seasonal ranges is estimated to range from less than 1% to 16% for the Bathurst herd. Most of the changes were associated with heath tundra and forest habitats, which include the dominant habitats in the non-winter and winter seasonal ranges (Appendix 12A). In addition, the incremental changes from the Project footprint were largely associated with the width of the buffer that was applied to the

Project winter access roads and trails and the transmission line. Due to the large area of seasonal ranges and computational constraints (Section 12.3.2.1), all linear features were given a width of 200 m, even though the actual width varies from 5 m to 30 m for Project components. Subsequently, Project-related changes in habitat fragmentation metrics were likely overestimated.

The Project footprint (which includes portions of the Tibbitt to Contwoyto winter road, the Twin Gorges to Nonacho Lake winter road, and temporary access trails along the transmission line ROW) changed the configuration of habitats on the landscape for the Bathurst herd. Although the presence of the Twin Gorges to Nonacho Lake winter road may represent a partial barrier to caribou and lead to some fragmentation of the population within the winter range (Trombulak and Frissell 1999), the road is only in operation for approximately ten weeks each year and is restricted to a three-year operation period during the construction phase. The winter road may act as a "leaky barrier" that some animals may manage to cross successfully (Tibbitt-to-Contwoyto Winter Road Joint Venture 2008), but it may restrict the landscape-scale movements of caribou for short periods of time (Treweek 1999).

12.3.3 Sensory Disturbance Leading to Changes in Habitat Quality, Movement and Behaviour

During construction, noise would be generated from mobile and stationary equipment, haul trucks on winter roads, helicopters, and other aircraft. During operations, transmission lines may lead to caribou avoidance of the area.

Sensory disturbances produced from the Project may result in an indirect effect on the quality of habitat available at the local and regional scales. For example, at the local scale, effect monitoring studies have suggested that caribou groups with calves spend less time feeding within 5 km of the Ekati Mine footprint (BHPB 2004), as compared to when they are farther from the Mine. At the regional scale, there is good evidence to suggest that caribou herds respond to diamond mine developments and linear developments (e.g. roads) by changing their distribution. The combination of direct (i.e. physical footprint) and indirect (e.g. noise and other sensory disturbances) effects can create a ZOI around the Project that can change the behaviour and occurrence of caribou (Section 9.5.4 Caribou Existing Environment). This ZOI appears to be greater than the estimated spatial extent of the independent effects from infrastructure, activities, or noise. For example, the estimated ZOI of diamond mines on caribou distribution may range from 10km to 50 km (Boulanger et al. 2004; Johnson et al. 2005; Golder 2005, De Beers 2008).

Specific to transmission lines, research has been completed on the sensory disturbance effects of transmission line noise or physical presence of towers on caribou. Available studies were used to qualitatively describe the likely range of caribou reactions to transmission lines during operations. For example, in Scandinavia, domestic reindeer (of the same species as Barren-ground caribou, *Rangifer tarandus*) resist crossing under power lines. Researchers attribute this behavior to the habitat alteration created by the combination of the power line hum noise and changes in snow conditions with large forest openings (Villmo 1975) (refer to Section 9.5.2.4).

Changes in the quantity and quality of habitat within the ZOI can influence the number of animals that the landscape is able to support (i.e. carrying capacity). Caribou travel great distances during their seasonal and annual movements and can be affected by the overlapping ZOI from the Project, and other developments. In other words, the incremental local and regional effects from the Project and other developments in the seasonal ranges accumulate together to influence the population size and distribution of caribou. Natural factors, such as insects, periodic hard winters, and long-term weather patterns also influence caribou population size and distribution.

12.3.3.1 METHODS

The effects of sensory disturbance from the transmission line construction and operation on habitat quality were investigated through a review of the literature on caribou responses to disturbance (Section 9.5.4.5). Changes to habitat quality were modelled using resource selection functions (RSF). Relative probability of use of a resource or habitat can be described by RSFs and have been used to describe caribou habitat preferences within the Slave Geological Province by Johnson et al., (2005). However, barren-ground caribou RSFs within the winter (boreal) range have not been developed. As a surrogate, woodland caribou habitat models were adapted to the Taiga Shield Ecozone.

The first step in classifying the quality of caribou habitat required establishing a foundation of land cover data, including both natural and anthropogenic landscape features. The human development database (described in Section 12.3.2.1) was used as the source of anthropogenic disturbance data. The Land Cover of Canada (1985 to 2000), provided by the Government of Canada, was applied in a GIS platform to represent natural land cover (as per Johnson et al. 2005). The land cover dataset was modified (as described in Section 12.3.2.1) and reclassified into 12 classes similar to Johnson et al. (2005). Visual inspections of the distribution of cover data in the areas that overlapped the SGP and Land Cover of Canada guided the reclassification process.

Methods for classifying caribou habitat quality then proceeded according to season. Analysis was completed for the following seasonal ranges that overlap with the Project:

- spring (northern migration/calving) – April 15 to June 14;
- summer (post-calving) – June 15 to August 31;
- autumn (rut) – September 1 to October 31; and
- winter – November 1 to April 14.

12.3.3.1.1 Spring, Summer, and Autumn Seasons

For the spring, summer, and autumn seasons, patches of habitat for each land cover type from the reclassified land cover dataset were identified such that each patch was a contiguous group of cells. Next, the proportional area of each patch, relative to that available for the related land cover type in a seasonal range, was determined. Based on the resulting raster layers, and the application of RSF coefficients and formulas in Johnson et al. (2005; Table 12.3.7), resource selection values were generated per cell. Water bodies were calculated as nil (zero) during the habitat mapping process.

Table 12.3.7 — Coefficients of Resource Selection Models for Caribou

Covariate	SPRING (Northern Migration/Calving)			SUMMER (Post-Calving)			AUTUMN (Rut)		
	Coef.	Lower 95% CI	Upper 95% CI	Coef.	Lower 95% CI	Upper 95% CI	Coef.	Lower 95% CI	Upper 95% CI
Sedge patch	1.091	0.299	1.882	0.870	0.309	1.431	0.139	-1.022	1.300
Riparian shrub patch	-3.171	-6.663	0.322	0.166	-2.100	2.432	2.273	0.556	3.991
Peat bog patch	n/a	n/a	n/a	n/a	n/a	n/a	0.081	-3.124	3.285
Low shrub patch	-0.071	-2.078	1.935	-2.732	-6.453	0.990	n/a	n/a	n/a
Heath tundra patch	1.263	0.760	1.765	1.070	0.651	1.489	0.462	-0.216	1.140
Heath rock patch	0.990	0.398	1.582	0.982	0.503	1.460	0.982	0.269	1.695
Rock patch	1.429	0.832	2.026	0.334	-0.191	0.860	-0.620	-2.128	0.888
Forest patch	-0.936	-2.765	0.893	n/a	n/a	n/a	1.483	0.681	2.285
Lichen patch	1.856	1.059	2.654	-0.450	-1.612	0.712	2.173	0.777	3.568
Esker patch	-1.303	-4.414	1.808	0.138	-1.829	2.105	-1.021	-5.705	3.663
Old burn patch	n/a	n/a	n/a	n/a	n/a	n/a	2.442	0.057	4.826
Unvegetated patch	1.776	0.922	2.629	-0.331	-1.501	0.839	2.266	0.731	3.800

Source: Johnson et al. 2005

n/a = not applicable; % CI = percent confidence interval; coef. = coefficient.

Effects of assumed disturbance, which were based on hypothetical (i.e. not modelled) disturbance coefficients (DC) and ZOI, were applied to the RSF outputs generated from land cover datasets. Hypothetical disturbance coefficients provide a surrogate to modelled coefficients, and are consistent with previous efforts to estimate effects from development on habitat quality (Johnson et al. 2005). Within each defined ZOI, DCs can reduce habitat quality. For example, a DC of 0.05 implies that habitat quality was reduced by 95% of the original value. Effects of assumed disturbance were used to quantify changes in the relative availability of different quality habitats during pristine conditions, 2007 existing conditions, and application of the Project. Analyzing a range of temporal conditions on the landscape is fundamental to understanding the cumulative effects of increases in development on caribou populations.

Values of DCs and ZOI were taken from published literature (Nelleman et al. 2001; Vistnes and Nelleman 2001; Mahoney and Schaefer 2002; Johnson et al. 2005; (Table 12.3.8). Correlation among disturbance effects could not be statistically controlled; therefore, the effects of multiple coefficients at the same location were not multiplied. The coefficient with the strongest effect was applied where ZOI overlapped, which increased certainty that the predicted effect would not be under-estimated.

Table 12.3.8 — Disturbance Coefficients for Development Footprints and Associated Zones of Influence

Type	Feature Type	Footprint Extent (m)	Footprint DC[5]	ZOI Range 1[1, 5] (km)	DC[4, 5]	ZOI Range 2 (km)[5]	DC[5]	ZOI Range 3 (km)[5]	DC[5]
Communications (e.g. microwave towers)	point	200	0.00	0 to 5	0.90	n/a	n/a	n/a	n/a
Community	polygon	actual[2]	0.00	0 to 1	0.05	1 to 5	0.50	5 to 20	0.75
Fuel storage	point	200	0.00	0 to 5	0.90	n/a	n/a	n/a	n/a
Lodge (outfitters, tourism)	point	200	0.00	0 to 5	0.10	n/a	n/a	n/a	n/a
Mine	polygon	actual[2]	0.00	0 to 1	0.05	1 to 5	0.50	5 to 30	0.75
Mineral exploration / Camp	point	1,000	0.00	0 to 10	0.50	10 to 15	0.75	n/a	n/a
Miscellaneous	point	200	0.00	0 to 5	0.90	n/a	n/a	n/a	n/a
Power (plant)	point	1,000	0.00	0 to 5	0.50	n/a	n/a	n/a	n/a
Quarry	point	200	0.00	0 to 5	0.75	n/a	n/a	n/a	n/a
Staging area	point	200	0.00	0 to 5	0.75	n/a	n/a	n/a	n/a
Transmission line[3]	line	200	0.00	0 to 1	0.05	1 to 5	0.75	n/a	n/a
All-season road	line	200	0.00	0 to 1	0.05	1 to 5	0.75	n/a	n/a
Winter roads	line	200	0.00	0 to 1	0.05	1 to 5	0.75	n/a	n/a
Seismic	line	200	0.25	0 to 1	0.50	n/a	n/a	n/a	n/a

Note: Values were guided by published literature (Johnson et al. 2005).

[1] From edge of measured or hypothetical footprint.

[2] Footprints were delineated from remote sensing imagery.

[3] DC and ZOI for transmission lines based on results reported in Mahoney and Schaefer 2002, Vistnes and Nelleman 2001 and Nelleman et al. 2003. Refer to Section 9.5.2.4 subheading Transmission Lines, for complete discussion. ZOI was deemed greater during seasons when caribou occur above the tree line due to visibility of the transmission line.

[4] Disturbance coefficient applied to RSF (raster) cell value, which was based on assumed disturbance.

[5] n/a = not applicable; m = metre; km = kilometre; DC = disturbance coefficient; ZOI = zone of influence.

For all closed mines and inactive land use permits, the physical footprint was carried through the entire effects analysis as it was assumed that direct disturbance to the landscape had not yet been reversed. The size of ZOI was similar for all permitted mines (i.e. 30 km) regardless of the level of activity or size of the Project footprint. In addition, the extent of the ZOI for exploration camps was set at 15 km for the duration of the permit period (i.e. five years) even though exploration typically does not occur throughout the year. This increased confidence that the assessment did not underestimate ecological effects from development.

After habitat maps and modelling for each seasonal range were completed, raster cells (ranging from 0 to 1) were divided into four categories (high, good, low, and poor) of approximate equal area (delineated by quartiles). However, the ArcGIS algorithm for this task was constrained by the large study areas (i.e. seasonal ranges), and distribution of cell values. Thus, category thresholds were manually determined by plotting a histogram of raster cell values, and running the equal area function on a lower range of data without outliers. Larger outlying values were grouped into the top category identified from the analysis on the lower (smaller) range of values. The RSF outputs based on only vegetation datasets were used as a pristine condition (i.e. no development) within the baseline case.

12.3.3.1.2 Winter Season

During winter, caribou typically inhabit forested areas below the treeline in the southern portion of their annual range (ENR 2008). Winter ranges are known to vary annually and appear to be a function of lichen consumption by caribou exceeding annual lichen growth (Arseneault et al. 1997), which leads to a shift in annual winter home ranges. An RSF does not currently exist for barren-ground caribou on their winter range. Given similar habitat use during the winter to woodland caribou, a habitat suitability index (HSI) model developed for woodland caribou was deemed to be appropriate for classifying winter barren-ground caribou habitat.

The most important winter food source for caribou are terrestrial lichens (Fuller and Keith 1981; Edmonds and Bloomfield, 1984; Thomas and Hervieux 1986). In years of high snow accumulation, terrestrial species are less accessible and there may be greater use of arboreal lichens (e.g. *Usnea* species, *Evernia mesomorpha*, *Alectoria* spp., *Bryoria trichoides*) (Manitoba Model Forest 1995). Peatlands, in particular treed fens and spruce bogs, provide caribou with the opportunity to forage on terrestrial lichens (Anderson 2000). Terrestrial lichens are also available in some non-peatland habitats, such as pine-dominated forest stands. Similarly, caribou feed in black spruce forests, principally on lichens, in the winter and then ruminate or bed in open areas (e.g. meadows and frozen lakes).

Predation is an important limiting factor for woodland caribou populations (Bergerud et al. 1984). Caribou avoid predators by separating themselves spatially from other ungulate prey (Bergerud et al. 1984; Stuart-Smith et al. 1997). As a result, upland areas thought to be suitable habitat for ungulates, such as moose, are not suitable habitat for caribou (Schneider et al. 2000).

On a regional scale, caribou may select winter home ranges that encompass large peatland complexes to reduce their risk of predation (Bergerud et al. 1984). Therefore, an assessment of habitat suitability should include the identification of large peatland complexes on a regional scale. Within their home range, a finer scale of habitat selection may occur based on the availability of forage. Habitat suitability at this scale is strongly influenced by the presence or absence of terrestrial lichens within particular habitat types.

Caribou are considered sensitive to numerous forms of human disturbances (Bradshaw 1995). These include activities generating noise, (e.g. blasting, heavy equipment operation, traffic, airstrip use), activities that alter habitat (e.g. road development, logging, construction, linear corridor clearing, fires, loss of lichens as a result of atmospheric pollution), and activities that directly interfere with caribou (e.g. human access including snowmobiles, vehicle collisions, and hunting). Activities that involve forest clearing (e.g. road construction, mining developments) may affect caribou through sensory disturbance (e.g. noise), increased human access, increased alternative prey and associated increases in predators, loss of cover, and loss of lichens (Dzus 2001, Chowns and Gates, 2004). Habitat alteration or fragmentation may also affect caribou by creating conditions suitable for moose and deer. Healthy moose and deer populations attract and support a greater number of predators (e.g. wolves), which may result in increased caribou predation. Overall, these factors may result in habitat avoidance. Several studies have documented the degree of caribou avoidance of forested habitat in response to human activities. These results were used to determine the ZOI for caribou to human infrastructure and sensory disturbance during the winter (i.e. when below treeline) (e.g. Bradshaw 1995; Dyer 1999; Dyer et al. 2001).

The assumptions for the winter caribou habitat suitability model include:

- caribou habitat selection is largely affected by two factors, predation risk and forage availability;
- caribou select areas of predominantly peatland habitat (i.e. bogs and fens) to avoid predation risk on a regional scale;
- caribou select peatlands and some upland habitats (e.g. pine-dominant stands) on a local scale, which provide opportunities to forage on terrestrial lichens (the main winter food source for caribou);
- caribou avoid areas with a high density of human use;
- caribou avoid roads, oil and gas developments, forestry operations; and
- water and mineral resources are not limiting.

The habitat composition within the winter range study area was assessed to determine the relative proportion of peatlands available for caribou. The area of peatlands was then used to rank the habitat at the winter range scale and determine a suitability index (SI) value, which ranges from 0.0 to 1.0 (Figure 12.3.1). SI (1) is an index of habitat suitability in relation to the proportion of peatland, while SI (2) is an index of habitat suitability in relation to the proportion of lichen. Based on research completed by Schneider et al. (2000), areas with greater than 50% peatland were considered highly suitable habitat for woodland caribou (SI (1) = 1.0). Therefore, this was assumed to be the case for barren-ground caribou. It is unknown as to the minimum peatland patch size or habitat configuration that would support caribou. As a result, SI (1) is set on a scale that gradually increases from 0.0 to 1.0 as peatland area expands from 0 to 50% for a given area (Figure 12.3.1). At this regional scale, areas with greater than 50% peatland are considered highly suitable habitat for barren-ground caribou in the winter.

Local level habitat selection by caribou involves the selection of certain vegetation types that provide the opportunity for caribou to forage. As a result, food availability was assessed based on the presence or absence of lichens. Estimates of the mean lichen percent cover per land cover class were needed to calculate the SI (2) (Figure 12.3.2). A robust vegetation data set describing the characteristics of land cover classes within the study area was not available. As a result, mean percent lichen (*Cladina* spp.) coverages could not be calculated from these data. Instead, each land cover class was assigned to one of the three lichen percent cover classes described in Figure 12.3.2 using professional judgement (Table 12.3.9). Vegetation types without terrestrial lichens were assumed to be unsuitable habitat for caribou (SI (2) = 0.0). Vegetation types with less than 5% lichens were assumed to provide limited forage opportunity for caribou and were assigned a value of 0.1. All vegetation types with greater than 5% cover of terrestrial lichens were assigned a SI (2) value of 1.0 to indicate that these habitats were suitable for caribou (Table 12.3.9).

Figure 12.3.1 — Relationship between Peatland Cover and the Regional Suitability Index SI (1)

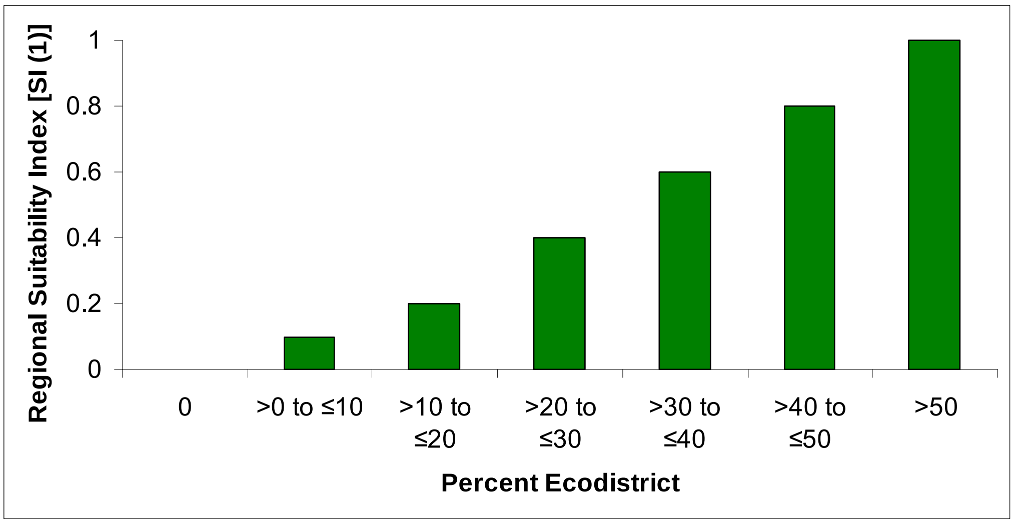


Figure 12.3.2 — Local Suitability Index for Mean Lichen Cover SI (2)

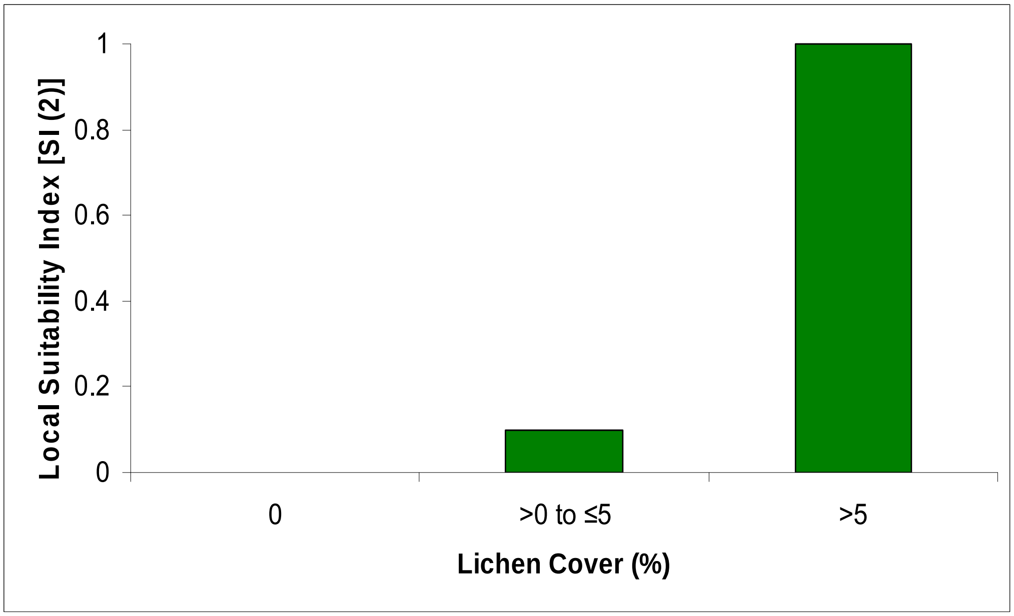


Table 12.3.9 — Food Index Value SI (2) for Land Cover Classes in the Winter Range Study Area

Land Cover of Canada Classes	Terrestrial Lichens %	SI(2)
Forest Land: High Density	> 5	1.0
Southern Forest (lowland)	> 5	1.0
Northern Forest	> 5	1.0
Southern Forest (upland)	> 0 ≤ 5	0.1
Deciduous Broadleaf Forest	0	0.0
Mixed Needleleaf Forest	> 0 ≤ 5	0.1
Mixed Intermediate Uniform Forest	0	0.0
Mixed Intermediate Heterogeneous Forest	> 0 ≤ 5	0.1
Mixed Broadleaf Forest	0	0.0
Burn: Low Green Vegetation Cover	0	0.0
Burn: Green Vegetation Cover	0	0.0
Transition Treed Shrubland	0	0.0
Wetland/Shrub: High Density	0	0.0
Wetland/Shrub: Medium Density	0	0.0
Grassland	0	0.0
Lichen and others	> 5	1.0
Shrub/Lichen Dominated	> 5	1.0

Land Cover of Canada Classes	Terrestrial Lichens %	SI(2)
Heather and Herbs	> 5	1.0
Low Vegetation Cover	> 0 ≤ 5	0.1
Very Low Vegetation Cover	> 0 ≤ 5	0.1
Bare Soil and Rock	0	0.0
Medium Biomass	0	0.0
Low Biomass	0	0.0
Cropland-Woodland and other	0	0.0
Woodland- Cropland	> 0 ≤ 5	0.1
Urban and Built-up	0	0.0
Water	0	0.0
Snow/ Ice	0	0.0

% = percent; SI (2) = suitability index; > = greater than; and ≤ = less than or equal to.

Due to data deficiencies, some terrestrial lichen percentages were estimated based on a combination of professional judgment and comparisons to similar ecotypes and wetlands types, based on the Land Cover of Canada classification.

The regional and local habitat suitability indices [SI (1) and SI (2)] are assumed to be equal in importance to caribou winter habitat selection. The two values were added together and the average was obtained. Habitat suitability was then reduced by the DCs within ZOIs of disturbances according to the following equation:

HSI = [SI (1) + SI (2)]/2 x DC

Research on woodland caribou in the boreal forest has provided some indication of the degree to which woodland caribou avoid human development (e.g. Dyer 1999). These research results were used to derive DC and ZOI for barren-ground caribou during the winter (Table 12.3.10 and 12.3.11).

Table 12.3.10 — Mean Caribou Use of Boreal Habitat within the Zones of Influence Surrounding Industrial Developments

Type of Development	Zone of Influence (m)	Effectiveness of Habitat Use (Percentage of Expected Use)
Roads[1]	0 to 100	<5
	100 to 250	22.7
	250 to 500	31.55 to 57.52
Facilities (e.g. camps)	0 to 250	45.31 (in late winter)
	250 to 500	70.57 to 108.15
Seismic lines[2]	0 to 100	47.64 to 75.66
	100 to 250	85.43 to 113.78

[1] These values are related to woodland caribou use of road development buffers in open conifer forest.

[2] There is no distinction between seismic lines with different levels of human activity.

m = metre; < = less than

Table 12.3.11 — Caribou Zones of Influence and Disturbance Coefficients by Disturbance Type: Winter Season

DISTURBANCE TYPE					
Roads and Transmission Line		Facilities and Developments[2]		Pipelines and Seismic Lines	
ZOI	DC[1]	ZOI (m)	DC	ZOI (m)	DC
100	0.0	250[2]	0.5	100(c)	0.5
250	0.25	>250	1.0	>100	1.0
500	0.50	n/a	n/a	n/a	n/a
1,000	0.75	n/a	n/a	n/a	n/a
>1000	1.0	n/a	n/a	n/a	n/a

[1] DCs are roughly based on the mean woodland caribou use of ZOI presented as a percentage of expected use (Dyer 1999).

[2] Value based on woodland caribou avoidance of new wellpads.

ZOI = zone of influence; DC = disturbance coefficients; n/a = not applicable; m = metres

Validation for the caribou winter HSI was completed using available barren-ground caribou satellite-collar observations, as well as model output from the 2007 baseline scenario. Caribou observations are in the form of satellite collar data from 89 animals spanning 12 years (1996 through 2007), collected by ENR. Observations collected in non-winter months (i.e. April 15 to October 31) were excluded from consideration, as this validation effort is specific to the caribou winter HSI model. Observations that appeared to be in error (e.g. one observation fell within the middle of a community) were removed.

In some cases, satellite-collar observations fell within the ZOI of disturbances present in the existing environment scenario, but those disturbances were not present when the observation occurred. For example, a caribou observation from 2004 may fall within the ZOI of a disturbance created in 2005. In that case, the degraded habitat quality at that location due to the ZOI around the 2005 disturbance would not accurately reflect the quality of that habitat in 2004, when the caribou was observed and before the disturbance existed. If such observations were included, validation results would be biased towards suggesting that caribou prefer areas within ZOIs more than they actually do. Therefore, observations that fell within the ZOI of a disturbance that was developed after the observation occurred were removed

Observations close together in both time and space are more likely to occur in similar habitats and environmental conditions than randomly placed observations (Legendre 1993). Therefore, these observations would not be completely independent of each other, which can lead to errors in the estimation of habitat preference (Boyce and McDonald, 1999). To reduce the spatial and temporal dependence between observations, the satellite-collar dataset was reduced by randomly selecting one observation per day for each individual. Collar data ranged from 3 to 421 observations per individual (median 118) across years, which would result in the behaviour of more frequently observed individuals having a greater effect on validation results than less frequently observed individuals. In an attempt to reduce possible bias, the satellite-collar data set was further reduced by randomly selecting the median count (i.e. 118 observations) of observations for more frequently observed animals. The final count of observations used in the validation was 3,838.

Manly's standardized selection ratio (Manly et al. 1972, 2002) was used to quantify habitat preference for poor, low, moderate and high classes, and a G-test for goodness of fit was performed to detect significant differences between classes (Table 12.3.12). High quality habitat appears to be avoided (Manly's standardized selection ratio of 0.04), but this may be due to the very small percentage of habitat classified as high quality within the winter range study area (0.5%). Moderate habitat is preferred over low and poor quality habitat. However, low quality habitat is not preferred over poor quality habitats, suggesting that some habitats that are actually poor quality are being classified as low, and vice versa.

Table 12.3.12 — Validation Results for the Caribou Winter Habitat Suitability Index Model

HSI Class	Area		Collared Caribou Observations	Manly's Selection Ratio	G-Test
	ha	%			
High	121,369	0.5	2	0.04	Significant ($P < 0.05$)
Moderate	15,599,527	63.5	2820	0.42	
Low	4,394,268	17.9	483	0.26	
Poor	4,451,984	18.1	533	0.28	

ha = hectare; % = percent; P = probability value; < = less than

For all seasonal range calculations (spring, summer, autumn, and winter), water bodies and physical disturbances were calculated as nil (zero) during the habitat mapping process. Relative decreases in the area of high, good, low, and poor-quality habitat were calculated. Relative versus absolute net decreases were calculated per habitat quality category because of unequal bin sizes. As a conservative approach, relative changes in the amount of different quality habitats were considered only for terrestrial habitat (although it is recognized that frozen water bodies are used for resting during the winter and travel during the northern migration). The following equations were used to calculate the relative change in the amount of different quality habitats for each seasonal range in each development scenario:

baseline = (existing value – pristine value) / pristine value
application = ([existing value + the Project] – [existing value]) / existing value)

The resulting value was then multiplied by 100 to give the percent change in habitat quality for each comparison, and provides both direction and magnitude of the effect.

12.3.3.2 Results

The RSF modelling indicates that the majority of the Bathurst caribou herd habitat that was altered due to human development activities occurred before 2007. High- and good-quality habitats combined (as defined by the seasonal RSFs) declined by 4.6% in the spring range, 6.9% in the summer/post-calving range, and 8.7% in the autumn/rut from pristine to existing conditions (Table 12.3.13). In the winter, high- and good-quality habitats combined (as defined by the HSI model) declined by 0.7% from pristine to existing conditions (Table 12.3.13).

The application of the Project to the existing landscape resulted in less than a 0.5% decrease in combined high- and good-quality habitats in any seasonal range (Table 12.3.13). In winter, application of the Project includes the Tibbitt to Contwoyto and the Twin Gorges to Nonacho Lake winter roads. Cumulatively, disturbances from pristine conditions to application of the Project removed 5% of predicted high- and good-quality habitats from spring range, 7.2% from summer (post-calving) range, 9% from the autumn (rut) range, and 0.9% from the winter range. Figures illustrating habitat quality within the Bathurst range estimated in the pristine and application scenarios are provided in Appendix 12B.

Table 12.3.13 — Relative Changes in the Availability of Different Quality Habitats for Bathurst Caribou Seasonal Home Ranges from Pristine Conditions through Application of the Project

Season	Pristine (ha)	Existing (ha)	% Change: Pristine to Existing	Application (ha)	% Change: Existing to Application
Spring (northern migration)					
High(1)	6,418,530	5,552,385	-4.3	5,493,231	-0.3
Good(2)	3,921,859	3,868,107	-0.3	3,893,848	0.1[1]
Low(3)	4,186,281	3,251,947	-4.6	3,200,973	-0.3
Poor(4)	5,789,543	7,643,775	9.1	7,728,161	0.4

Season	Pristine (ha)	Existing (ha)	% Change: Pristine to Existing	Application (ha)	% Change: Existing to Application
Nil (water)	3,725,280	3,725,280	n/a	3,725,280	n/a
Total[2]	20,316,213	20,316,214	n/a	20,316,213	n/a
SUMMER / POST-CALVING					
High(1)	3,388,846	2,956,259	-4.2	2,926,363	-0.3
Good(2)	2,698,869	2,415,500	-2.7	2,419,592	0.0
Low(3)	2,637,826	1,736,442	-8.7	1,702,509	-0.3
Poor(4)	1,633,121	3,250,462	15.6	3,310,200	0.6
Nil (water)	1,603,578	1,603,578	n/a	1,603,578	n/a
Total[2]	10,358,662	10,358,662	n/a	10,358,664	n/a
AUTUMN / RUT					
High(1)	4,447,856	4,395,918	-0.3	4,383,631	-0.1
Good(2)	3,906,937	2,552,354	-8.4	2,523,490	-0.2
Low(3)	3,121,783	2,381,158	-4.6	2,350,099	-0.2
Poor(4)	4,665,848	6,812,994	13.3	6,885,204	0.4
Nil (water)	2,933,273	2,933,273	n/a	2,933,273	n/a
Total[2]	**16,142,424**	**16,142,424**	**n/a**	**16,142,424**	**n/a**
WINTER					
High(1)	121,369	121,369	0.0	121,369	0.0
Good(2)	15,737,717	15,599,527	-0.7	15,550,918	-0.2
Low(3)	4,332,987	4,394,268	0.3	4,432,579	0.2
Poor(4)	0	76,908	0.4	87,205	0.1
Nil (water)	4,375,076	4,375,076	n/a	4,375,076	n/a
Total[2]	**20,192,072**	**20,192,072**	**n/a**	**20,192,071**	**n/a**

Notes:

Percent change per habitat category was calculated as area lost or gained divided by total area of terrestrial habitat. Pristine landscapes (no development) were compared to maps modified by hypothetical disturbance coefficients and zones of influence (i.e. assumed disturbance); habitat categories ranked (1 to 4)

[1] Increases are due to expiration of exploration permits (i.e. only direct effects from footprint remain).

[2] Across categories (1 to 4) and for total terrestrial habitat only.

ha = hectares; % = percent; n/a = not applicable

12.3.3.3 SENSORY DISTURBANCE EFFECTS ON CARIBOU DISTRIBUTION AND MOVEMENT

During construction, noise would be generated from mobile and stationary equipment, haul trucks on winter roads, helicopters, and other aircraft. Helicopter operations to support construction would extend throughout the year, from the commencement of construction until the transmission line becomes operational. Extensive use of low-level helicopter flights would be required to place transmission line towers, string the conductor, and to accommodate poor weather conditions. Barren-ground caribou reactions to helicopters were studied by Miller and Gunn (1978) and Gunn et al. (1983). Further, caribou reactions to stressors (including aircraft) have been monitored at the Ekati Diamond Mine since 2001. The data from these studies were used to qualitatively describe the likely range of caribou reactions to helicopters and other sensory disturbance sources during construction of the Project (refer to Section 9.5.4 Caribou Existing Environment for summary of aircraft sensory disturbance effects).

Within Section 12.3.3.1, results of indirect effects modelling using ZOI and DCs are presented. These results incorporate the potential sensory disturbance effects. For example, noise from helicopters and vehicles on the winter roads are deemed the most likely sensory disturbance that caribou would encounter during construction of the Project. Gunn et al. (1983) reported that caribou disperse 1 to 3 km from helicopter landings. The ZOI and DC used for the transmission line ROW and winter roads, where the helicopters would be primarily located, included a 75% reduction in caribou use around the transmission line ROW and winter roads up to a 5 km distance (Table 12.3.8). Because studies have documented that some ungulate species, such as muskoxen, are alerted by the noise at distances over 1 km (McLaren and Green 1985), there is potential for trucks moving along a winter access road to alter caribou movement and behaviour. Some studies have found caribou were displaced within 2 to 4 km of roads (Dau and Cameron 1986; Cameron et al. 2005). Other studies have observed that resting and feeding behaviour was common for caribou near airstrips or roads (Gunn et al. 1998; BHPB 2007). Thus, the 5 km ZOI and DCs used for winter roads encompass any effects associated with vehicle or people noise along the winter roads during construction.

Traffic associated with the Project along the proposed winter roads is predicted to affect the behaviour and movement of caribou (Treweek 1999; Trombulak and Frissell 1999). However, the frequency and duration of effects from winter roads occurs for a 10 week period each year. Part of the effect from winter roads was estimated in the analysis of habitat fragmentation (Section 12.3.2.2), which considered changes in habitat patch size, number, and connectivity from associated barrier effects of development. These effects can influence the winter range movements of caribou. For example, incremental changes to habitat configuration (e.g. location, size, and number of similar habitat patches) from the Project (including a 200 m corridor along the winter access road) ranged from 0% to 6% (Table 12.3.6). Although the presence of the winter roads may represent a partial barrier to caribou and lead to some fragmentation of the population within the winter range (Trombulak and Frissell 1999), the roads would only be in operation for approximately ten weeks each year. Based on the current literature, the spatial extent of changes to the behaviour of caribou from activity along winter roads is predicted to be within 5 km of the roads.

Similarly, during operations, the presence of the transmission line can be expected to represent sensory disturbance effects similar to that used to develop the ZOI and DC for the indirect effects on habitat (i.e. 75% reduced use within 5 km of the transmission line). The DC and ZOI for the transmission line were based on results reported in Mahoney and Schaefer (2002), Vistnes and Nelleman (2001) and Nelleman et al. (2003) (refer to Section 9.5.4 for complete discussion). The ZOI was deemed greater during seasons when caribou occur above the tree line due to visibility of the transmission line.

Noise from Project activities would be generated from mobile and stationary equipment, blasting, helicopters, and other aircraft. During operation, noise would be limited to activities at the Twin Gorges facilities, which is not within the Bathurst caribou herd's range, and minimal noise from wind on the transmission line and towers. However, during construction, caribou may be exposed to noise from transmission line construction, staging camps, winter roads, and at the Nonacho Lake Control Structure. A summary of the main sources of noise and likely distance of noise attenuation from each of these activities is provided in Appendix 12C. A summary of the sources and magnitude of noise from activities to which caribou may be exposed is provided below.

Table 12.3.14 lists the predicted noise levels at various distances from two ground-based scenarios (representing site clearing and preparation, and the staging areas). The main sources of noise from these activities include helicopters, small-scale blasting, heavy equipment, and chain saws. The analysis assumed that equipment noise sources were working continuously within a 500 m x 250 m area (although some sources, particularly helicopters, would be mobile).

Table 12.3.14 — Transmission Line Construction Scenario Noise Predictions by Distance from Activity

Distance from source to nearest receiver (m)	PREDICTED NOISE LEVEL L_D (DBA)[1]				
	Clearing and Preparation (Staging or ROW)	Staging Areas	Helicopter Work (hovering at 200 m)	Helicopter Work (fly-by at 200 m)	Blasting
250	51	49	59	50	75
500	46	46	55	47	71
1,000	41	42	47	41	64
2,000	34	35	39	34	55
3,000	30	30	33	29	49
4,000	26	25	28	25	45
5,000	22	22	25	21	41
10,000	6	6	9	6	25

Notes: m = metres; ROW = right of way; dBA = A-weighted decibels

[1] (daytime) noise levels, average noise level over a 10-hour work day.

At approximately 2 km (i.e. 2,000 m) from most construction activity, noise from construction work along the transmission line ROW or at staging areas can be expected to be lower than the baseline level of 35 dBA (Table 12.3.14) (MGP, 2004; ERBC, 2007). Helicopter activity involving hovering would propagate farther, reaching a noise level of 35 dBA at about 2.5 km. Blasting may attenuate to 35 dBA at about 7 km, but, this is a short-term, or instantaneous, event so disturbances to this distance would not be sustained. However, the character of construction noise would differ from natural sounds. Given the variability in caribou movements, the length of the transmission line, and the differences in construction schedules for the various transmission line sectors, it is difficult to predict when or where caribou may be exposed to construction noise. Construction activity would however be most intense during the winter months, when caribou are most commonly found below the treeline.

Winter roads would be used for three winters during the construction period. A total of approximately 80 truck loads are required to move material to the Project's northern sector, and up to 150 truckloads are estimated for the southern sector. Convoys of three trucks are assumed, with up to two convoys per day. For the purpose of calculating the noise from the winter roads, the worst-case scenario becomes a maximum of six highway-type transport trucks in an hour (larger and more frequent convoys than are anticipated to be required for the Project). The sound power output of a typical highway truck is 99 dBA (FHWA, 2006). Based on the same calculation methods used for the construction activity (ISO, 1996), this indicates that the hourly noise level from the passage of six highway trucks would reach the upper end of ambient noise levels (35 dBA) within approximately 500 m of the roadway. Noise levels would diminish to 25 dBA at approximately 1,500 m.

Caribou may also be exposed to noise from construction activity at the Nonacho Lake Control Structure. Activity here includes the staging of materials by winter road in the late winter of 2010 and 2011, and construction activity into the spring and summer. Demobilization would occur in the winter of 2011-12 (see Section 6.5, Project Construction). Sources of noise during construction would include blasting, crushers, and rock drills. Noise from these activities, assuming that equipment is working continuously within a 500 m by 250 m area, is anticipated to drop below baseline levels within approximately 3 km. Blasting may attenuate for 7 km, but this would not be sustained. Again, the character of construction noise would differ from natural sounds, so the activity may still be audible beyond these distances.

The exposure of caribou to noise at Nonacho Lake would be of short duration. Historic caribou movements indicate that caribou are not regularly present in this area, and that they would only be present from approximately January to late April or early May. A summary of the sources of Project noise and estimated attenuation distances is provided in Appendix 12C.

Overhead transmission lines may generate electric field noise that is audible, which is referred to as corona noise. Corona noise is generated by occasional discharges on insulators or in the air near the conductors. This noise is perceived as a hum or buzz and becomes more pronounced in periods of high humidity. An audible corona noise level of 55 dBA at 15 m from the source is a design constraint used by other transmission line operators (BCTC, 2008). Based on distance attenuation only, this would diminish to 25 dBA at 50 m from the transmission line. Specific to the Project, audible noise levels generated by the lines during fair weather are expected to be below 30 dB. Corona noise levels may rise in humid conditions, but are not predicted to exceed 35 dB, and are unlikely to be audible from the ground. (Teshmont 2008).

12.3.4 Direct and Indirect Habitat Loss Leading to Change in Abundance

The direct and indirect habitat loss from the Project and all existing and previous developments within the Bathurst caribou range has been documented in Sections 12.3.2 and 12.3.3. This habitat loss reduces the amount of useable habitat within the Bathurst caribou range. Ultimately, habitat loss may lead to a reduced carrying capacity (the number of caribou that the landscape can support). To investigate the possible effects to caribou abundance from habitat loss, Population Viability Analysis (PVA) was performed to estimate if the likelihood of population decline or persistence for the Bathurst herd changes with the different development scenarios (i.e. pristine, existing, and application scenarios, Section 12.3.4.1).

12.3.4.1 Population Viability Analysis Methods

An assessment of the incremental effects of the Project and cumulative effects of all development within the Bathurst range on the viability of the Bathurst herd was completed. RAMAS 5.0® software was used for this assessment, as existing software allows for transparency.

An increasingly important modelling tool in the conservation and management of species is PVA (Akçakaya et al. 2004). In this study, previously published estimates of age-specific survival and fecundity rates, and considerations of internal population mechanisms were used to quantify the relative contribution of natural and human factors to the current decline phase of the caribou population (during the past 10 to 12 years). It is emphasized that the models are not used to predict the number of caribou in 5 years, 10 years, or 30 years from now. Due to the lack of information for survival and reproductive rates for the all phases (increase, decrease, and no change) of the population cycle, the model should not be used to estimate future population sizes.

Rather, the focus of the PVA models is to determine the relative changes in the risk to population viability (i.e. the likelihood of population persistence) for different development scenarios. Local and regional effects from the Project and other developments on habitat quantity and quality (which includes behaviour), and vital rates were incorporated into model simulations. For example, results from the habitat quality analysis, which includes direct and indirect habitat effects from development (Table 12.3.13) were used as parameter inputs in the population models. The PVA was used to estimate the incremental effect from the Project, and the relative contribution of natural factors (e.g. insect outbreaks, deep snow) and human activities (e.g. existing development, hunting) on the current phase of the population cycle in caribou.

12.3.4.1.1 Structure of Pristine Model and Simulations

A 60-year projection was used to simulate an approximate cycle in population size of the Bathurst caribou herd (Kendrick et al. 2005; ENR 2008, internet site). The entire Bathurst range was used as the study area (Figure 12.1.1). Input parameters included survival and fecundity rates (vital rates), carrying capacity, initial population size, an extreme weather-related event, and a management action. In subsequent models (e.g. existing and application development conditions) and sensitivity analyses, input parameters were changed through different modifier variables (Table 12.3.15).

The models projected population sizes assuming no spatial structure (i.e. there was only one population, and not separate sub-populations). All simulations were run over a 60-year period and replicated 5,000 times. At each time step, the number of calves, yearlings, sub-adults, and adults were projected using a set of vital rates (i.e. survival and fecundity) drawn from a random normal distribution with mean values taken from the stage matrix and standard deviations taken from the standard deviation matrix. Standard deviations included both measurement error (uncertainty) in estimates and temporal variation associated with natural and human-related factors.

Table 12.3.15 — Input Parameters and Associated Modifier Variables for Simulations in the Population Models

Input Parameters	Modifier Variables
Survival, fecundity, carrying capacity (K)	Habitat
Initial population size	Actual size reported in literature
Extreme weather-related event	Insect harassment, deep and hard snow
Management actions	Harvest rate

12.3.4.1.1.1 Survival and Fecundity

A Leslie matrix was used to model an age-structured caribou herd for the following four stages (Table 12.3.16):

- female calves (young-of-year);
- yearlings (age 1);
- sub-adults (age 2); and
- reproductively mature adults (age 3 and older).

The mating system of the herd was assumed to be polygynous, where each male is capable of mating with up to two or more female caribou. Modelling focused on the adult female segment of the population, as this segment most directly influences herd productivity (Boulanger and Gunn 2007). A "birth-pulse" population was assumed, in which all breeding takes place in a short period of time.

Table 12.3.16 — Stage Matrix Comprised of Estimated Fecundity and Survival Rates of Four Stages of Female Bathurst Caribou for Pristine Simulation

Age Class	Calf[1]	Yearling[1]	Sub-adult[1]	Adult[1]
Calf	0	0	0	0.42 (0.13)[3]
Yearling	0.71 (0.21)	0	0	0
Subadult	0	0.93 (0.28)[2]	0	0
Adult	0	0	0.95 (0.29)[2]	0.95 (0.29)[2]

Note: Pristine simulations refers to conditions of no development.

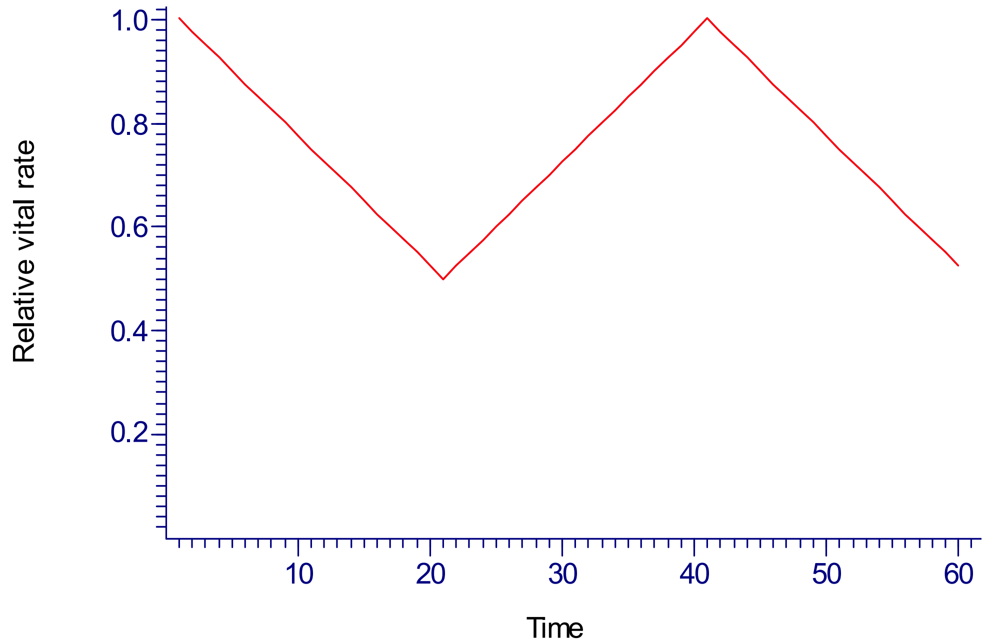
[1] Values are mean estimated fecundity and survival rates; values in parenthesis are standard deviation.

[2] Higher values of survival (i.e. 0.93 and 0.95) were used for survival because they resulted in stronger cyclical trends based on visual inspection of population projections; these values are also within the range of rates reported for Bathurst caribou (Boulanger and Gunn 2007).

[3] Value is a product of estimated fecundity rate for no development multiplied by 0.5 (i.e. female population only) and adult survival rate.

The Leslie matrix was based on a "post-breeding" census of caribou, and assumes no mortality took place between breeding and the census. Vital rates for the stage matrices were taken from Boulanger and Gunn (2007) (Table 12.3.16). It was also assumed that the minimum age of reproduction was three years, and the sex ratio at birth was equal. Initial fecundity rates (0.89) were based on the upper range of values reported in the literature (Cameron et al., 2005; Boulanger and Gunn, 2007). However, for the stage matrix, fecundity rates were multiplied by adult female survival rates and by 0.5 (because simulations were for the female population only [Akçakaya et al. 2004]). It was assumed that vital rates had an approximate coefficient of variation (CV [SD / mean]) equal to 0.3, which increased confidence that the potential variation in survival and fecundity was captured in the models. To simulate a 60-year cycle in population size, rates for calf survival and fecundity were varied over time with 50% maximum reductions of the values in the stage matrix at year 20 and year 60 (Figure 12.3.3).

Figure 12.3.3 — Temporal Trend (years) in the Relative Rate of Calf Survival and Fecundity for Female Bathurst Caribou



Because the vital rates in the above stage matrix do not account for hunting pressure, harvest of caribou was incorporated through the management option in RAMAS 5.0. Annual harvest rates for pristine simulations were set at 4% for female caribou (mean = 4.1%, range = 1.4 to 7.0% [Boulanger and Gunn, 2007]).

12.3.4.1.1.2 Stochasticity

Random events associated with environmental variation and the unpredictable nature of demographic variation can also influence population size. Demographic stochasticity is the sampling variation in the number of survivors and the number of offspring that occurs (even if survival rates and fecundities were constant) because a population is made up of a finite number of individuals. Thus, the demographic stochasticity option in RAMAS 5.0 was used for all models (Akçakaya et al. 2004). In addition, environmental stochasticity was modelled by drawing values randomly from log-normal distributions described by fecundity and survival values and their associated standard deviations (Table 12.3.16).

The effects of stochasticity on fecundity, survival, and carrying capacity (K) were assumed to be correlated within the herd. Modelling incorporated a CV of 0.30 for population size (N) to increase confidence that the temporal variation in N was not underestimated. In addition, an extreme weather-related event (e.g. calm weather leading to high oesterid fly activity, or deep, hard-packed snow years) was modelled as reducing vital rates in all stages (i.e. across the population) by 12.5% once every 10 years (Miller and Gunn 2003; Tews et al. 2006).

12.3.4.1.1.3 *Density Dependence and Carrying Capacity*

Some studies have shown that density-dependent effects of overgrazing on calving, post-calving, and winter home ranges can result in periodic range shifts and population fluctuations (Messier et al., 1988; Ferguson and Messier, 2000). In the analysis here, a simple ceiling model was used that affected all vital rates and was based on the abundance of all stages (Akçakaya et al., 2004). Under the ceiling type of density dependence, the population grows exponentially until it reaches carrying capacity. A population that reaches carrying capacity remains at that level until a population decline (e.g. a random fluctuation or extreme weather event) decreases it below carrying capacity.

Carrying capacity (K) was estimated to be 259,136 female caribou, which was the highest recorded population size from 1986 to 2007 (Boulanger and Gunn, 2007). A CV equal to 0.30 was applied to K to increase confidence that potential variation in K was captured in the models. Carrying capacity was reduced in the development scenarios to reflect combined losses of good- and high-quality habitats (e.g. pristine versus existing conditions [Table 12.3.13]). The reduction in K was based on the season with the highest levels of preferred habitat disturbed by development (the autumn rut, see Table 12.3.13), as follows:

- in the pristine environment scenario, K = 259,136 female caribou;
- in the existing (2007) environment scenario, K was reduced by 8.7%; and
- in the application scenario, K was reduced by a further 0.3% from the existing environment scenario.

All simulations started with 65,000 female caribou, which is the approximate size of the current population of female caribou (Boulanger and Gunn, 2007).

12.3.4.1.1.4 *Sensitivity and Effects Analyses*

Sensitivity analyses were completed to determine the relative influences of model parameters on population viability. Sensitivity simulations were performed by varying specific model inputs (e.g. adult survival rate) while holding others constant to evaluate the relative influences of model parameters on the probability of population decline. All comparisons were made by examination of terminal abundance probabilities and associated risk curves (Akçakaya et al. 2004). Terminal abundance risk was defined as the probability of the population decreasing below 1,000 animals.

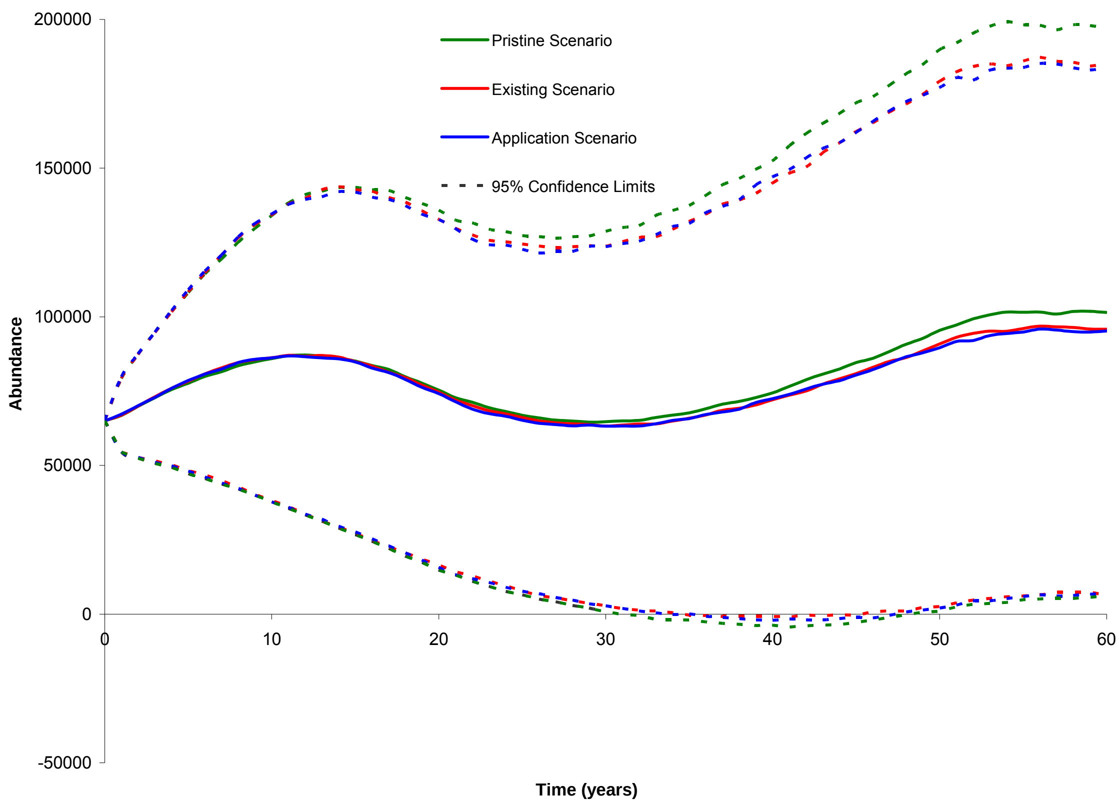
The intent of the PVA in the DAR is to estimate the relative contribution of different natural and human disturbance factors on changes to population size and risk of decline. The consensus among many population ecologists is that relative results of PVA, either from sensitivity analyses or comparisons among development scenarios, are more reliable for assessing changes to population size and risk of decline rather than absolute values (McCarthy et al. 2003; Schtickzelle et al. 2005).

Estimates of absolute population changes are almost always biased because of inaccurate or incomplete data for vital rates in the stage matrix. In other words, predicting future population size with incomplete data on survival and reproduction rates would likely lead to incorrect conclusions, especially in populations that exhibit natural cycles over decades like caribou. For the Bathurst herd, there is not enough information on vital rates during the phases when caribou population size is increasing, or remains stable, to accurately predict the number of animals in the near or distant future. In this assessment, terminal abundance probabilities are used only for relative comparisons of input parameters among models.

12.3.4.2 POPULATION VIABILITY ANALYSIS RESULTS

The pristine model produced a population trajectory that fluctuated over 60 years to simulate natural population cycles for the Bathurst caribou herd (Figure 12.3.4). Results indicate that there is a very small difference in population trajectories between pristine, existing, and application scenarios. Simulations showed that the difference between successive runs of the same development scenario was more substantial than the difference between development scenarios. In other words, the differences between successive runs of the pristine case were larger than the differences between the pristine and Project application scenarios. This large degree of within-scenario variation is exemplified by the width of 95% confidence intervals around mean abundance trends for each development scenario (i.e. the dotted lines in Figure 12.3.4). Similar to population trajectories, there was no difference between development scenarios with respect to the risk that that the Bathurst population would decrease over the 60-year simulation, given the chosen population parameters.

Figure 12.3.4 — Population Trajectories of Female Bathurst Caribou Mean (± 1 SD) Abundance for a 60-Year Cycle across Development Scenarios



Based on the selected parameter inputs, there is about an 18% probability that the Bathurst population would decrease below 1,000 females at least once over the 60-year simulation (i.e. terminal abundance risk) (Table 12.3.17). Again, there is a greater difference between simulation runs within a given development scenario than there is between development scenarios. In other words, while there is variation in PVA results, there is no detectable difference in risk of decline for the Bathurst caribou population between the pristine, existing, and Project application scenarios. The difference between simulation runs for a single development scenario results from random effects, which are built into the simulation. For example, the uncertainty associated with survival and reproduction rates was represented with large standard deviations surrounding these rates in the PVA.

Table 12.3.17 — Effects Analysis for Development Scenarios and Sensitivity Analysis for Parameter Inputs

Development Scenario	TERMINAL ABUNDANCE RISK[1,2] (%)						
	No Change to Vital and Harvest Rates	Probability of Extreme Weather Events		Fecundity/Survival Rate Means		Carrying Capacity	Harvest Rate
		+10%	+20%	-5%	-10%	-10%	+5%
Pristine	18	18	18	41	90	20	35
Existing	18	18	18	41	90	20	35
Application	18	18	18	41	90	20	35

[1] Probability that the population would decrease below 1,000 females during the 60 year period.

[2] % = percent; PVA = Population Viability Analysis; + = increase; - = decrease

The similarity between development scenario results (Figure 12.3.4) suggests that the change in carrying capacity caused by a reduction in quality habitat from pristine to 2007 existing and application scenarios was not sufficient to have a measurable effect on the Bathurst caribou population, according to this PVA. For example, carrying capacity was reduced from one development scenario to the next based on the season with the highest levels of preferred (i.e. good- and high-quality) habitat disturbed by development. The 8.7% decrease in carrying capacity from pristine to 2007 existing conditions, and the 0.3% decrease from existing to application scenarios had a very limited effect on results (i.e. the difference between development scenarios was negligible). However, habitat-related factors that could affect the reproduction and survival rates of caribou were not directly applied to the Leslie matrices in this PVA for different development scenarios because of limited empirical knowledge.

For example, natural changes in food abundance and quality on summer and winter ranges have been determined to be important elements in tundra caribou population dynamics (Reimers 1983; Skogland 1990; Post and Klein 1999). Extreme weather events such as late spring snowfall or late snowmelt can influence access to food and result in lower calf weights or delayed parturition (time of calving), which influences survival of young (Skogland 1984; Adamczewski et al. 1987; Cameron et al. 1995). Factors that influence adult female food intake from summer through winter also determine pregnancy and calving rates. High insect abundance can also decrease forage intake, milk production, and calf growth and survival (Russell et al. 1993;

Hagemoen and Reimers 2002; Weladji et al. 2003). Changes to behaviour (e.g. decreased time spent feeding or increased time spent moving away from disturbance) within the ZOI of developments can affect the energy balance of caribou and alter survival and reproduction. However, there is little knowledge about the separate and direct implications from these different effects on the magnitude of changes to reproduction and survival rates in barren-ground caribou. The degree that caribou may increase food intake after moving through a ZOI associated with development or being harassed by insects is also not known. Therefore, average reproduction and survival rates were not changed for each development scenario because the many interacting factors that could affect these rates are not sufficiently understood.

Influences from extreme weather events, changes to carrying capacity (e.g. habitat quality and quantity), reproduction and survival rates, and harvest rates on the caribou population size were estimated indirectly through sensitivity analysis of each development scenario. Sensitivity analyses suggest that small to moderate changes in some input parameters are sufficient to have large effects on the results of the PVA (Table 12.3.16). Results were fairly robust to changes in the probability of extreme weather events. However, results were sensitive to estimated mean fecundity and survival rates. For example, decreases in rates of fecundity and survival rates of 5% and 10% resulted in a 41% and 90% increase in terminal abundance risk, respectively, for each development scenario. Simulations similarly suggest that the population is also sensitive to changes in harvest rate. Changing from a harvest rate of 4% to 9% of adult females results in a 17% increase in the probability of terminal abundance risk for each development scenario. Population modelling by Boulanger and Gunn (2007) found that the population trajectory of the Bathurst herd was more sensitive to variation in adult female survival than the production and survival of calves.

Sensitivity analyses also suggested that a further decrease of 10% in carrying capacity (i.e. in addition to the 9% decrease from pristine to application scenarios) increased the probability of terminal abundance risk by about 2%, from 18% to 20%, for the different development scenarios. Therefore, results of the PVA and sensitivity analysis suggest that while disturbance to quality habitat does increase the risk of decline for the Bathurst caribou population, factors that affect fecundity, and particularly survival, are most important in driving changes in population size.

12.3.5 Use of Linear Corridors by Wolves Leading to Change in Predation Rate

Wolf predation is often cited as a main cause of caribou mortality (Fuller, 1989; Gasaway et al., 1989; Bergerud et al., 1984; Edmonds, 1988; Seip, 1992; Stuart-Smith et al., 1997). It has been speculated that linear developments provide increased access for predators, most notably wolves, into caribou habitat, particularly below the treeline (Bergerud et al., 1984; Edmonds and Bloomfield, 1984; Thurber et al., 1994; Seip and Cichowski, 1996; James and Stuart-Smith, 2000). Although wolves tend to avoid areas with high densities of roads (Theil, 1985; Mech et al., 1988; Fuller, 1989; Fuller et al., 1992), corridors that receive little human use may be attractive to wolves as easy travel corridors (Horejsi, 1981; Edmonds and Bloomfield, 1984; Eccles and Duncan, 1986; Thurber et al., 1994; James & Stuart-Smith, 2000). Use of linear developments by wolves has been documented as providing more efficient travel routes, particularly when snowmobile trails with packed snow are present (Edmonds and Bloomfield, 1984; Cumming and Hyer, 1996). Banfield (1971) also noted that wolves hunted caribou from the Porcupine Herd in the Yukon along cleared lines, where they had an advantage over their prey. James and Stuart-Smith (2000) found that caribou mortalities attributable to wolf predation in north-eastern Alberta were closer than other mortalities to linear corridors, indicating that caribou near linear corridors were at a higher risk of predation. During the same study, James (1999) reported that wolves traveling along linear corridors moved 2.8 times faster than in the forest, which may improve their search efficiency for prey; kill sites also were closer to corridors than expected. Further, it was also shown that wolves preferred linear corridors while caribou avoided them. The temporary access trails, transmission line ROW, and Twin Gorges to Nonacho Lake winter road may improve the mobility of wolves during the winter in the boreal regions. The effect of this avoidance on caribou distribution is included in the RSF models in Section 12.3.3 (Tables 12.3.8 and 12.3.11).

The consequence of enhanced predator mobility is the increased chance of prey encounters and ultimately, caribou predation risk (Bergerud, 1983). Bergerud et al. (1984) suggest that caribou selection of low productivity habitat creates a spatial separation from other prey species (commonly moose), as an anti-predator strategy against wolves. Results supporting this hypothesis have been reported for woodland caribou (Cumming and Hyer, 1996; James, 1999). Linear developments have been hypothesized to erode the effectiveness of these habitat refuges by providing suitable travel corridors within forested areas and habitat enhancement for alternative prey, and increasing the biomass of prey. This could allow wolf numbers to increase to higher levels, ultimately leading to a predicted increase in caribou predation (Bergerud et al., 1984; Seip, 1992; Jalkotzy et al., 1997; Doucet and Thompson, 2002).

Predator travel along the transmission line ROW and winter access roads would be improved within the southern sector of the Project (with the exception of the area to be hand-cleared from Twin Gorges to north of Indian Shack and within the boundaries of the proposed East Arm National Park, where vegetation with a height of <3 m would remain intact in the hand-cleared area). Although there would be improved access between the lakes along the Twin Gorges to Nonacho Lake winter road, and along the temporary access trails to be cut under the transmission line, following construction the winter roads and temporary access trails would no longer be maintained, and natural habitat regeneration would be allowed to proceed. The structure of the existing forest must also be considered. Assuming that wolves are able to travel more quickly within an ROW because of the lack of vegetation, the Project ROW may not lead to the removal of enough vegetation to cause a change in wolf behaviour. Only 28% of the Project footprint within the Bathurst range is within forest habitats, and only 4% is within closed forests. This indicates that there are currently few natural impediments to wolf travel. Permanent slash would be placed across the ROW in an effort to discourage predator use (as suggested by ENR, 2007b). Further, the southern extent of the Bathurst caribou range ends near the southern end of Nonacho Lake (Figure 12.1.1). This indicates that wolves would rarely be able to benefit from the improved access provided by the Project. Effects would be limited to the winter season when caribou are within boreal areas.

12.3.6 Effects to Harvesting Opportunities

12.3.6.1 ACCESS TO CARIBOU

The Project's winter access roads along the transmission line ROW, the Twin Gorges to Nonacho Lake winter road, and the Tibbitt to Contwoyto winter spur roads may increase human access to caribou when in operation (approximately 8 to 10 weeks each year). Ziemann (2007) has tracked the level of hunting activity for 2004 through 2006, and reported between 255 and 538 caribou were harvested annually along the Tibbitt to Contwoyto winter road. The number of hunting vehicles on the Tibbitt to Contwoyto winter road to hunt ranged from 573 vehicles in 2004 to 284 vehicles in 2006 (Ziemann, 2007), indicating that new Project winter roads may be used to access areas for hunting caribou.

Dezé intends to mitigate increased access through controlled use of the proposed winter roads. By limiting the use of these roads to vehicles involved in Project construction and restricting the use of the roads by the public, many of the concerns regarding effects due to improved access should be mitigated. The winter road from Fort Smith to Nonacho Lake would be closed with locked gates at two locations (Slave River and Twin Gorges) and only Project vehicles would be permitted to use the road. Further, the entrance to the winter road at the Slave River would be blocked at the end of each hauling season, and permanently blocked following construction (as requested by ENR 2007b).

Despite these mitigation activities, it is anticipated that some unauthorized use of the winter roads may occur, leading to some hunting in previously inaccessible areas. However, considering that the old winter road alignment from Fort Smith to Twin Gorges is currently passable with snow machines (prior to the proposed upgrades), accessing new areas (i.e. the winter road from Twin Gorges to Nonacho Lake and the spur roads to the staging areas) would require travel along approximately 60 km of a private road and crossing two control gates. Further, unauthorized access would likely be by snowmobile, rather than truck (as is usual on the Tibbitt to Contwoyto winter road). Trucks using the Tibbitt to Contwoyto winter road are often used to haul snow machines, the combination of which greatly improves hunting success. Following the Project construction phase, access from Fort Smith could only be by snow machine, as the winter roads would no longer be maintained.

In summary, although hunting of barren-ground caribou may be increased within the Fort Smith region through the development of the winter road from Fort Smith to Nonacho Lake, this winter road would only be in operation for the three years of construction and would be made inaccessible to vehicles after this period. Snowmobiles would have long-term access within the Project area since they would be able to use the winter roads and the proposed 5 m wide temporary access trails. However, people would have to travel by snowmobile for a distance of 150 km to 200 km from Fort Smith to reach the most southerly portion of the Bathurst caribou winter range, and access control structures would be placed along the temporary access trails. Given the travel distance, planned access control mitigation, and the variability in barren-ground caribou winter distribution, it is predicted that the magnitude of the effect of increased access on caribou abundance may only approach or slightly exceed the limits of existing conditions.

12.3.6.2 AVAILABILITY OF CARIBOU

Availability of caribou for human use is related to population size and distribution. The analysis completed in Section 12.3.4 examined the cumulative effects from the Project, other developments, natural factors, and harvest rates on caribou population size. The results indicate that the addition of the Project is predicted to have little detectable effect on the modelled caribou population projections.

The spatial extent of current development is likely large enough to have some influence on caribou movement and distribution within their winter, spring, post-calving, and autumn ranges, at the local and regional scales. However, it is not known if the magnitude and duration of effects from previous and existing development is large enough to cause a shift in a seasonal range of caribou relative to natural factors. It is likely that natural environmental factors that operate on large spatial scales and over long periods of time have greater influences on seasonal distributions of caribou relative to the cumulative and incremental impacts from the Project. For example, some studies of caribou have shown that the historical cumulative effect of overgrazing on calving, summer or winter ranges can result in periodic range shifts and large population fluctuations (Messier et al. 1988; Ferguson and Messier, 2000). Traditional knowledge also contends that fire frequency and intensity affects caribou numbers and distribution (Kendrick et al. 2005).

12.4 RESIDUAL EFFECTS SUMMARY

12.4.1.1 PROJECT FOOTPRINT LEADING TO HABITAT LOSS AND FRAGMENTATION

At the local scale, the Project footprint would decrease the amount of quality habitat (i.e. heath tundra, sedge association, and lichen veneer) for caribou by 0.2% or less per seasonal range (spring, summer, autumn, winter) for the Bathurst herd. For about half the habitat types, the incremental change from the Project compared to the existing landscape was less than 0.1%. In total, the Project footprint comprises less than 1% of any seasonal range. At the scale of the population (and considering all seasons where the Project interacts with caribou), the cumulative habitat-specific changes resulting from the Project and previous and existing developments is anticipated to be 0.7% or less for quality habitat types.

Increasing development from pristine to 2007 existing conditions has resulted in habitat fragmentation or changes to the size, number, and distribution of habitat patches in the seasonal ranges of caribou. For example, decreases in habitat patch size and increases in the number of habitat patches ranged from 0.8 to 6.7% for quality habitats (e.g. heath tundra, sedge association, riparian shrub, and lichen veneer) within the spring, summer, and autumn ranges of the Bathurst herd (Table 12.3.3 to Table 12.3.5). Decreases in the mean distance to nearest neighbour for these habitats ranged from less than 1% to about 12%. Thus, development has resulted in the fragmentation of the landscape by decreasing the size and distance between some habitat patches while increasing the number of habitat patches for caribou.

In the winter range, development (which includes the Tibbitt to Contwoyto winter road) has also changed the configuration of habitats on the existing landscape for the Bathurst herd. For example, the decreases in the size of quality habitat patches (e.g. heath tundra, sedge association, and forest) ranged from 0.9 to 10.4%, while increases in the number of quality patches ranged from 0.8% to 11% (Table 12.3.6). Decreases in the mean distance to nearest neighbour for quality habitat patches ranged from 6.5% to 11.7%.

Addition of the Project resulted in incremental changes to the size, number, and distribution of similar habitats within caribou seasonal ranges. The increase in the number of patches for quality habitats within seasonal ranges varied from 0 to 9.8% relative to existing conditions, while the decrease in patch size ranged from 0 to about 6% (Table 12.3.3 to Table 12.3.6).

Relative to pristine conditions, cumulative changes from the Project and previous and existing developments on the location, size, and number of quality habitat patches within caribou seasonal ranges is estimated to range from less than 1% to 16% for the Bathurst herd. Most of the changes were associated with heath tundra and forest habitats, which include the dominant habitats in the non-winter and winter seasonal ranges (Appendix 12A). In addition, the incremental changes from the Project footprint were largely associated with the width of the buffer that was applied to the Project winter access roads and trails, and the transmission line. Due to the large area of seasonal ranges and computational constraints (Section 12.3.2.1), all linear features were given a width of 200 m, even though the actual width varies from 5 m to 30 m for Project components. Subsequently, Project-related changes in habitat fragmentation metrics were likely overestimated.

The Project footprint (which includes portions of the Tibbitt to Contwoyto winter road, the Twin Gorges to Nonacho Lake winter road, and temporary access trails along the transmission line ROW) changed the configuration of habitats on the landscape for the Bathurst herd. Although the presence of the Twin Gorges to Nonacho Lake winter road may represent a partial barrier to caribou and lead to some fragmentation of the population within the winter range (Trombulak and Frissell 1999), the road is only in operation for approximately 10 weeks each year and is restricted to a three-year operation period during the construction phase. The winter road may act as a "leaky barrier" that some animals may manage to cross successfully (Tibbitt to Contwoyto Winter Road Joint Venture 2008), but it may restrict the landscape-scale movements of caribou for short periods of time (Treweek 1999).

12.4.1.2 SENSORY DISTURBANCES LEADING TO A CHANGE IN HABITAT QUALITY, AND MOVEMENT AND BEHAVIOUR

In addition to direct habitat effects, indirect changes to habitat quality from the Project have the potential to affect the population size and distribution of caribou through altered movement and behaviour. Sensory disturbance (e.g. combined effects from noise, dust, physical presence of Project, human activity) resulting from the construction and operation of the Project can reduce habitat quality in both the Project footprint, as well as in adjacent habitats that are not directly affected by the Project. Although the indirect effects of the Project from sensory disturbance have local effects on habitat quality, the effect on the movement and behaviour of caribou is expected to extend to the entire Bathurst population. The cumulative sensory disturbance effects from the Project, as well as from previous and existing developments, are predicted to affect movement and behaviour of the caribou population within the entire Bathurst herd range.

Sensory disturbance effects are anticipated to influence caribou during both construction and operation of the Project. Effects on preferred habitats (i.e. good- and high-quality habitats) were evaluated for the four caribou seasonal ranges:

- spring (northern migration/calving),
- summer (post-calving),
- autumn (rut), and
- winter.

The majority of Bathurst caribou habitat altered due to human development activities occurred before 2007. Preferred habitat (i.e. high- and good-quality habitats combined) declined by 4.6% in the spring range, 6.9% in the summer/post-calving range, and about 8.7% in the autumn/rut range from pristine to existing conditions. In the winter, preferred habitats declined by about 0.7% from pristine to existing conditions. The application of the Project to the existing landscape resulted in a less than 0.5% decrease in combined high- and good-quality habitats in any seasonal range. In winter, application of the Project includes the Tibbitt to Contwoyto and the Twin Gorges to Nonacho Lake winter roads. Cumulatively, disturbances from pristine conditions to application of the Project removed 5.0% of predicted high- and good-quality habitats from spring range, 7.2% from summer/post-calving range, 9.0% from the autumn/rut range, and about 0.9% from the winter range.

Based on the current literature, the spatial extent of changes to the behaviour of caribou from activity along winter roads is predicted to be within 5 km of a road. Similarly, during operations, noise from the transmission line can be expected to reduce use by 75% within 5 km of the transmission line (based on results reported in Vistnes and Nelleman, 2001, Mahoney and Schaefer, 2002; Nelleman et al. 2003). This level of reduced use around the transmission line may actually overestimate the effect on caribou behaviour, as no hum is expected from the conductor line (Teshmont, 2008). The spatial extent of changes to caribou behaviour is predicted to be greater during seasons when caribou are present above the treeline due to visibility of the transmission line.

12.4.1.3 Direct And Indirect Habitat Loss Leading To Change In Abundance

The direct and indirect habitat loss from the Project and all existing and previous developments reduces the amount of useable habitat within the Bathurst caribou range. Ultimately, habitat loss and reduced habitat quality may lead to a reduced carrying capacity (the number of caribou that the landscape can support). To investigate the possible effects to caribou abundance from habitat loss, a population viability analysis was completed to estimate if the likelihood of population decline or persistence for the Bathurst herd changes with the different development scenarios. Results suggested that there was a very small difference in population trajectories between pristine, existing, and application scenarios. Simulations showed that the difference between successive runs of the same development scenario was more substantial than the difference between development scenarios.

12.4.1.4 Use Of Linear Corridors By Wolves Leading To Change In Predation Rate

Wolf travel along the transmission line and winter access road ROWs would be improved within the treed portion of the Project, with the exception of the area to be hand-cleared from Twin Gorges to north of Indian Shack and within the boundaries of the proposed East Arm National Park (where vegetation of height <3 m would remain intact in the hand-cleared area). Although there would likely be improved access between the lakes along the Twin Gorges to Nonacho Lake winter road and along the temporary access trails to be cut under the transmission line, following construction the winter roads and temporary access trails would no longer be maintained and natural habitat regeneration would be allowed to proceed. Relative to baseline conditions, there are few natural impediments to wolf travel, as much of the Project footprint would be within open forest and treeless land cover classes. Placing slash across these corridors would reduce their benefit to wolves (ENR, 2007b).

12.4.1.5 Effects To Harvesting Opportunities

Changes in the accessibility, abundance, and distribution of barren-ground caribou may influence the continued opportunity for traditional and non-traditional use of this species (i.e. harvesting activities, wilderness value, and wildlife viewing potential). Negative effects to caribou from increased access were considered to approach or slightly exceed existing conditions (Section 12.3.6.1), and the pathway for improved access leading to increased opportunities for caribou harvesting was considered minor (i.e. invalid) (Section 12.2).

Although the spatial extent of current development is likely large enough to have some influence on caribou movement and distribution within their winter, spring, summer, and autumn ranges, at the local and regional scales, the addition of the Project is predicted to have little detectable effect on the modelled population projections for caribou. With respect to caribou distribution, the current literature suggests that the spatial extent of changes to the behaviour of caribou from activity along winter roads is predicted to be within 5 km of a road. Cumulatively, high and good quality habitats combined declined by 5.0% in the spring range, 7.2% in the summer/post-calving range, 9.0% in the autumn/rut, and about 0.9% from the winter range. However, it is not known if the duration and magnitude of effects from previous and existing development is large enough to cause a shift in a seasonal range of caribou relative to natural factors.

12.5 RESIDUAL EFFECT CLASSIFICATION

The purpose of the residual effect classification is to describe the residual effects from the Project on caribou using a scale of common words, rather than numbers or units. The use of common words or criteria is a requirement in the TOR (MVEIRB, 2008). The following criteria were used to assess the residual effects from the Project (Table 12.5.1):

- direction
- magnitude
- geographic extent
- duration
- reversibility
- frequency
- likelihood
- ecological context

12.5.1 Methods

The effects analyses and residual effects summary presented the incremental and cumulative changes from the Project on barren-ground caribou, and the use of caribou by people who value these animals as part of their culture and livelihood. Incremental effects represent the Project-specific changes relative to the existing environment (in 2007), while cumulative effects refer to the sum of all effects from development and natural factors. Natural factors can include periodic harsh and mild winters, extreme insect years, and changes to seasonal range conditions. It is the goal of the cumulative effects assessment to estimate the contribution of these different types of effects, in addition to Project effects, to the amount of change in the caribou population. Cumulative effects from the Project and other developments influence most of the seasonal ranges of the Bathurst caribou herd (except for the calving range). In contrast, the geographic extent of incremental effects from the Project typically occur at the local scale (e.g. habitat loss due to the Project footprint) and regional scale (e.g. combined habitat loss, dust, noise, and sensory disturbance from Project activities [i.e. zone of influence]).

For caribou, the assessment and classification of residual effects were based on the predicted cumulative changes from pristine conditions through application of the Project. The spatial boundary of the assessment is at the scale of the seasonal ranges (population level), which is a requirement in the TOR (MVEIRB 2008). The incremental effects from the Project relative to 2007 existing conditions are also classified.

Essentially, the only difference in the outcome of effect criteria between cumulative and incremental effects from the Project is in the magnitude and geographic extent of effects. The magnitude for cumulative effects involves changes from pristine conditions through application of the Project, while incremental impacts are based on changes from the Project relative to 2007 existing values. Cumulative effects from the Project and other developments influence the entire seasonal ranges (i.e. beyond regional scale effects). In contrast, the geographic extent of incremental impacts from the Project typically has a local and regional influence on the seasonal ranges of caribou. The predicted scales for the remaining impact criteria (direction, duration, reversibility, frequency, likelihood, ecological context) are equivalent for assessing cumulative and incremental effects from the Project. The results from the residual effect classification are then used to assess significance of the Project effects on caribou and the use of caribou by people (Section 12.6).

To provide transparency in the DAR, the definitions for residual effect criteria were ecologically or logically based on caribou. The scale for the residual effects criteria for classifying effects from the Project are specifically defined for caribou, and definitions for each criterion are provided in Table 12.5.1. A more detailed explanation for magnitude is also provided below. Although professional judgement is inevitable in some cases, a strong effort was made to classify effects using scientific principles, supporting evidence, and a conservative approach where uncertainties exist.

Where quantitative values were available (e.g. habitat loss and fragmentation, habitat suitability), the magnitude of an effects pathway for caribou was determined as follows:

- negligible: no detectable change from the Project relative to baseline values,
- low: less than 5% change from the Project relative to baseline values,
- moderate: 5 to 10% change from the Project relative to baseline values, and
- high: more than 10% change from the Project relative to baseline values, and there is likely a change of state from baseline conditions.

The definition of magnitude provided in Table 12.5.1 is applicable for more qualitative results (e.g. effects on caribou movement and behaviour, and related effects to people).

Ecological context refers to the intrinsic value or perceived importance of the VC. Ecological context has been largely assigned through the issue prioritization presented in the KLOI and SON approach. For example, given the ecological, cultural, and socio-economic importance of caribou, the ecological context of caribou is high, which was implicitly considered in the classification of effects and assessment of significance. As such, ecological context is not classified in the same manner as the other criteria.

Table 12.5.1 — Definitions of Terms Used in the Residual Effect Classification

Direction	Magnitude	Geographic Extent	Duration	Reversibility[1]	Frequency	Likelihood
Neutral: no residual effect **Adverse:** a less favourable change relative to baseline values or conditions **Beneficial:** an improvement over baseline values or conditions	**Negligible:** no predicted detectable change from baseline values **Low:** effect is predicted to be within the range of baseline values **Moderate:** effect is predicted to be at or slightly exceeds the limits of baseline values **High:** effect is predicted to be beyond the upper or lower limit of baseline values so that there is likely a change of state from baseline conditions	**Local:** small-scale direct and indirect effect from the Project (e.g. footprint, physical hazards, and dust deposition) **Regional:** the predicted maximum spatial extent of combined direct and indirect effects from the Project that exceed local-scale effects (can include cumulative direct and indirect effects from the Project and other developments at the regional scale) **Beyond Regional:** cumulative local and regional effects from the Project and other developments extend beyond the regional scale	**Short-term:** effect is reversible at end of one year **Medium-term:** effect is reversible at the end of the construction phase **Long-term:** effect is reversible after the assumed 40-year operation period	**Reversible:** effect would not result in a permanent change of state of the population compared to "similar" environments not influenced by the Project **Irreversible:** effect is not reversible (i.e. duration of impact is indefinite or permanent)	**Isolated:** confined to a specific discrete period **Periodic:** occurs intermittently but repeatedly over the 40-year assessment period **Continuous:** occurs continually over the 40-year assessment period	**Unlikely:** effect is likely to occur less than once in 100 years **Possible:** effect is possible within a year; or at least one chance of occurring in the next 100 years **Likely:** effect is probable within a year; or at least one chance of occurring in the next 10 years **Highly Likely:** effect is very probable (100% chance) within a year

[1] "similar" implies an environment of the same type, region, and time period

12.5.2 Results

12.5.2.1 Project Footprint Leading To Habitat Loss And Fragmentation

Incremental direct effects from the Project footprint (i.e. habitat loss) are local in geographic extent. However, individuals from the population may interact with other developments and activities throughout their respective seasonal ranges (defined as the distribution of the Bathurst herd population for this assessment). Therefore, the cumulative effects from direct habitat loss and fragmentation from the Project and other developments on population size and distribution are expected to be beyond regional in geographic extent (Table 12.5.2). These changes are highly likely to occur.

The magnitude of the incremental and cumulative effects of habitat loss and fragmentation from the Project and other developments on caribou is predicted to be low (Table 12.5.2). The incremental decrease in the amount of quality habitats (i.e. heath tundra, sedge wetland, lichen veneer, and forest) from the Project footprint was estimated to be less than or equal 0.2% for each seasonal range (spring, summer, fall, and winter). For about half of the available habitat types, the incremental change from the Project compared to the existing landscape was less than 0.1%. The cumulative decrease in the quantity of habitats within seasonal ranges from pristine conditions to application of the Project is estimated to be less than 1.2% for any given habitat. This change is well below the 40% threshold value identified for habitat loss associated with declines in bird and mammal species (Andrén, 1994, 1999; Fahrig, 1997; With, 1997; Mönkkönen and Reunanen, 1999).

Although best management practices and a vegetation management plan would be integrated into the construction and operation of the Project, and are part of the land use permits and environmental agreements for existing developments, arctic terrestrial ecosystems are slow to respond to disturbance. While vegetation would likely begin to regenerate naturally along winter access roads, trails, and staging areas following the completion of construction activities, at least 80 years is required for spruce to reach maturity in the boreal forest. In addition, the duration of disturbance to habitat for some components of the Project (e.g. transmission line towers and Nonacho Lake facilities) is indefinite. Therefore, development footprints and related loss of habitat for 2007 baseline and application landscapes was assumed to be permanent (i.e. not reversible within the temporal boundary of the assessment) (Table 12.5.2).

Relative to pristine conditions, cumulative changes from the Project and previous and existing developments on the location, size, and number of quality habitat patches within seasonal ranges is estimated to range from less than 1% to 16% for the Bathurst herd. Most of the changes were associated with heath tundra and forest habitats, which include the dominant habitats in the non-winter and winter seasonal ranges. In addition, the incremental changes from the Project footprint were largely associated with the width of the buffer that was applied to the Project winter access roads and trails, and the transmission line. Due to the large area of seasonal ranges and computational constraints (Section 12.3.2.1), all linear features were given a width of 200 m, even though the actual width varies from 5 m to 30 m for Project components. Subsequently, Project-related changes in habitat fragmentation metrics were likely overestimated.

The Project footprint (which includes portions of the Tibbitt to Contwoyto winter road, the Twin Gorges to Nonacho Lake winter road, and temporary access trails along the transmission line ROW) changed the configuration of habitats on the landscape for the Bathurst herd. Although the presence of the Twin Gorges to Nonacho Lake winter road may represent a partial barrier to caribou and lead to some fragmentation of the population within the winter range (Trombulak and Frissell, 1999), the road would only be in operation for approximately 10 weeks each year and is restricted to a three-year operation period during the construction phase. The winter road may act as a "leaky barrier" that some animals may manage to cross successfully (Tibbitt to Contwoyto Winter Road Joint Venture 2008), but it may restrict the landscape-scale movements of caribou for short periods of time (Treweek 1999).

The frequency of effects from the Project footprint and associated habitat disturbance and fragmentation on barren-ground caribou would occur periodically over the assessment period (Table 12.5.2). For example, construction activities are anticipated to occur during the winter season for three years. During operation, vegetation under the transmission line in the boreal forest would be cleared routinely, except within the proposed East Arm National Park, which would be hand-cleared to maintain a height of less than 3 m.

12.5.2.2 SENSORY DISTURBANCE LEADING TO CHANGES IN HABITAT QUALITY

In addition to direct habitat effects, indirect changes to habitat quality from sensory disturbances have the potential to affect caribou abundance and distribution through altered movement and behaviour. Sensory disturbance (e.g. combined effects from noise, dust, physical presence of the Project, and human activity) resulting from the construction and operation of the Project can reduce habitat quality at the local and regional scales (e.g. local and regional geographic extent; Table 12.5.2). For example, analysis indicated that most noise from construction activities along the transmission line (e.g. equipment, helicopters, and blasting) should reach baseline levels (35 dBA) within 2 km to 3 km of the activity. Noise from haul trucks is expected to reach baseline levels at approximately 500 m, and attenuate to 25 dBA at 1.5 km from a road. Noise from crushers, rock drills, and blasting is predicted to reach baseline levels within 3 km to 7 km of the source.

Gunn et al. (1983) reported that caribou disperse 1 km to 3 km from helicopter landings. Because studies have documented that some ungulate species, such as muskoxen, are alerted by the noise at distances over 1 km (McLaren and Green 1985), there is potential for trucks moving along a winter access road or trail to alter caribou movement and behaviour during the winter. Some studies have found caribou were displaced within 2 to 4 km of roads (Dau and Cameron 1986; Cameron et al. 2005). Other studies have observed that resting and feeding behaviour was common for caribou near airstrips or roads (Gunn et al. 1998; BHPB 2007).

Studies of caribou reactions to transmission lines have indicated a range of reactions from no apparent avoidance to influences on behaviour and distribution extending 5 km from the transmission line (see Section 9.5.4 Caribou Existing Environment). This level of reduced use around the transmission line ROW may actually overestimate the effect on caribou behaviour, as no audible noise is expected from the conductor line for the Project (Section 12.3.3.3). However, the spatial extent of changes to caribou behaviour were predicted to be greater during seasons when caribou are present above the treeline due to the improved visibility of the transmission line on the tundra.

All of these Project stressors can combine with similar effects from other developments and decrease the amount of quality habitat on seasonal ranges for supporting caribou populations (i.e. carrying capacity). Sensory disturbance to caribou and associated changes in habitat quality was estimated using resource selection functions (i.e. habitat suitability models), and included knowledge of the local and regional effects from development activities on caribou presented above. Effects on preferred habitats (i.e. good- and high-quality habitats) were evaluated across four seasonal ranges: spring (northern migration), summer (post-calving), autumn (rut), and winter. Thus, the geographic extent of the cumulative effects from changes to habitat quality and carrying capacity on caribou population size and distribution is beyond regional (i.e. the effect includes local and regional influences from the Project and other existing developments).

Habitat models predicted that the cumulative decrease from the Project and other developments in preferred habitats (i.e. high- and good-quality habitats combined) was 5% in the spring range, 7% in the summer/post-calving range, 9% in the autumn/rut range, and 1% in the winter range. In winter, application of the Project includes the Tibbitt to Contwoyto and the Twin Gorges to Nonacho Lake winter roads. The magnitude of the cumulative effect from development-related changes to habitat quality and carrying capacity on caribou population size and distribution is predicted to be moderate during construction and operation. The incremental effect from the Project on preferred habitat was low (i.e. less than 0.5% for each seasonal range) (Table 12.5.2).

Sensory effects likely end soon after the cessation of the stressor (i.e. noise, smells, and activity). Therefore, sensory disturbance created during construction is predicted to end shortly after construction, and is a medium-term effect. Alternately, the duration of incremental and cumulative sensory disturbance effects during operation (mostly from the presence of the transmission line) are predicted to be long-term, and reversible following the end of operation of the Project (Table 12.5.2). The frequency of sensory disturbance effects from the Project and other developments within the seasonal ranges of the herd is expected to be continuous during construction and operation. Given the historical movement paths and trails identified for the Bathurst caribou herd in relation to the transmission line ROW, it is highly likely that the Bathurst caribou herd would have to cross or intersect the transmission line each year during migration and post-calving movements (see Section 9.5.4 Caribou Existing Environment).

12.5.2.3 DIRECT AND INDIRECT HABITAT LOSS LEADING TO CHANGE IN CARIBOU ABUNDANCE

Cumulative changes to the amount of different quality habitats (through direct loss and sensory disturbance) can affect caribou abundance by decreasing the carrying capacity of the landscape. Population viability analysis was used to determine the relative changes in the decrease and risk to population viability (i.e. the likelihood of population persistence) for the pristine, 2007 existing conditions, and application landscape scenarios. Results from the habitat quality analysis, which includes direct and indirect habitat loss from development (Table 12.3.13) were used as parameter inputs in the population models. The PVA was used to estimate the incremental effect from the Project, and the relative contribution of natural factors (e.g. insect outbreaks, deep snow) and human activities (e.g. existing development, hunting) on the current phase of the population cycle in caribou.

Results indicated that there was little detectable change in population size and risk of population decline between the different development scenarios for the 60-year simulation period. The 9% decrease in the amount of quality habitat on the annual range from pristine conditions to application of the Project had less influence on the population trajectories than successive runs of the same development scenario. In other words, the differences between successive runs of the pristine case were larger than the differences between the pristine and Project application scenarios. Sensitivity analyses also suggested that a further decrease of 10% in carrying capacity (i.e. in addition to the 9% decrease from pristine to application scenarios) increased the probability of population decline by approximately 2%. Therefore, the magnitude of incremental and cumulative effects from habitat loss from development on caribou abundance was predicted to be negligible (Table 12.5.2). Cumulative changes to caribou abundance would be beyond regional in geographic extent, and Project-specific effects would occur at the local and regional scales. The duration of incremental and cumulative effects from the Project and other existing developments on the population size of the Bathurst herd is predicted to be long term, and reversible following the end of operation of the Project (Table 12.5.2).

12.5.2.4 USE OF LINEAR CORRIDORS BY WOLVES LEADING TO CHANGE IN PREDATION RATE

Wolves have been documented to use linear corridors (e.g. roads, trails, seismic lines) within boreal environments, which allow them to travel faster and possibly improve hunting success. Likewise, caribou limit the use of linear corridors, probably as a predator avoidance strategy. Linear corridors would be created within the boreal regions of the Bathurst caribou winter range (due to winter roads, temporary access trails, and the transmission line ROW), and the use of these corridors by wolves is anticipated to be similar during both the construction and operation phase.

The nature of the Taiga Shield forest, which includes many open lakes and forest, must be considered in the assessment. As such, the benefit to wolves from a winter road portage between lakes is likely limited. As the Project would only create a small number of linear corridors (albeit long), the incremental effect was considered to have a low magnitude on increased caribou predation rate (Table 12.5.2). As there are few other linear corridors within the boreal winter range (predominantly existing winter roads and snowmobile portages), the magnitude of the cumulative effect was also considered to be low. Incremental effects are limited to the vicinity of the Project linear corridors (local), but are beyond regional at the cumulative level (as there are other such corridors throughout the Bathurst winter range in boreal environments). Effects are reversible in the long-term, and occur during the winter when caribou are in the forest (i.e. frequency of effects is seasonal or periodic).

12.5.2.5 Effects To Harvesting Opportunities

Effects to traditional and non-traditional harvesting opportunities are predominantly a function of caribou abundance, distribution, and access. Given the length of travel distance, planned mitigation practices and designs, and the variability in barren-ground caribou winter distribution an increase in harvesting opportunities from improved access was considered to be a minor pathway (see Section 12.2). However, changes to caribou abundance and distribution from the Project and existing developments can decrease harvesting opportunities for traditional and non-traditional land users.

Principal pathways influencing caribou abundance and distribution are related to direct habitat loss and fragmentation, and sensory disturbance causing a decrease in the amount of quality habitat. The magnitude of incremental and cumulative changes from direct habitat loss and fragmentation on caribou is expected to be low, and low to moderate for effects from sensory disturbance. Results from the PVA models also predicted that cumulative and incremental decreases in carrying capacity (a function of direct and indirect habitat loss) had a negligible influence on caribou abundance. The effect from the Project and other developments on the distribution of caribou across their seasonal ranges is expected to be low in magnitude (i.e. changes should be within the range of baseline conditions). There are natural environmental factors that operate over large scales of space and time (e.g. fire, snowfall, climate-related changes in food abundance and quality) that likely have greater influences on seasonal distributions of caribou relative to effects from the Project and other developments. For example, some studies of caribou have shown that the historical cumulative effect of overgrazing on calving, summer or winter ranges can result in periodic range shifts and large population fluctuations (Messier et al. 1988; Ferguson and Messier 2000). Traditional knowledge also contends that fire frequency and intensity affects caribou numbers and distribution (Kendrick et al. 2005).

Relative to pristine conditions, cumulative effects from the Project and existing developments are predicted to result in lower encounter rates between people and caribou on their seasonal ranges (beyond regional geographic extent). The magnitude of the cumulative effect is anticipated to be with range of current baseline values (i.e. low). However, the local to regional incremental effect from the Project is not expected to result in a detectable change in encounter rates between people and caribou on their seasonal ranges (negligible magnitude). Because the ecological context for human use of caribou is considered high, the predicted magnitude from cumulative development on use of caribou by people was increased from low to moderate, and negligible to low for incremental effects from the Project (Table 12.5.3). The duration of effects on the continued opportunity for harvesting of caribou are expected to be reversible in the medium to long term. Effects on harvesting opportunities would likely be greater during construction of the Project, due to the level and type of activity (e.g. vegetation clearing, truck and helicopter traffic, human presence, and blasting), but these effects occur only during the winter and are expected to be reversible following construction (medium term duration). During operation, effects should be mostly attributed to the presence of the transmission line and associated ROW, and are predicted to be reversible at the end of operation (Table 12.5.3)

Table 12.5.2 — Summary of Residual Effect Classification of Valid Pathways for Cumulative and Incremental Effects to Barren-Ground Caribou

Pathway	Project Phase	Direc-tion	MAGNITUDE		GEOGRAPHIC EXTENT		Duration	Reversibility	Frequency	Likeli-hood
			Incre-mental	Cumu-lative	Incre-mental	Cumu-lative				
Project footprint leading to habitat loss and fragmentation	Construction and Operation	Adverse	Low	Low	Local	Beyond regional	Irreversible	Irreversible	Periodic	Highly likely
Sensory disturbance leading to changes in habitat quality	Construction	Adverse	Low	Moderate	Local to regional	Beyond regional	Medium-term	Reversible	Continuous	Highly likely
	Operation	Adverse	Low	Moderate	Regional	Beyond regional	Long-term	Reversible	Continuous	Highly likely
Direct and indirect habitat loss leading to change in caribou abundance	Construction and Operation	Adverse	Negli-gible	Negligible	Local to Regional	Beyond regional	Long-term	Reversible	Continuous	Likely
Use of linear corridors by wolves leading to change in predation rate	Construction and Operation	Adverse	Low	Low	Local	Beyond regional	Long-term	Reversible	Periodic	Highly likely

Table 12.5.3 — Classification of Residual Effects to Human Use of Barren-Ground Caribou

Pathway	Project Phase	Direc-tion	MAGNITUDE		GEOGRAPHIC EXTENT		Duration	Reversibility	Frequency	Likelih ood
			Incre-mental	Cumu-lative	Incre-mental	Cumu-lative				
Effects to harvesting opportunities	Construction and Operation	Adverse	Low	Moderate	Local to Regional	Beyond Regional	Medium to Long-term	Reversible	Continuous	Likely

12.6 DETERMINATION OF SIGNIFICANCE

12.6.1 Methods

The classification of residual effects on valid pathways for barren-ground caribou provides the foundation for determining significance from the Project on assessment endpoints (Section 12.5). Based on the residual effects analysis and classification, assessment endpoints that are linked to valid pathways for caribou include:

- persistence of caribou abundance,
- persistence of caribou distribution, and
- persistence of traditional and non-traditional harvesting opportunities.

Although persistence of caribou health was identified as an assessment endpoint, the pathways to this endpoint were determined to be invalid (Section 12.2.2)

In the DAR, determining significance considers the entire set of pathways that influence a particular assessment endpoint. Significance is only determined for assessment endpoints, and not individual pathways. Assessment endpoints represent the ultimate ecological properties and services of caribou that should be protected for use by future human generations. Magnitude, geographic extent, and duration (which includes reversibility) were the principal criteria used to predict significance. Other criteria, such as frequency, likelihood, and ecological context were used as modifiers (where applicable) in the determination of significance.

The relative contribution of each pathway is then used to predict the significance of effects (e.g. magnitude of low to high). For example, a pathway with a high magnitude, large geographic extent, and long-term duration would be given more weight in determining significance, relative to pathways with smaller-scale effects. In other words, the relative effect from each pathway is considered, and pathways that are predicted to have the greatest influence on changes to assessment endpoints were also assumed to contribute the most to the determination of significance. Similar to the residual effects classification, determination of significance was completed for assessment endpoints for construction and operation phases independently (where assessed).

12.6.2 Results

Cumulative effects from the Project, previous and existing developments, harvesting, and natural factors on caribou population abundance and distribution were analyzed and assessed through valid pathways in the previous sections. The geographic extent of cumulative effects from these Project pathways was considered to occur across the seasonal ranges of caribou (i.e. beyond regional), except for the calving range. In contrast, Project-specific (incremental) effects were determined to be local to regional in spatial extent (Table 12.6.1). The probability of cumulative and incremental effects occurring is predicted to be likely to highly likely for all pathways (Table 12.5.2), which does not change the expected magnitude and duration (or significance). The frequency of most effects is anticipated to occur continuously throughout the life of the Project. However, changes to predation rate on caribou from wolves associated with linear corridors created by the Project should be limited to the winter range (i.e. periodic frequency). Similarly, direct loss of habitat from the Project is expected to occur periodically from winter construction over a three-year period, and from limiting the height of vegetation under the transmission line during operation (Table 12.5.2).

The magnitude of these pathways is expected to be negligible to low for incremental effects from the Project, and low to moderate for cumulative effects from the Project and other developments (Table 12.6.1). Although direct disturbance to habitats from the Project and previous and existing development footprints were calculated to represent less than 2% of seasonal ranges, the effect was assumed to be irreversible within the temporal boundary of the assessment. For the other pathways, the duration of effects was predicted to be reversible at the end of construction (medium-term) or operation (long-term) (Table 12.5.2). Considering all of the pathways, the incremental and cumulative changes from the Project and other developments were not anticipated to have a significant effect on the caribou assessment endpoints (Table 12.6.1).

The persistence of caribou abundance is linked to direct and indirect habitat loss, and use of linear corridors by wolves leading to changes in caribou predation rate (Table 12.6.1). Of these two pathways, effects from direct and indirect habitat loss were given a greater weight in the determination of significance. This pathway was assessed through population viability analysis, which determined the relative changes in the decrease and risk to the caribou population for the pristine, 2007 existing conditions, and application landscape scenarios. Changes in habitat were the focus of the analysis, but the model also varied survival (which includes predation), reproduction, and harvest rates. Results indicated that changes to the amount of quality habitat from development (i.e. carrying capacity) on the seasonal ranges had negligible effects on caribou population size relative to harvest rate, and survival and reproduction rates (Section 12.3.4.2). Thus, the magnitude was considered to be negligible for both incremental and cumulative effects, and was predicted to occur continuously during construction and operation of the Project.

In contrast, the magnitude of the incremental and cumulative changes to caribou predation rate from wolves using linear corridors was predicted to be within the range of current baseline conditions (i.e. low magnitude). The creation of winter road portages and trails in the Taiga Shield forest, which currently includes many open lakes and forest, is expected to provide limited benefit for wolves hunting caribou. The effect should occur periodically on the winter range only, during construction and operation of the Project. Effects from direct and indirect habitat loss and increased predation from wolves are anticipated to be reversible in the long term (i.e. following the end of operation). Overall, incremental and cumulative effects to the persistence of the caribou population were considered to be not significant (Table 12.6.1).

The persistence of caribou distribution (or the continuation of historic caribou migratory patterns and use of travel routes) is linked to development footprints leading to habitat loss and fragmentation, and sensory disturbance (Table 12.6.1). Habitat fragmentation can negatively influence individuals and populations, but fragmentation effects have less impact than habitat loss (Fahrig 1997; Andrén 1999; Fahrig 2003). The breaking apart of habitats on the landscape changes patch size and number, connectivity between similar habitat patches, and the amount of interior and edge of remnant patches. These landscape-scale changes have been shown to alter abiotic (moisture, nutrients) and biotic processes, such as dispersal and predation. However, fragmentation studies have shown that not all effects were negative (see reviews by Debinski and Holt 2000; Fahrig 2003). For example, of the 17 studies reviewed by Fahrig (2003), the likelihood of positive or negative effects from fragmentation was similar.

The magnitude of the incremental and cumulative effects of direct habitat loss and fragmentation from the Project and other developments on caribou is predicted to be low (Table 12.5.2). Incremental decreases in the amount of quality habitats from the Project footprint were estimated to be less than or equal 0.2% for each seasonal range. The cumulative decrease in the quantity of habitats within seasonal ranges from pristine conditions to application of the Project is estimated to be less than 2% for any given habitat. Although best management practices and a vegetation management plan would be integrated into the construction and operation of the Project, and are part of the land use permits and environmental agreements for existing developments, arctic terrestrial ecosystems are slow to respond to disturbance. In addition, the duration of disturbance to habitat for some components of the Project (e.g. transmission line towers and Nonacho Lake facilities) is indefinite. Therefore, development footprints and related loss of habitat for caribou were assumed to be permanent (i.e. not reversible within the temporal boundary of the assessment) (Table 12.5.2).

Relative to pristine conditions, cumulative changes from the Project and previous and existing developments on the location, size, and number of quality habitat patches (e.g. heath tundra, sedge association, riparian shrub, lichen veneer, and forest) within seasonal ranges is estimated to range from less than 1% to 16% for the Bathurst herd. Most of the changes were associated with heath tundra and forest habitats, which include the dominant habitats in the non-winter and winter seasonal ranges. In addition, the incremental changes from the Project footprint were largely associated with the width of the buffer that was applied to the Project winter access roads and trails and the transmission line. Due to the large area of seasonal ranges and computational constraints (Section 12.3.2.1), all linear features were given a width of 200 m, even though the actual width varies from 5 m to 30 m for Project components. Subsequently, Project-related changes in habitat fragmentation metrics were likely overestimated.

Sensory disturbance to caribou and associated changes in habitat quality was estimated using resource selection functions (i.e. habitat suitability models), and included knowledge of the local and regional effects from development activities on caribou (Section 12.3.3.3). Habitat models predicted that the cumulative decrease from the Project and other developments in preferred habitats (i.e. high and good quality habitats combined) was 5% in the spring range, 7% in the summer/post-calving range, 9% in the autumn/rut range, and 1% in the winter range. In winter, application of the Project included the Tibbitt to Contwoyto and the Twin Gorges to Nonacho Lake winter roads. The magnitude of the cumulative effect from development-related changes to habitat quality and carrying capacity on caribou population size and distribution is predicted to be moderate during construction and operation. The incremental effect from the Project on preferred habitat was low (i.e. less than 0.5% for each seasonal range) (Table 12.5.2).

Reductions in preferred habitats due to development also may result in an increase in the density of caribou where habitat is suitable and there are a lower number of developments. The change in the distribution of caribou associated with the zone of influence from the Project and other developments is expected to be within the range of baseline conditions (low magnitude). There are natural environmental factors that operate over large scales of space and time (e.g. fire, snowfall, climate related changes in food abundance and quality) that likely have greater influences on seasonal distributions of caribou relative to impacts from the Project and other developments.

Sensory effects likely end soon after the cessation of the stressor (i.e. noise, smells, and activity). Therefore, sensory disturbance created during construction is predicted to end shortly after construction, and is a medium-term effect. Alternately, the duration of incremental and cumulative sensory disturbance effects during operation (mostly from the presence of the transmission line) are predicted to be long-term, and reversible following the end of operation of the Project (Table 12.5.2). Overall, incremental and cumulative effects to the persistence of caribou distribution were considered to be not significant (Table 12.6.1). However, given the high ecological context for caribou, the likelihood of significant cumulative effects is considered to be possible during the operation of the Project.

Continued opportunities for traditional and non-traditional use of caribou are related to population abundance and distribution of caribou. Therefore, the geographic extent of the cumulative effects from development on the use of caribou by people is beyond regional (Table 12.6.1). Given that the duration of the cumulative effects from the Project and other developments are anticipated to occur over the medium to long term, the effects to people should also be reversible in the medium to long term. The probability of the effects occurring is predicted to be likely, and the frequency is anticipated to occur continuously throughout the life of the Project, which does not change the expected magnitude (or significance) of effects.

Relative to pristine conditions, cumulative effects from development are predicted to result in lower encounter rates between humans and caribou on their seasonal ranges. Because the ecological context for human use of caribou is considered high, the predicted magnitude from cumulative development on use of caribou by people was increased from low to moderate, and negligible to low for incremental effects from the Project (Section 12.5.2.5). However, analysis of incremental and cumulative changes from direct habitat loss and fragmentation, sensory disturbance, and wolf predation are not predicted to result in significant effects to caribou abundance and distribution. Subsequently, cumulative effects from development also are not predicted to have a significant adverse affect on continued opportunities for use of caribou by people that value the animals as part of their culture and livelihood (Table 12.6.1).

Table 12.6.1 — Summary of the Significance of Effects to the Bathurst Caribou Assessment Endpoints

Valued Component Assessment Endpoints	Pathways	Project Phase	MAGNITUDE		GEOGRAPHIC EXTENT		Duration	SIGNIFICANCE	
			Incre-mental	Cumu-lative	Incre-mental	Cumu-lative		Incre-mental	Cumu-lative
Persistence of abundance	Direct and indirect habitat loss leading to change in abundance Use of linear corridors by wolves leading to change in predation rate	Construction and Operation	Negligible to Low	Negligible to Low	Local to Regional	Beyond Regional	Long-term	Not Significant	Not Significant
Persistence of distribution	Project footprint leading to direct habitat loss and fragmentation Sensory disturbance causing change in habitat quality, and altered movement and behaviour	Construction	Low	Low to Moderate	Local to Regional	Beyond Regional	Medium term to Irreversible	Not Significant	Not Significant
		Operation	Low	Low to Moderate	Local to Regional	Beyond Regional	Long-term to Irreversible	Not Significant	Not Significant
Persistence of harvesting opportunities	Effects to harvesting opportunities	Construction and Operation	Low	Moderate	Local to Regional	Beyond Regional	Medium to Long-term	Not Significant	Not Significant

12.7 UNCERTAINTY

Uncertainty refers to the level of confidence in the effects predictions. The purpose of this section is to highlight areas of low certainty, and to discuss how uncertainty has been addressed to increase the level of confidence that effects would not be worse than predicted. Confidence in effects analyses can be related to many elements, including the following:

- adequacy of baseline data for understanding current conditions and future changes unrelated to the Project (e.g. extent of future developments, climate change, catastrophic events);
- model inputs;
- incomplete understanding or simplified representation of a system being modeled either physically, numerically, or conceptually;
- understanding of Project-related effects on complex ecosystems that contain interactions across different scales of time and space (e.g. how and why the Project would influence caribou); and
- knowledge of the effectiveness of the mitigation for reducing or removing effects (e.g. restricted public access on temporary winter roads and along the transmission line south of the treeline).

Uncertainty in these elements can result in uncertainty in the prediction of residual effects. Where possible, a strong attempt was made to reduce uncertainty in the effects analysis to increase the level of confidence in effect predictions. This was accomplished through implementing a conservative approach when information is limited so that effects are typically overestimated. In addition, data from effects monitoring programs at existing projects and the literature were used as inputs for models rather than strictly hypothetical or theoretical values.

It is understood that development activities would directly and indirectly affect habitat, and caribou behaviour and movement. Although direct disturbance from development footprints was calculated to represent less than 5% of the entire Bathurst caribou annual home range, long-term monitoring studies documenting the resilience of caribou to development and the time required to reverse effects are lacking.

Some uncertainty exists in the description of previous and existing developments, as there is little or no information collected on parameters such as the actual dates and seasons of activities, their precise location, or their geographic extent (or the information is not easily available). Several assumptions were made concerning the temporal and spatial extent of effects from the different types of development. For example, although the land use permit for mineral exploration was assumed to be active for five years, there are no data on the actual frequency and length of time that exploration activities occurred during that period. The assumption likely overestimates the effect from exploration activities. In addition, the database contains no information on the size of the physical footprint of the development; therefore, the physical area of the footprint was estimated using a number of assumptions. For example, a 1,000 m radius (314 ha) was used to estimate the area of the footprint for exploration sites and power plants. For all closed mines and inactive land use permits, the physical footprint was carried through each assessment case as it was assumed that direct effects to the landscape had not yet been reversed.

Adding to the challenges of understanding complex systems is the difficulty of forecasting a future that may be outside the range of observable baseline environmental conditions such as factors related to climate change (Walther et al. 2002). Potential future habitat conservation efforts, such as the proposed East Arm National Park, also generate uncertainty in impact predictions.

Another source of uncertainty when predicting effects to caribou is the large degree of variation in their seasonal movements. Although there are broad annual patterns (such as wintering south of the treeline, and calving in mid-June near Bathurst Inlet), the exact timing of caribou movements, and their travel routes can change substantially from year to year. For example, Bathurst caribou may winter anywhere between Great Bear Lake and northern Saskatchewan. Given this unpredictability, it is difficult to estimate when or where the Project construction activities may influence caribou. Effects to caribou from construction activities and the operation of the transmission line may only take place if there are caribou in the vicinity. In particular, the exposure of caribou to Project construction is difficult to estimate because of the seasonal nature and short duration of the construction activities.

When faced with uncertainty in quantitative data, a cautious approach was taken within this DAR. For example, the transmission line ROW is anticipated to vary from 15 m to 30 m wide within boreal areas, and no clearing is anticipated in the tundra. Regardless, habitat loss was calculated assuming a 30 m wide ROW for the entire length of the transmission line. Due to data and computational constraints, the ROW was considered to be 200 m wide for the calculation of fragmentation metrics. When calculating resource selection functions, the largest disturbance coefficients were typically used for each development type. In this way, effects to caribou were likely overestimated, and the resulting estimate of change and effect can be considered the upper limit.

The effect of the transmission line during operations on caribou behaviour, movements and distribution is another source of uncertainty. Baseline surveys have indicated that Bathurst caribou would forage and bed below the existing Snare Hydro to Yellowknife transmission line (Golder 2008), which is larger than the proposed Project's transmission line. However, the data from the Snare Hydro to Yellowknife transmission line represent only the winter range for barren-ground caribou. Published literature regarding the response of caribou to transmission lines in tundra settings was very limited. The best available examples were the responses of Scandinavian reindeer to alpine transmission lines (Section 9.5.4 Caribou Existing Environment). Movements of satellite-collared caribou indicate that the proposed transmission line intersects the usual post-calving migration route. As such, it can be assumed that that the majority of the Bathurst herd cows and calves would pass under the transmission line at least once per year, and likely more frequently. The effect that this may have on caribou behaviour and movement, particularly on a tundra environment where such features are visible for long distances, is largely uncertain. The rate of habituation to such features is also not well understood.

12.7.1 Reasonably Foreseeable Projects

Potential future developments of varying numbers, sizes, and types in the Bathurst annual range could contribute to cumulative effects to barren-ground caribou and contribute to the uncertainty in the effect predictions. The following proposed projects have been selected as a suite of major developments that may occur in the reasonably foreseeable future, and a description of the key components of each is provided below.

- a small scale diamond mine in the Lac de Gras region owned by Peregrine Diamonds Ltd., which hauls ore to Ekati for processing;
- the Tyhee NWT Corp Yellowknife Gold Project;
- the Bathurst Inlet Port and Road Project (BIPR); and
- the East Arm National Park.

Peregrine Diamonds Ltd.'s WO property is located in the Lac de Gras region, near the proposed transmission line route. This property contains two kimberlite pipes, DO-27 and DO-18, which have shown results that are favourable in regards to farther expansion of the site (Peregrine Diamonds 2008). A possible scenario for this Projectis the development of a small-scale underground mine and construction of an all-season haul road for the transportation of ore to the Ekati Mine site for processing. The viability of the Peregrine Diamonds property would improve with the presence of the Taltson transmission line, providing an example of development that may be facilitated by the Project. The Peregrine Project would introduce a fourth operating mine within the post-calving range of the Bathurst caribou. Although the mine would likely be of a smaller scale than Ekati and Diavik, the possibility of a haul road connecting the Peregrine Project to Ekati could introduce incremental effects. The largest effect from the Peregrine Project on Bathurst caribou could be an extended zone of influence introduced around mines in the area and the all-season haul road, leading to further direct and indirect habitat loss for caribou.

The Yellowknife Gold Project proposed by Tyhee NWT Corporation anticipates a combination open pit and underground mining operation with a lifespan of 8 to 13 years depending on production rates. It is expected that approximately 190 people would be employed at the site when in full operation (Tyhee 2008). The property is located 90 km north of Yellowknife on the former Discovery Mine site, an existing disturbed area. Access would be provided by existing winter road routes and by air. Although this property could not be easily serviced by the Project, it also lies within the winter range of the Bathurst caribou herd. Although access to this mine would likely be via winter road only, this is also the season when caribou would be present in the area. Further, the maintenance of a the winter road would lead to improved caribou hunting activities for residents of Yellowknife.

The proposed Bathurst Inlet Port and Road (BIPR) Project would provide access to the Arctic Ocean for projects located within the interior of the Northwest Territories and Nunavut. The proposed 211 km all-weather road, which would begin at a planned port facility south of the community of Bathurst Inlet, Nunavut, would connect with the existing ice road on Contwoyto Lake (BIRP 2008). It is expected that this road would reduce the fuel and supply costs for northern communities and any developments that are along the proposed route. Employment would peak during construction, and opportunities would be staffed mainly by Nunavut residents. The

BIPR project could lead to cumulative effects to wildlife in the Slave Geological Province. This road would traverse at least part of the Bathurst caribou herd's migration route to the calving ground near Bathurst Inlet, but it is anticipated that all hauling operations would be suspended during this short and sensitive period. Although this would not mitigate direct habitat loss, it would reduce the degree of sensory disturbance to caribou. As there are no residents in the region, it is unlikely that this road would be used by hunters. The presence of the BIPR project may also induce further mining development. However, there is some uncertainty regarding the feasibility of this project, which was originally proposed in 1999 (CBC, 2008)

The study area for the proposed East Arm National Park intersects the proposed Project corridor near Reliance. Depending upon the length of time for the park feasibility study to be completed and the time to negotiate the remaining stages of the park planning process, the proposed East Arm National Park may not be created until the Project is well into the operations phase. There is also ambiguity in predicting the status of the existing fishing, hunting lodges, and camps in the proposed park area. This assessment assumes that existing lodges would no longer allow hunting, but would remain as tourist lodges. From a conservation perspective, the proposed East Arm National Park would be beneficial to Bathurst caribou as it would place limits on future development and habitat loss within the park boundaries.

12.8 MONITORING

Three categories of monitoring were identified in the TOR (MVEIRB 2008), as follows:

- Compliance inspection: monitoring the activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments.
- Environmental monitoring: monitoring to track conditions or issues during the development lifespan, and subsequent adaptation of Project management.
- Follow-up monitoring: programs designed to verify the accuracy of impact predictions, to reduce uncertainty, and to determine the effectiveness of mitigation.

These programs would form part of the environmental management system (EMS) for the Project. If monitoring or follow-up detects effects beyond those predicted, unanticipated effects, or the need for improved or modified design features, then adaptive management would be implemented. This may include increased monitoring, changes in monitoring and mitigation plans, and/or additional mitigation.

Environmental monitors would be hired during the Project construction phase to oversee issues such as camp waste disposal, human-wildlife conflicts, and managing any unanticipated Project conflicts with wildlife (i.e. environmental monitoring). Environmental monitors would also document the presence of caribou near construction areas, communicate this information to construction managers, and carry out any deterrent action that may be necessary (documented in the Human Wildlife Conflict Management Plan). This type of monitoring has been demonstrated to be of great value at the Diavik, Ekati and Snap Lake diamond mines.

Follow-up monitoring is also proposed. Unauthorized use of the proposed winter roads from Fort Smith to Twin Gorges and from Twin Gorges to Nonacho Lake would be documented by the environmental monitors. Further, any evidence of wildlife harvesting, ice fishing, recreational snowmobiling, firewood harvesting, camping, or any other such activities would be recorded. An example of a similar monitoring program is that conducted by ENR on the Tibbitt to Contwoyto winter road (Ziemann, 2007). Caribou monitoring beyond that described in the Human Wildlife Conflict Management Plan would be outlined in the Wildlife Monitoring Plan, which would be developed during the permitting process, following approval of the Project.

APPENDIX 12A

ABSOLUTE VALUES IN LANDSCAPE METRICS

Northern migration Change in Landscape Metrics from Development Relative to Pristine and 2007 Baseline Conditions for the Bathurst Herd

Habitat	Total Area		Number of Patches		Total Edge		Mean Area of Patch		Coefficient of Variation for Patch Area		Mean Distance to Nearest Neighbour	
	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application
Esker	-148.0	-12.0	-28.0	-3.0	-27200.0	-2400.0	0.0	0.0	0.0	0.0	5.6	0.8
Lichen veneer	-2060.0	0.0	2.0	0.0	12000.0	0.0	-62.1	0.0	1.5	0.0	-107.1	0.0
Rock association	-19876.0	-1380.0	30.0	24.0	211400.0	103200.0	-94.8	-62.5	8.4	4.4	-52.2	-41.3
Heath tundra	-30588.0	-3940.0	33.0	45.0	346400.0	320000.0	-429.4	-483.9	35.9	-397.6	-66.5	-75.9
Heath rock	-5452.0	-20.0	13.0	0.0	-11200.0	-400.0	-29.2	0.0	4.4	0.0	-35.6	0.0
Sedge association	-576.0	-56.0	5.0	2.0	-4400.0	4000.0	-25.8	-8.9	3.4	1.1	-668.0	-65.3
Riparian shrub	-2224.0	-504.0	6.0	10.0	-20000.0	43200.0	-10.4	-12.8	1.1	0.8	-37.0	-56.8
Low shrub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forest	-20948.0	-3588.0	27.0	43.0	229800.0	295600.0	-195.7	-261.3	32.8	-68.9	-25.3	-66.1
Young burn	-1724.0	-232.0	4.0	2.0	10000.0	16400.0	-73.2	-32.4	3.3	0.9	-362.5	-38.3
Old burn	-352.0	-512.0	1.0	6.0	2800.0	41400.0	-9.0	-44.5	0.9	-6.3	-37.3	-223.1
Nonvegetated	-19112.0	-640.0	9.0	8.0	249400.0	42400.0	-87.8	-55.0	3.8	1.9	-48.5	-49.1

Note: Baseline = relative change from Pristine to 2007 Baseline; Application = relative change from 2007 Baseline to Application Conditions.

Post-calving Change in Landscape Metrics from Development Relative to Pristine and Baseline Conditions for the Bathurst Herd

Habitat	Total Area		Number of Patches		Total Edge		Mean Area of Patch		Coefficient of Variation for Patch Area		Mean Distance to Nearest Neighbour	
	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application
Esker	-132.0	-12.0	-24.0	-3.0	-24000.0	-2400.0	0.0	0.0	-0.1	0.0	5.4	1.5
Lichen veneer	-532.0	0.0	1.0	0.0	400.0	0.0	-37.7	0.0	0.9	0.0	-231.7	0.0
Rock association	-15752.0	-1224.0	24.0	19.0	197800.0	94400.0	-132.8	-84.3	10.6	5.1	-59.5	-76.2
Heath tundra	-27740.0	-3940.0	29.0	46.0	313600.0	320000.0	-809.6	-1019.4	46.3	-317.2	-54.1	-83.3
Heath rock	-4176.0	-20.0	13.0	0.0	-25400.0	-400.0	-42.6	0.0	7.8	0.0	-54.8	0.0
Sedge association	-488.0	-56.0	4.0	2.0	-3600.0	4000.0	-19.5	-8.5	2.5	1.0	-61.7	-43.9
Riparian shrub	-1120.0	-476.0	3.0	8.0	-15600.0	41200.0	-9.2	-18.1	1.1	0.9	-24.2	-64.6
Low shrub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forest	-8592.0	-1844.0	24.0	34.0	24800.0	140800.0	-99.7	-114.8	12.4	13.8	-33.8	-85.1
Young burn	-200.0	0.0	2.0	0.0	1600.0	0.0	-283.2	0.0	20.3	0.0	-5684.7	0.0
Old burn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nonvegetated	-12216.0	-564.0	4.0	6.0	193400.0	38000.0	-152.8	-152.7	2.4	2.1	-63.1	-126.6

Note: Baseline = relative change from Pristine to 2007 Baseline conditions; Application = relative change from 2007 Baseline to Application Conditions.

Rut Change in Landscape Metrics from Development Relative to Pristine and 2007 Baseline Conditions for the Bathurst Herd

Habitat	Total Area		Number of Patches		Total Edge		Mean Area of Patch		Coefficient of Variation for Patch Area		Mean Distance to Nearest Neighbour	
	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application
Esker	-136.0	-12.0	-25.0	-3.0	-24800.0	-2400.0	0.0	0.0	0.0	0.0	6.9	1.1
Lichen veneer	-1640.0	0.0	1.0	0.0	10000.0	0.0	-95.5	0.0	3.3	0.0	-211.0	0.0
Rock association	-16468.0	-1380.0	25.0	24.0	150000.0	103200.0	-84.8	-64.3	8.0	2.7	-54.6	-55.2
Heath tundra	-28936.0	-3940.0	34.0	45.0	329400.0	320000.0	-447.1	-483.0	30.7	-370.0	-72.9	-79.9
Heath rock	-3748.0	-20.0	12.0	0.0	-24000.0	-400.0	-40.7	0.0	3.9	0.0	-59.4	0.0
Sedge association	-500.0	-56.0	5.0	2.0	-4400.0	4000.0	-19.4	-7.0	2.4	0.8	-426.8	-34.3
Riparian shrub	-2948.0	-504.0	9.0	10.0	-16000.0	43200.0	-16.6	-14.6	2.0	1.6	-38.7	-45.2
Low shrub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forest	-25924.0	-3424.0	31.0	40.0	298800.0	283600.0	-264.8	-283.1	42.3	-135.9	-25.0	-63.3
Young burn	-2148.0	-232.0	5.0	2.0	6400.0	16400.0	-75.5	-25.4	3.3	0.6	-382.3	-41.8
Old burn	-384.0	-312.0	1.0	4.0	2000.0	23400.0	-14.9	-48.4	1.4	1.7	-72.8	-310.5
Nonvegetated	-19796.0	-640.0	8.0	8.0	262200.0	42400.0	-88.8	-57.7	3.6	1.8	-37.2	-56.2

Note: Baseline = relative change from Pristine to 2007 Baseline Conditions; Application = relative change from 2007 Baseline to Application Conditions.

Winter Period Change in Landscape Metrics from Development [a] Relative to Pristine and 2007 Baseline Conditions [a] for the Bathurst Herd

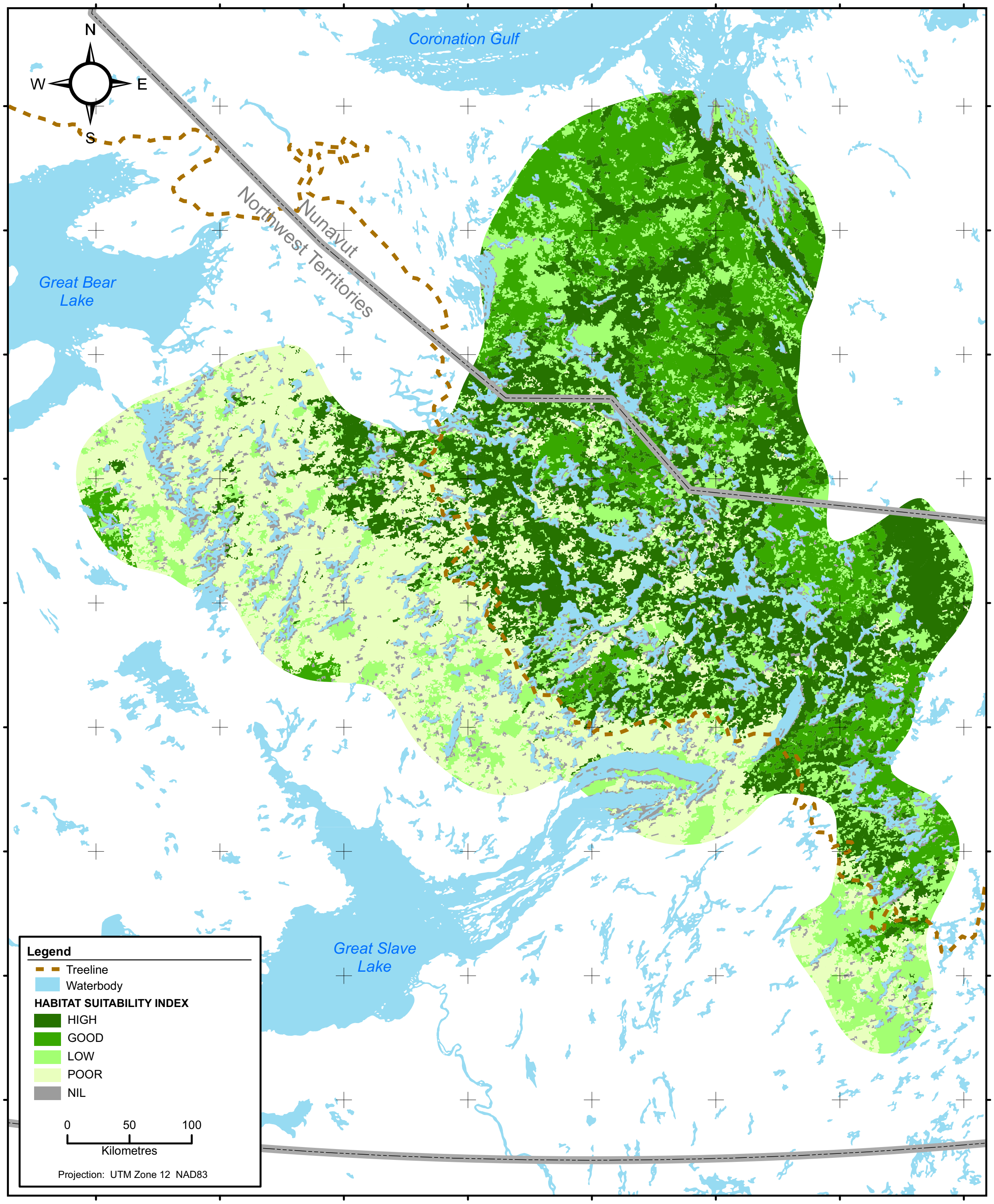
Habitat	Total Area		Number of Patches		Total Edge		Mean Area of Patch		Coefficient of Variation for Patch Area		Mean Distance to Nearest Neighbour	
	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application	Baseline	Application
Esker	-72.0	-4.0	-13.0	-1.0	-13200.0	-800.0	0.0	0.0	0.0	0.0	5.1	0.4
Lichen veneer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rock association	-11740.0	-1028.0	48.0	17.0	71200.0	77600.0	-125.3	-38.4	-5.4	-2.8	-160.1	-37.8
Heath tundra	-12092.0	-2152.0	27.0	30.0	207800.0	164000.0	-290.0	-270.1	15.8	-37.7	-182.2	-113.2
Heath rock	-96.0	0.0	0.0	0.0	-1600.0	0.0	-0.9	0.0	0.2	0.0	6.4	0.0
Sedge association	-96.0	0.0	1.0	0.0	-800.0	0.0	-7.5	0.0	0.9	0.0	-824.0	0.0
Riparian shrub	-4124.0	-1372.0	35.0	16.0	54800.0	105200.0	-47.2	-20.3	5.6	-8.1	-97.8	-30.1
Low shrub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forest	-52384.0	-4192.0	100.0	45.0	1754800.0	344400.0	-1347.0	-504.0	-1077.8	-12.7	-86.6	-40.2
Young burn	-4656.0	-1784.0	26.0	18.0	119200.0	151200.0	-246.8	-151.5	13.3	-2.5	-271.1	-155.5
Old burn	-1048.0	-1012.0	7.0	16.0	5600.0	71600.0	-21.5	-44.7	1.9	0.2	-50.9	-137.0
Nonvegetated	-36828.0	-4308.0	116.0	36.0	1761400.0	387400.0	-461.0	-119.3	32.3	10.2	-259.8	-81.8

Note: Baseline = relative change from Pristine to 2007 Baseline Conditions; Application = relative change from 2007 Baseline to Application Conditions.

[a] Application and 2007 Baseline for winter fragmentation analysis include winter access, the Tibbitt-to-Contwoyto winter road, and the Twin Gorges to Nonacho Road

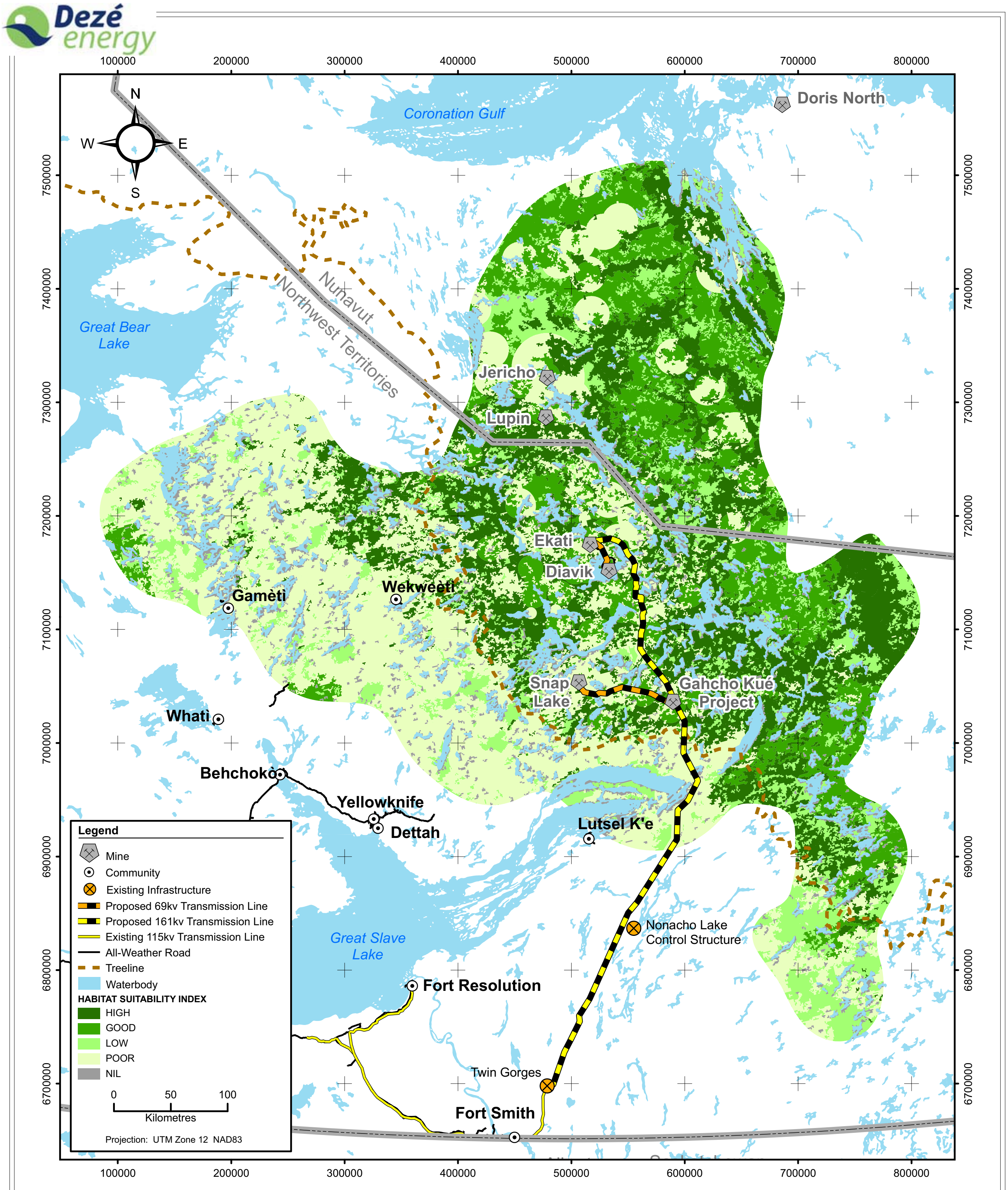
APPENDIX 12B

HABITAT SUITABILTY MAPS FOR BATHURST CARIBOU



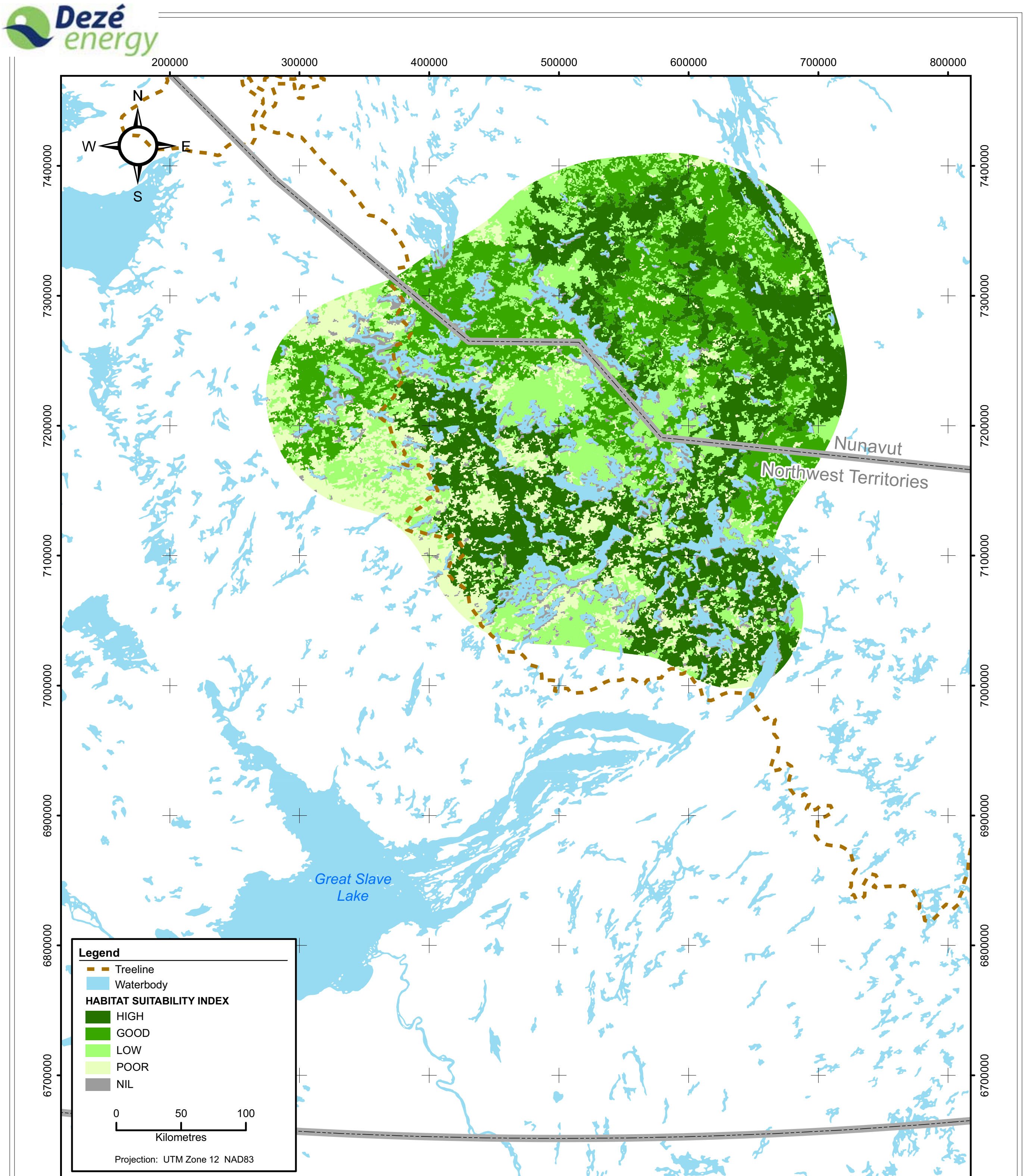
TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report** **2009**	**Habitat Suitability for Bathurst Caribou: Northern Migration Pristine Conditions**	**Figure** **12B.1**

Golder/GM_217



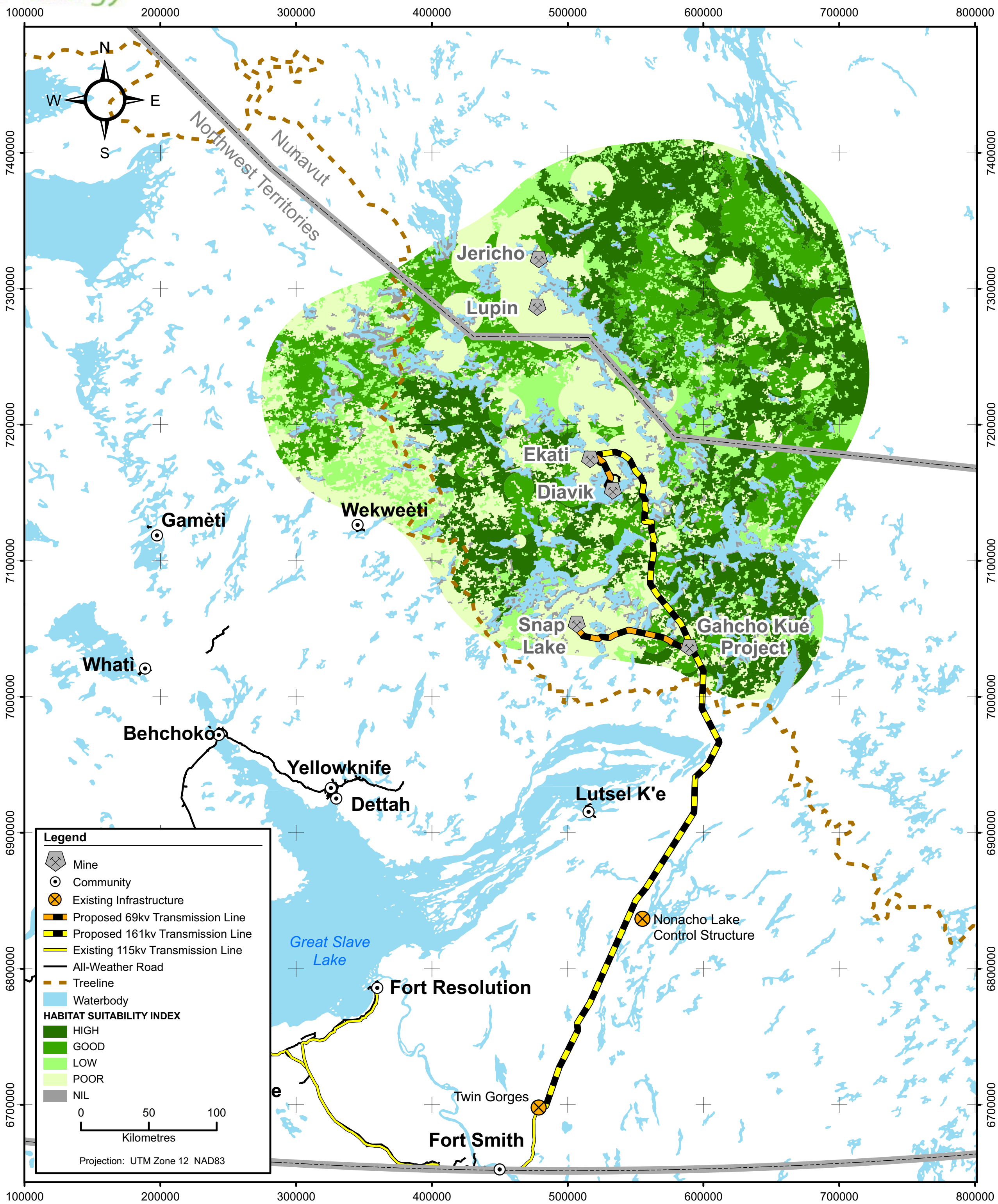
TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Habitat Suitability for Bathurst Caribou: Northern Migration Application Conditions	Figure 12B.2

Golder/GM_218



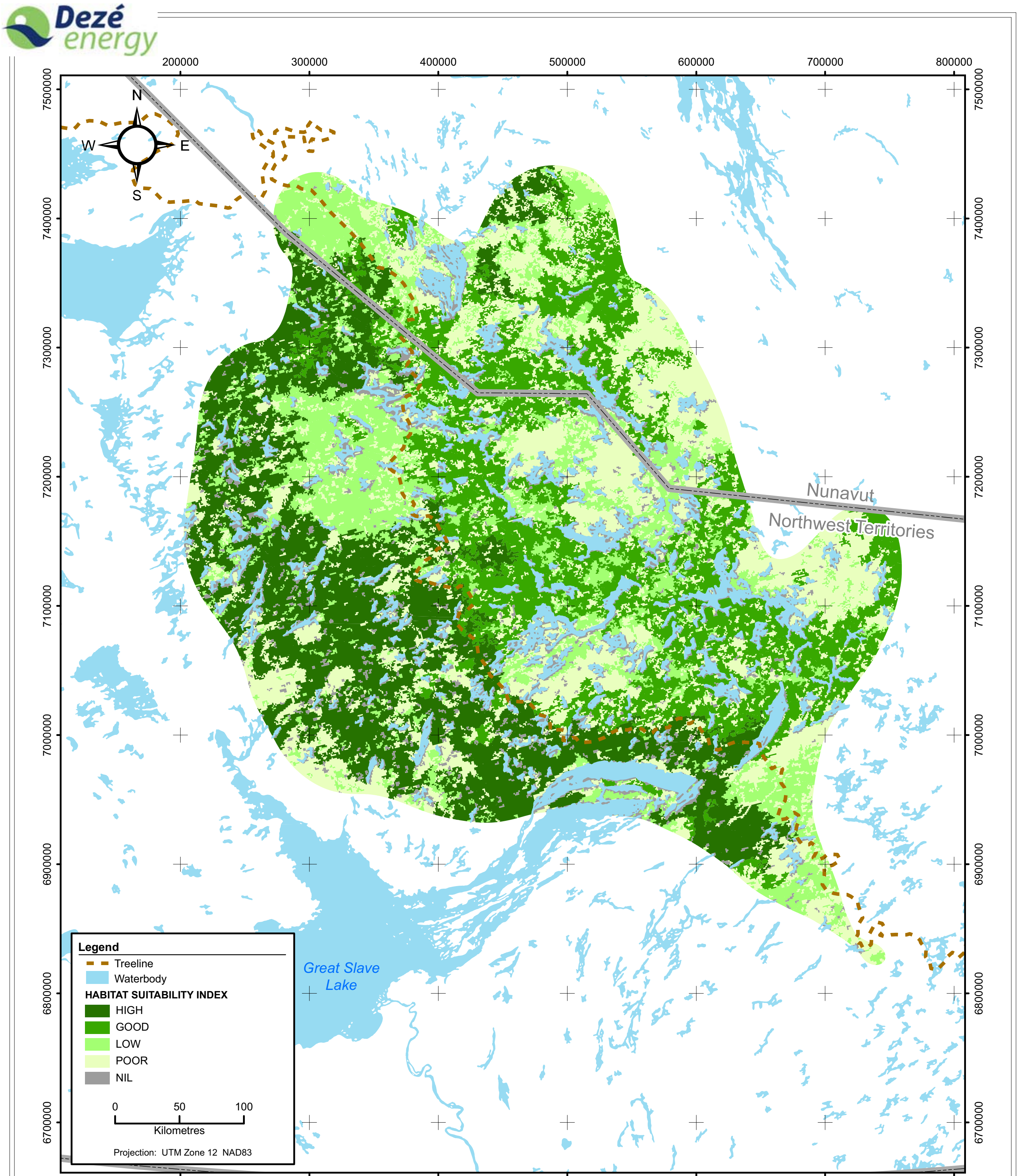
TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Habitat Suitability for Bathurst Caribou: Post Calving Pristine Conditions	Figure 12B.3

Golder/GM_215



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Habitat Suitability for Bathurst Caribou: Post Calving Application Conditions**	**Figure 12B.4**

Golder/GM_216



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report** **2009**	**Habitat Suitability for Bathurst Caribou:** **Rut Pristine Conditions**	**Figure** **12B.5**

Golder/GM_213

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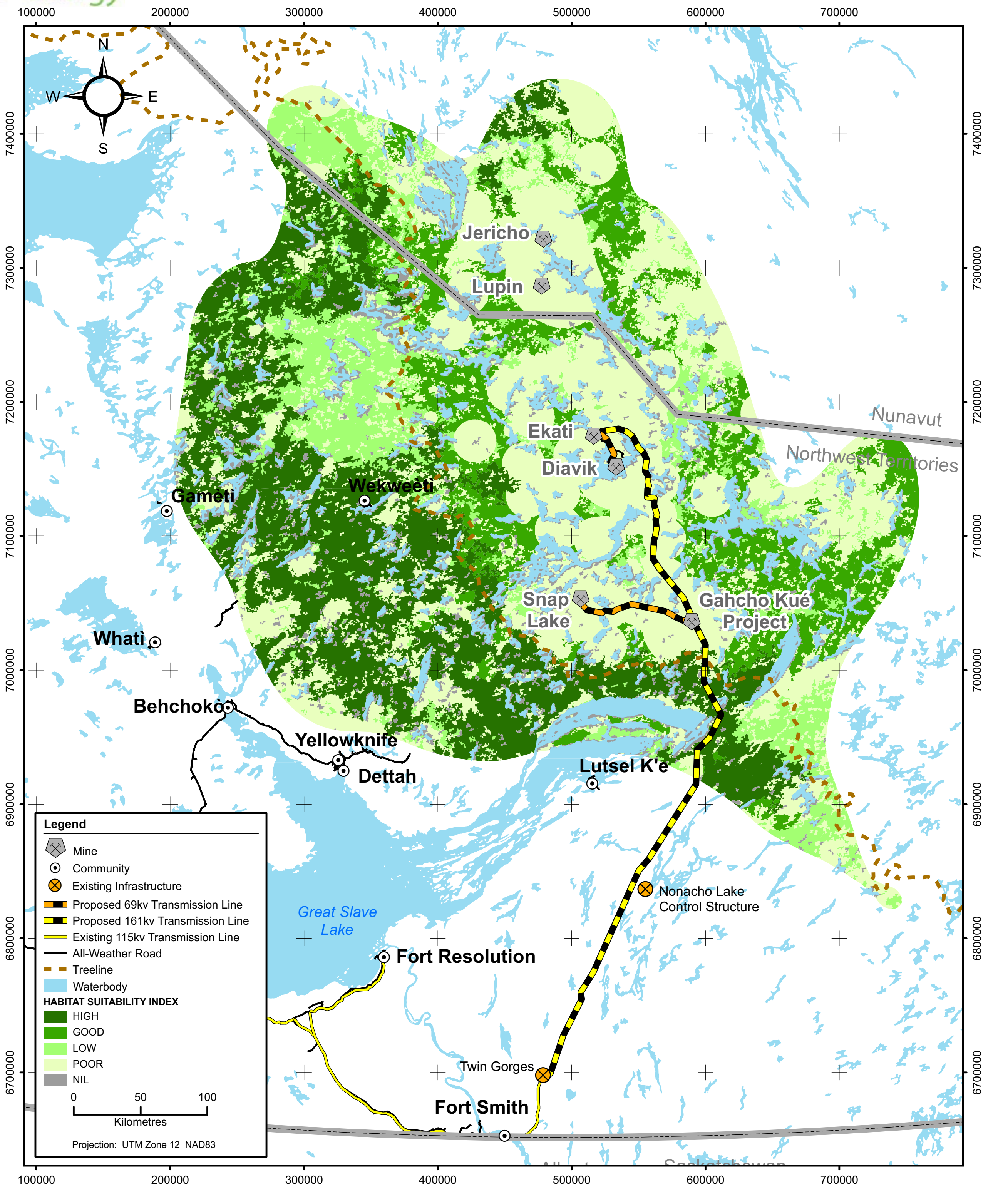
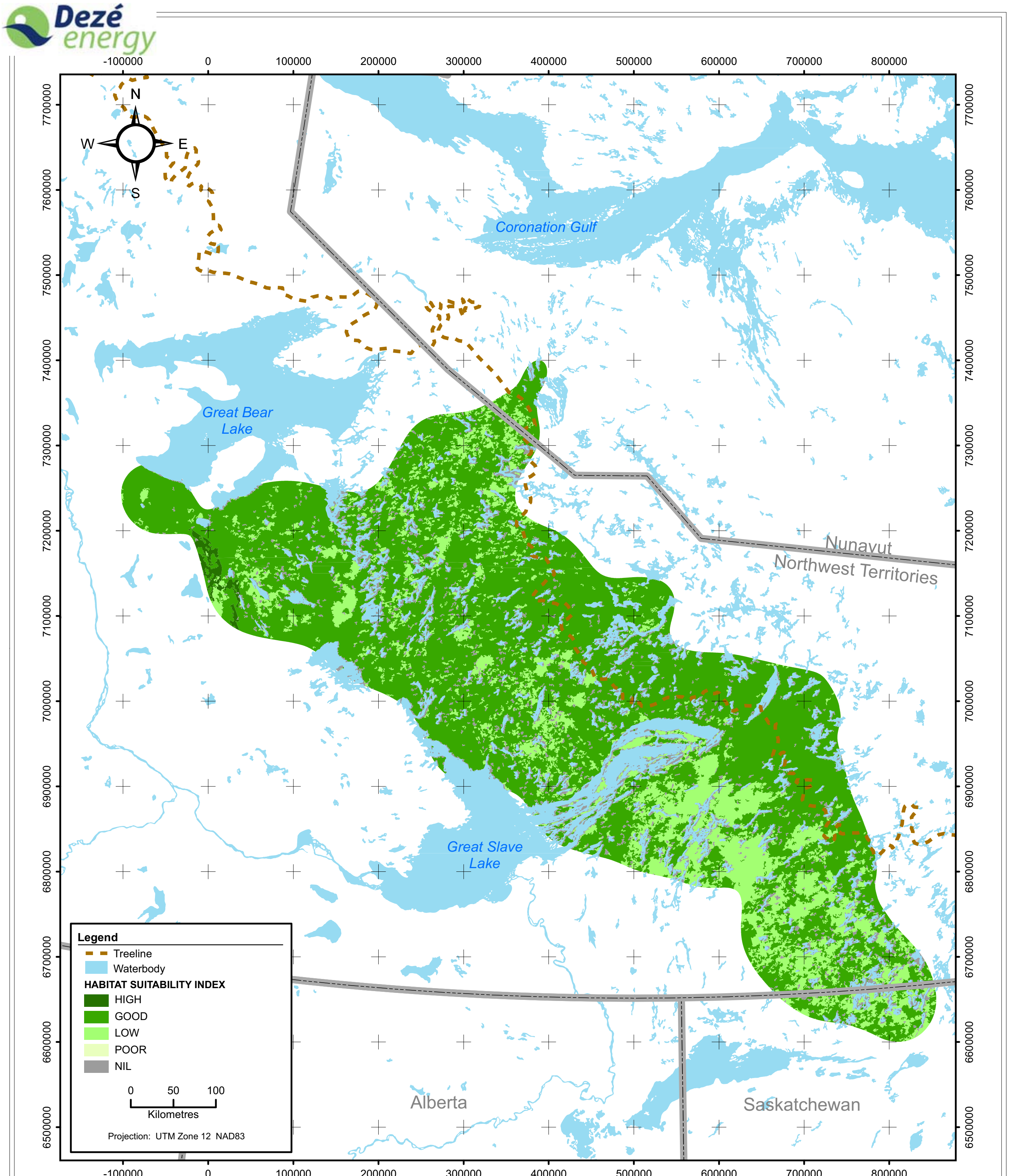


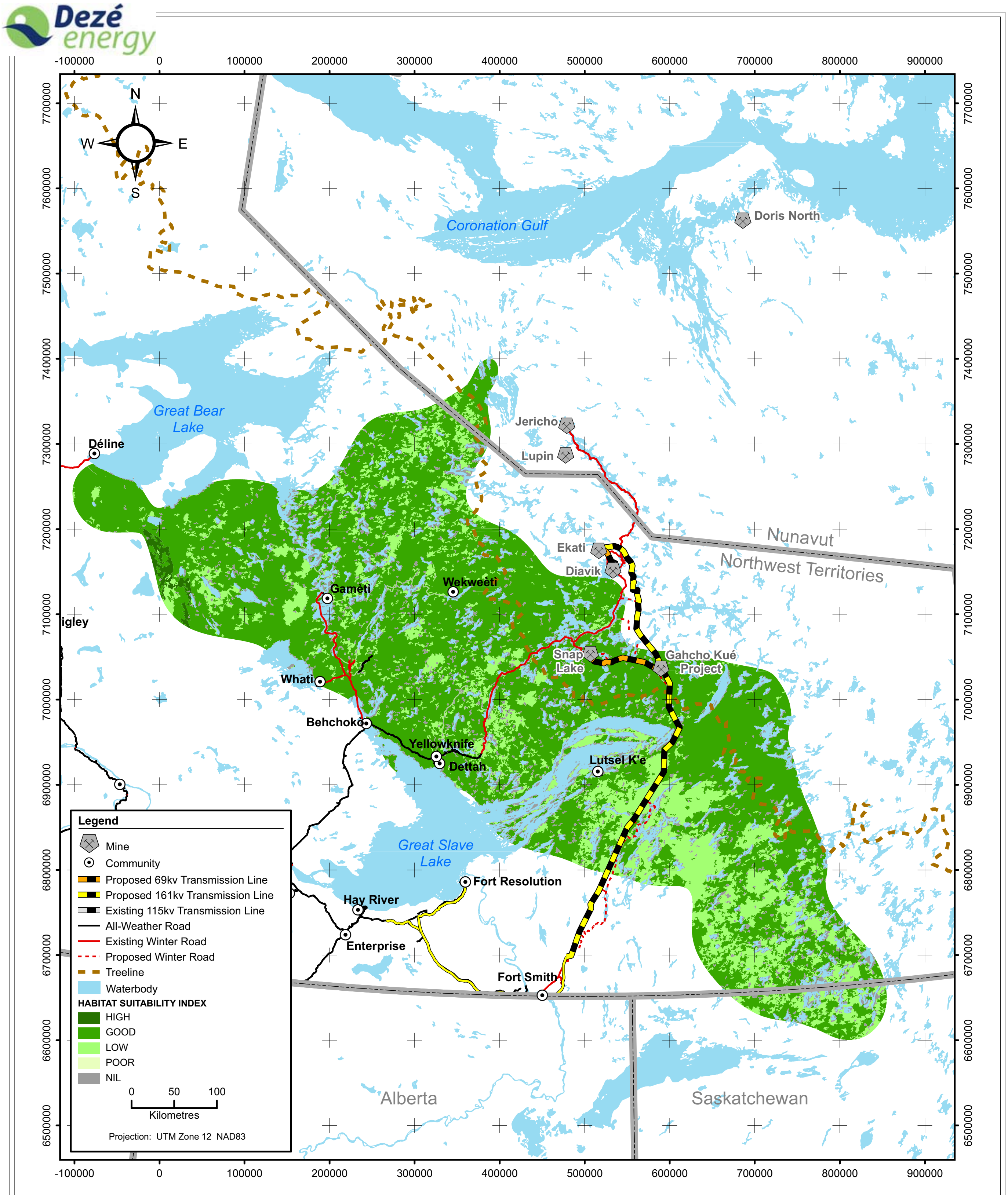
TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Habitat Suitability for Bathurst Caribou: Rut Application Conditions	Figure 12B.6

Golder/GM_214



TALTSON **Hydroelectric Expansion Project**	**Developer's Assessment Report** **2009**	**Habitat Suitability for Bathurst Caribou:** **Winter Pristine Conditions**	**Figure** **12B.7**

Golder/GM_219



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Habitat Suitability for Bathurst Caribou: Winter Application Case	Figure 12B.8

Golder/GM_220